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R.H.M.J. Lemmens, I. Soerianegara and W.C. Wong
(Editors)

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Foreword

Many tree species in the forests of South-East Asia are currently of minor commercial importance, but history shows that the importance of timbers in the market can change drastically. Before the 1950s, 'meranti' was often considered an inferior timber, yet it is now the world's most important timber trade group. New methods of wood preservation and other technologies have extended the potential uses of many timbers. In a continuously changing market, it is difficult to predict the valuable timber species for the future.

Where this is compatible with forest sustainability, ITTO supports the increased use of what are now minor commercial timbers or lesser-known timbers, as one way to increase the value of the forest and thereby assist in its survival. Such increased use must be planned and executed efficiently, and to do this we need reliable information.

Thus, this Prosea volume on minor commercial timbers is an important contribution. It gives information on the use of the wood and other parts of the tree, serves as an aid for identifying the tree and its wood and surveys current knowledge of the species' silviculture and ecology. Species that can play an important role in sustainable forest management and promising species for the establishment of timber plantations or for use in agroforestry systems are described.

Reading this volume, however, it becomes evident that our knowledge is still far from complete. Research on various tree species of current minor economic importance, especially on their ecological, silvicultural and propagation characteristics, is undoubtedly worthwhile and necessary to ensure the sustainability of South-East Asian tropical forests. Through such research, we will be well prepared if and when these 'minor' commercial species become important in the world timber trade.

This publication has been achieved through the efforts of a large team consisting of authors, editors, associate editors and Prosea personnel, and through specific grants made available by the International Tropical Timber Organization and the Commission of the European Union. My congratulations to all those involved for producing this excellent volume.

Yokohama, June 1995

B.C.Y. Freezailah
Executive Director
International Tropical Timber Organization (ITTO)

1 Introduction

The general aspects of timber trees have already been highlighted in the introduction to Volume 5(1): 'Timber trees: Major commercial timbers'. These included definitions, role, trade, botany, ecology, wood properties, wood processing, forest management, silviculture, harvesting, agroforestry and urban forestry, forest and timber policy, biodiversity, conservation, breeding, forestry research and prospects. The introduction to the present volume gives more specific information on the choice of genera and the importance, trade, utilization and prospects of minor commercial timbers. In addition, recent developments in sustainable forest management and eco-labelling of timber, particularly in Indonesia, are discussed briefly.

1.1 Choice of genera

The most important trade and export timbers, including all dipterocarp genera, were covered in Volume 5(1). In the introduction to that volume (paragraph 1.3) it was explained that the choice of the genera to be dealt with in each of the 3 volumes on timber trees (Major commercial timbers, Minor commercial timbers and Lesser-used timbers) was somewhat arbitrary; the importance of a genus may change rapidly in the course of time.

In general, the timbers covered in the present volume are economically less important than those in Volume 5(1). However, some of the genera are often of considerable economic importance locally, for example jelutong (*Dyera costulata*) in Malaysia, and *Nothofagus*, *Burckella* and *Podocarpaceae* such as *Dacrycarpus* and *Dacrydium* in Papua New Guinea. In some cases, such as ebony (*Diospyros*) and, less important, lanete (*Wrightia*), the timber has some economic importance but no trade figures are available because the wood is used in the area of origin for carving.

This volume also deals with several genera containing important timber plantation trees such as wattle (*Acacia*, particularly *A. mangium*) and surian (*Toona*). The most important timber plantation trees, however, were covered in Volume 5(1). Some species are planted primarily for other purposes but also yield timber, e.g. *Artocarpus*, *Durio* and *Mangifera* spp. planted for their edible fruits, black wattle (*Acacia mearnsii*) locally planted for its tanniferous bark, and para rubber (*Hevea brasiliensis*) mainly planted for latex production.

The most important families of timber trees dealt with in this volume are *Anacardiaceae* (7 genera), *Burseraceae* (kedondong; 3 genera), *Fagaceae* (4 genera), *Lauraceae* (medang; 4 genera) and *Meliaceae* (5 genera), which all yield hardwood, and *Podocarpaceae* (7 genera) yielding softwood.

1.2 Economic importance

In general, minor commercial timbers have restricted importance on the international market. Some, however, are of local economic importance as domestic consumers are less discriminating and are greatly influenced by prices because of their lower purchasing power. The increasing production of wood-based panels (especially medium density fibreboard) in South-East Asia has led to several minor commercial timbers becoming the major source of raw material for the manufacture of these panels. Rubberwood, for instance, which is an important timber for furniture manufacturing, is also the main raw material for particle board and medium density fibreboard in Malaysia. Veneers have also been produced from rubberwood logs and are laminated to serve as components for furniture.

1.3 Trade

Both the domestic and international timber trade are typically oriented on trade groups. Traditionally, importers specify well-known timbers in their orders, making it extremely difficult to introduce new timbers with similar or even superior physical and mechanical characteristics. The more demanding consumers only buy wooden articles or furniture made from a particular familiar timber, such as teak and rosewood.

Most countries only keep records of the exported or imported volumes of major commercial timbers. It is therefore almost impossible to accurately assess the trade in individual minor commercial timbers. The statistics often give only one figure denoting the total volume of minor commercial timbers traded. Even Malaysia, with a long history of exporting sawn tropical hardwood, uses the terms 'mixed-medium-hardwood (MMH)' and 'mixed-light-hardwood (MLH)' to lump together the export volumes and values of all commercial timbers that are not well established, only distinguishing two density classes. At times, the volume exported as MMH and MLH could well exceed that of some individual major commercial timbers. Other countries use 'red-wood' or 'white-wood' and differentiate groups of minor commercial timbers solely on colour. It has been estimated that almost half of the total amount of timber imported from South-East Asia by Japan in the first half of the 1990s consisted of mixed consignments of timber graded on density and colour. Sometimes one lot contains a few dozen timber species.

The end-use classification system was proposed in the 1970s to promote the use of minor commercial timbers. This system involves identifying the desirable properties of a timber for the production of various end products. A timber will only be considered suitable for the production of a specific product if it possesses these desirable properties. Computer programmes have since been developed to allow a timber to be matched with the properties required. This end-use classification system makes it easier to introduce new timbers and market them together with other established ones as a group for the manufacture of products destined for a particular end-use such as furniture, flooring, etc. All species in the group then lose their individual identities, and new markets for timbers suitable for various end-uses are created. The users are offered a package of various timbers at a lower price to meet their requirements. This system sounds logical and beneficial to both suppliers and users, but has met with limited success so far because the users are reluctant to change and to adopt the concept.

1.4 Utilization

Timbers are heterogeneous by nature. Although the minor commercial timbers could be marketed together with the accepted ones as a group, their individual characteristics and processing properties are not entirely similar. The use of such a group does confront users with some inconveniences, due to slight differences in colour and processing characteristics. Unless there is a substantial price incentive, users will find it more economic and convenient to continue to use established commercial timbers. It is relevant to stress here that the minor commercial timbers do not necessarily have inferior properties compared with the major commercial timbers.

The tropical forests in South-East Asia are known for their species richness. No less than 3000 tree species are found in Peninsular Malaysia alone. Formerly, Peninsular Malaysia marketed 53 commercial timbers comprising about 400 botanical species, as stated in the Malaysian Grading Rules of 1968. The revised Malaysian Grading Rules of 1984 (Malaysian Timber Industry Board, 1984) listed 100 commercial timbers comprising about 650 species, which is less than one-quarter of the number of tree species known. In Indonesia, about 120 commercial timber trade groups are marketed, comprising only a minor portion of the 4000 tree species known.

Many of the minor commercial timbers are currently grossly under-utilized for the following reasons:

- They are not readily identifiable in the field or in the market.
- They are not available in sufficient quantity for individual promotion.
- Their long-term supply is uncertain.
- Their physical and mechanical properties are not fully known.
- Practical solutions to processing and utilization problems are still lacking.
- There is a lack of specific market promotion.
- Methodologies to season and treat mixed consignments of species are still lacking.

With the application of modern science and technology it should be possible to solve the processing problems of individual species and to exploit their specific properties.

1.5 Sustainable forest management and eco-labelling of timber

Guidelines and criteria

Certification of timber ('eco-labelling') is considered an appropriate means of attaining the sustainable management of forest from which the timber is harvested. The members of the International Tropical Timber Organization (ITTO) have agreed that the implementation of eco-labelling of tropical timber will start in 2000. ITTO has drafted guidelines for sustainable management of tropical forest (1990) and criteria for the measurement of sustainable tropical forest management (1992). According to ITTO (1990), sustainable forest man-

agement is the process of managing permanent forest land to achieve one or more clearly specified objectives with regard to the realization of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment.
The criteria for sustainable forest management listed by ITTO (1992) refer to resource security, continuity of timber production, conservation of flora and fauna, acceptable levels of environmental impact, socio-economic benefits, and community consultation and recognition of community rights.
Well-managed forest should be sustainable with regard to the production of forest products, ecological functions and socio-economic benefits for local communities. The eco-label of forest products should guarantee that:
- The forest management has actually reached certain standards of sustainability.
- The products originate from such sustainably managed forest.
- The processing of the products has not caused harmful environmental effects.

At present, the most important aspect is to secure the sustainability of the natural production forests through the certification of sustainable forest management.

Implementation

The time is ripe to implement the criteria for sustainable forest management at national level and to try to evaluate them in forest concessions. The Indonesian government has resolved on the following measures to ensure the sustainable use of natural forest:
- Almost 50 million ha of the total 114 million ha of forested land has been designated as protection and conservation forest in which logging is prohibited. About 64 million ha has been designated as production forest: 31 million ha is limited production forest where only selective felling is allowed, and 33 million ha is regular production forest where selective felling and clear-felling are allowed.
- Regulations on environmental impact assessment are being enforced for concessions.
- The annual allowable cut of the natural forest is determined for each concession to prevent over-cutting.
- Regulations pertaining to the sustainable management of natural forest including the Indonesian selective felling and replanting system are issued and continuously enforced.
- In each forest concession 700 ha of genetic resources conservation area is established.
- Protection areas in production forest are excluded from exploitation.

Independent institutions should be established to certify sustainable forest management and to carry out eco-labelling of forest products. It is essential that all parties in producing and consuming countries unconditionally accept the authority of these controlling bodies. The entire system of sustainable management and eco-labelling depends on effective control. The Indonesian eco-labelling working group has already convened an international conference on for-

est products certification systems, attended by many non-governmental organizations and representatives of producing and consuming countries. The results have been published (Indonesian Eco-labelling Working Group, 1994).
Correct identification of trees and their product, i.e. wood, is another prerequisite. The input of well-trained botanists and wood anatomists is required to achieve an effective system of eco-labelling.

1.6 Prospects

With the growing emphasis on sustainable use and on the conservation of forest for its environmental functions, many timber-producing countries are committed to reducing the area to be opened up annually for forest exploitation. In the future, the flow of logs and products of major commercial timbers to the international market will be reduced considerably, resulting in substantial price increases. However, there will still be a consistent demand for timber in construction because of its versatility and favourable strength to weight ratio. Its natural beauty and warmth, unparalleled by synthetic products, will still render wood a preferred material for the manufacture of quality furniture and indoor decoration, especially for more affluent households. With the impending reduction in the supply of major commercial timbers, greater attention to and wider acceptance of minor commercial timbers available at a relative low price are anticipated. Some relatively abundant minor commercial timbers that are currently sold and exported in groups may be marketed individually in the near future on the basis of their physical and mechanical properties.
There appear to be good prospects for increasing the utilization of minor commercial timbers and developing domestic and international markets. However, only the minor commercial timbers in adequate supply, with known properties and solvable processing problems will stand a reasonable chance of gaining market acceptance. The end-use classification system is an adequate and hence promising means of encouraging the use of minor commercial timbers which have to be marketed in groups because of insufficient supply for individual promotion, but it needs to be refined and promoted more actively.
Certain major commercial timbers are popular because of their unique properties. With the advances in wood science and technology it is now technically feasible to make some minor commercial timbers resemble the major commercial ones in terms of appearance and workability and to substitute them in many applications. A wide range of wood finishes and other surface treatments is available to improve the appearance of timber. Even physical properties can be modified and enhanced, within certain limits, through chemical treatment, polymerization, densification and other processes. The constraints are caused by institutional weaknesses. Most research and development institutions in the tropics lack trained manpower, research facilities and funds, and therefore urgently need external assistance. Furthermore, the introduction and development of new timbers on the international market require intensive promotional programmes, for which the national marketing bodies or the suppliers themselves lack the funds.

Many minor commercial timbers in the low to medium density range are now being used as core veneers for the manufacture of plywood. The present trend to replace an increasing amount of solid timber and even plywood, which have to be manufactured from the more costly large-diameter logs, by wood-based panels is expected to continue. The manufacture of these panels generally does not require logs of large diameter. Moreover, the properties of the wood are less important for the final quality of the panels, which is mainly determined by the manufacturing parameters adopted. There is no preference for wood from the major rather than the minor commercial species, as long as it falls within the requisite density range, is easily converted into chips, particles or fibres and is compatible with the binders used. Using modern techniques to make any wood suitable for many applications will reduce the areas to be logged annually to satisfy the demands. However, one should not overlook the danger that this might lead to indiscriminate logging and clear-felling or over-cutting of certain areas of natural forest. It is therefore necessary to maintain the delicate balance between intensive utilization of the forest and sustainable forest management.

2 Alphabetical treatment of genera

Acacia Miller

Gard. Dict. abr. ed. 4 (1754).
LEGUMINOSAE
$x = 13$; $2n = 26$ for the majority of species, *A. auriculiformis, A. catechu*: $2n = 26$, *A. leucophloea*: $2n = 26, 52$

Trade groups Wattle: medium-weight hardwood, e.g. *Acacia auriculiformis* A. Cunn. ex Benth., *A. catechu* (L.f.) Willd., *A. mangium* Willd.

Vernacular names Wattle, brown salwood, acacia (En). Acacie (Fr). Indonesia: akasia (general).

Origin and geographic distribution *Acacia* is a large genus with over 1300 species, which is widely distributed in the tropics and subtropics. Most of the species are found on the Southern Hemisphere and the main centre of diversity is located in Australia and the Pacific. Within the Malesian region 29 species occur native or naturalized. Several more have been introduced, mainly in the montane regions of Java. Most of the timber-producing species are found in New Guinea.

Uses The timber of *Acacia* species is used for furniture and cabinet making, light to heavy construction, door and window frames, mouldings, light flooring, poles, posts, panelling, mine timber, boat building, carts, wheels, joinery, turnery, oil crushers, tool handles, agricultural implements, matchboxes and splints, particle board, hardboard, veneer and plywood, pulp and paper. The wood is tough and resilient and particularly suitable for axe handles and sports equipment. The pulp is suitable for the manufacture of liner boards, bags, wrapping papers and multiwall sacks. The wood makes a good fuelwood and good charcoal, as it has a high energy value. The sawdust provides a good medium for the production of shiitake mushrooms.

The trees are also planted in fire-breaks and wind-breaks, for shade, soil protection, and as ornamentals. The leaves and pods of some species are used for animal fodder. The germinated seeds can be cooked and eaten as a vegetable. Several species are important tannin-producing trees and a dye can be extracted from the bark of one species (*A. mearnsii*). An extract of the heartwood is used medicinally and is sometimes chewed with betel (*Areca catechu* L.). A gum produced by the stem or the roots is also used in local medicine.

Production and international trade Significant areas of plantations, mainly of *A. mangium* and *A. auriculiformis*, have been or are being established in Indonesia, Malaysia and Papua New Guinea, and also in India, Sri Lanka and Thailand. The wood from these plantations is mainly used as pulp, but no statistics are available on production and trade. The international trade in wattle timber is relatively small. Wood chips of plantation-grown *A. mangium* are exported to Japan from Papua New Guinea, and small quantities of *A. mangium* timber are exported from Peninsular Malaysia and Sabah, for instance to Taiwan.

Properties Wattle is a medium-weight hardwood. The heartwood is pale olive-brown, grey-brown to pink, darkening to reddish-brown or dark red, and often attractively streaked. The sapwood is yellowish-white, cream or straw-coloured and distinctly demarcated from the heartwood. Heartwood formation varies significantly with provenance. Like the wood of other fast-growing tree species, the wood from wattle plantations has the inherent potential disadvantage of small diameter, knottiness, low density, little strength, large proportion of reaction wood, greater incidence of spiral growth, greater growth stress and greater proportion of juvenile wood. The density is (490–)560–1000 kg/m^3 at 15% moisture content; the density of plantation-grown wood of *A. mangium* can be as little as 450 kg/m^3 at 15% moisture content. The grain is straight to shallowly interlocked, texture fine to medium and even.

The mechanical properties of *A. leucophloea* wood from Indonesia have been tested at 14% moisture content, with the following results: the modulus of rupture 85–86 N/mm^2, modulus of elasticity 10340–10780 N/mm^2, compression parallel to grain 51.5–53.5 N/mm^2 and shear 8–10.5 N/mm^2. Wood of *A. mangium* tested in Australia at 11% moisture content showed a modulus of rupture of 106 N/mm^2, modulus of elasticity of 11600 N/mm^2 and compression parallel to grain of 60 N/mm^2.

The rates of shrinkage are fairly low to moderate: from green to 12% moisture content 1.0–1.4% radial and 2.3–4.2% tangential. When seasoned with care, end-splitting and surface checking are not significant during drying. Boards 25 mm thick take about 3 months to air dry. The timber kiln dries rapidly but marked collapse may occur in early stages of seasoning; this can be remedied by reconditioning.

The wood is easy to work with all tools, but boards of *A. auriculiformis* tend to split when sawn. It is recommended to saw the comparatively heavy wood of *A. catechu* when green. Wattle wood planes easily to a smooth, lustrous surface using cutting angles of 15–25° and finishes well with sharp tools. It drills quite easily, provided the base is supported to prevent end-chipping, and it turns well under low to moderate pressure. The nailing and screwing properties are satisfactory. The wood takes a good polish.

Wattle wood is usually durable when exposed to the weather, but is not durable in contact with the ground. It is mostly resistant to termite attack, but *A. auriculiformis* wood can be attacked by the root fungus *Ganoderma lucidum* and is liable to marine borer attack. The heartwood is moderately resistant to preservative treatment, but the sapwood is permeable.

The pulping properties are excellent and comparable to commercial eucalypts. In tests in Australia using the sulphate process, wood chips of *A. mangium* from a 9-year-old plantation required only moderate amounts of alkali to yield in excess of 50% of screened pulp with excellent paper-making properties. Pulp yields were even higher (up to 75%) with the neutral sulphite semichemical process, and the pulp was readily bleached to brightness levels acceptable for use in fine papers. The hybrid of *A. mangium* and *A. auriculiformis* has a yield of over 55% in sulphate pulping and the quality of the pulp is generally better than that of *A. mangium* or *A. auriculiformis*.

A. auriculiformis wood contains 66% holocellulose, 35% α-cellulose, 31% lignin, 16% pentosan and 1.5% ash; the solubility is 9.7% in alcohol-benzene, 10.6% in hot water and 24.0% in alkali. Wood of *A. mangium* contains 78% holocellulose, 46.5% α-cellulose, 27% lignin, 14% pentosan and 0.2% ash; the solubility is 3.8% in alcohol-benzene, 3.3% in hot water and 13.4% in alkali. Wood of the hybrid between these species from Sabah contains 79% holocellulose, 47% α-cellulose, 26.5% lignin, 13.5% pentosan and 0.6% ash; the solubility is 3.8% in alcohol-benzene, 2.5% in hot water and 13.9% in alkali. The energy value of *A. mangium* wood is 20 100–20 500 kJ/kg and of *A. mearnsii* wood is about 19 700 kJ/kg.

The bark and wood contain abundant tannins, e.g. up to 40% on dry weight basis in the bark of *A. mearnsii*, making wattles commercially important for tanning sole leather.

Description Armed or unarmed lianas, shrubs or small to fairly large trees up to 35(–39) m tall; bole branchless for up to 21 m, up to 100 cm in diameter, not buttressed; bark surface (of timber trees) dark grey or brown, deeply longitudinally fissured, inner bark pale brown or red to pink. Leaves arranged spirally, bipinnate and consisting of many opposite, sessile or short-stalked leaflets, or a phyllode made up of a flattened petiole and the proximal part of the rachis; extrafloral nectaries usually present on petiole and rachis; stipules present, spinescent or not. Inflorescences consisting of pedunculate glomerules or spikes borne in axillary clusters or aggregated into terminal panicles. Flowers bisexual, or male and bisexual, actinomorphic, 4–5-merous, white or pale greenish to yellow; calyx and corolla connate, valvate; stamens many, free or united only at base; ovary solitary, superior, 1-celled, style filiform, stigma small. Fruit a dehiscent or indehiscent pod, very variable in shape, texture and indumentum. Seeds in 1 row, usually elliptical to oblong, more or less flattened; testa hard; funicle usually without an aril. Seedling with epigeal germination; cotyledons borne above the soil level, petiolate, ear-shaped with flabellate venation; basic foliage sequence from pinnate to bipinnate to a phyllode.

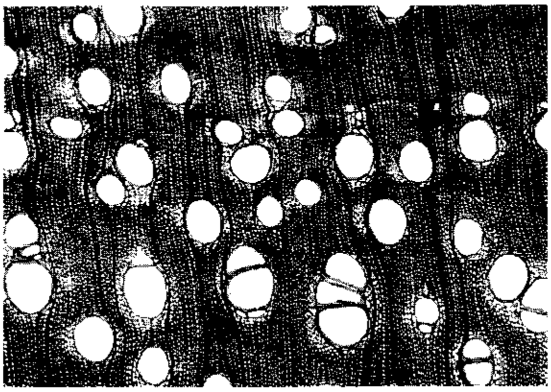
Wood anatomy

– Macroscopic characters:

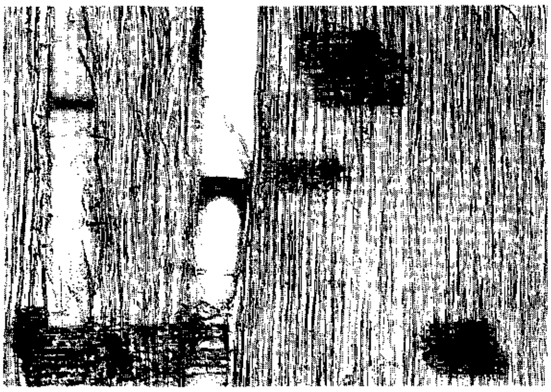
Heartwood pale pinkish-brown to dark brown, sometimes olive-brown to grey-brown, clearly demarcated from the pale yellow to straw-coloured sapwood which is up to 60 mm wide in *A. auriculiformis*, narrower in other species. Grain usually straight, sometimes interlocked. Texture fine to medium, even; streaky figure sometimes evident due to darker coloured streaks, wood lustrous. Growth rings indistinct to absent, but reportedly visible in wood from plantations of *A. mangium* in Thailand; vessels intermediate to large and distinct to the naked eye, evenly distributed; parenchyma not abundant, around pores, very occasionally in irregular bands; rays small, invisible to barely visible to the naked eye as individual rays, more conspicuous on radial surface particularly when extraneous materials abundant; ripple marks absent.

– Microscopic characters:

Growth rings indistinct or absent, sometimes poorly defined growth zones evident. Vessels diffuse, 4–6(–9)/mm^2, solitary (c. 40%) and in radial multiples of 2–3(–4), round to mostly oval, average tangential diameter (90–)120–160(–270) μm; perforations simple; intervessel pits alternate, vestured, polygonal and often crowded, 6–9 μm in diameter; vessel-ray pits similar to intervessel pits but half-bordered; helical thickenings absent; tyloses absent. Fibres (0.9–)1.1–1.2(–1.3) mm long, non-septate, thin-walled to moderately thick-walled, with inconspicuous and simple to minutely bordered pits; tension-wood fibres common.



transverse section (×25)



radial section (×75)

tangential section (×75)

Acacia mangium

Parenchyma sparse to moderately abundant paratracheal, vasicentric, usually in prominent sheaths, 2–4 cells wide around the pores, tending to aliform particularly around the smaller pores, in 2–4-celled strands. Rays 4–6(–8)/mm, 1–2(–3)-seriate, 0.2–0.4 mm (10–40 cells) high, homocellular. Prismatic crystals in chambered parenchyma strands. Silica absent. Wood showing fluorescence in UV light.

Species studied: *A. aulacocarpa*, *A. auriculiformis*, *A. crassicarpa*, *A. decurrens* (Wendl.) Willd., *A. mangium*, *A. mearnsii*.

The heartwood of plantation-grown material tends to be paler. Sometimes the wood of *Albizia* may superficially resemble pale-coloured wattle, but it can easily be differentiated from wattle by more abundant parenchyma and, in some species, septate fibres; additionally, the density is lower.

Growth and development Most *Acacia* species grow fast. The considerable amount of growth data on *A. mangium* confirms that it can achieve a mean annual diameter increment of up to 5 cm and a height increment of up to 5 m in the first 4 or 5 years. *A. mangium* is reported to grow 3 m tall in the first year in Sabah and Sumatra, and in the Philippines it reached an average height of 8.3 m and diameter of 9.4 cm after 2 years. However, growth declines rapidly after 7 or 8 years and except under ideal conditions or over long periods (more than 20 years), the tree will probably not exceed 35 cm in diameter and 35 m in height. In Sabah, 14-year-old *A. mangium* trees were 30 m tall and 40 cm in diameter. Provenances from Papua New Guinea consistently show better growth in height and diameter, and the form is also superior.

Early growth of *A. auriculiformis*, *A. crassicarpa* and *A. leptocarpa* is fast during the first 6 months. *A. leptocarpa* trees reached a mean height of 3.0 m in 6 months. *A. auriculiformis* in Papua New Guinea reached 6 m height and 5 cm diameter in 2 years, in Malaysia it reached 9–12 m height after 3 years on clay soils and 6 m height on nutrient-poor sandy soils; in Sabah the growth rate is comparable to *A. mangium*. However, early growth of *A. leucophloea* is slow, and the mean annual diameter increment of *A. catechu* in Thailand is only 0.8–1.3 cm.

In the first 2 years both the diameter growth and height growth of *A. mangium* trees are significantly greater at a spacing of 2 m × 2 m and 2.5 m × 2.5 m than at 3 m × 3 m. Height growth is almost halved on sites dominated by the grass *Imperata cylindrica* (L.) Raeuschel.

A. mangium trees form a symbiosis with soil bacteria of the genus *Rhizobium*, leading to nodules, in which the bacteria transform free nitrogen into organic and inorganic compounds containing nitrogen. Some *Rhizobium* strains are more effective in promoting growth than others. Optimal growth is achieved most effectively if vesicular-arbuscular mycorrhizal (VAM) fungi such as *Glomus fasciculatus* and *Gigaspora margarita* are present in combination with *Rhizobium*. Uninoculated seedlings died after 2 years in degraded grasslands. Technologies for the commercial production of rhizobial and VAM inoculants are now available in South-East Asia. The ecto-mycorrhizal fungus *Thelephora ramaroides* has been identified in Sabah in association with *A. mangium*.

A. mangium and *A. auriculiformis* flower more or less continuously. *A. mearnsii* can be expected to flower and fruit profusely every year. *A. mangium* flowers precociously and viable seed can be harvested 24 months after planting. The flowering to fruiting period is 6–7 months. The fragrant flowers are pollinated by insects such as bees.

Other botanical information *Acacia* is easily distinguishable from other genera of the subfamily *Mimosoideae* by its many stamens which are free or united only at the base. The genus is subdivided into 3 subgenera. Pollen morphological characters support this division. The mainly African and American subgenus *Acacia* is characterized by its spinescent stipules. The pantropical subgenus *Aculeiferum* Vassal has non-spinescent stipules but the internodes are armed with prickles. The large and mainly Australian subgenus *Phyllodineae* (DC.) Seringe (synonym: subgenus *Heterophyllum* Vassal) usually bears non-spinescent stipules, whereas the leaves are generally reduced to phyllodes. It has been suggested to treat the latter subgenera as distinct genera (*Senegalia* for subgenus *Aculeiferum* and *Racosperma* for subgenus *Phyllodineae*), but no consensus has been reached on this yet.

Ecology The species of *Acacia* mainly occur in savanna ecosystems, having a greater tendency to exploit arid or semi-arid regions rather than wetter forested regions, and may constitute a characteristic element of the vegetation there. The exceptions are several tropical species (including *A. auriculiformis* and *A. mangium*) found in areas of high rainfall in northern Australia, New Guinea and adjacent islands. The prevailing climate in these areas is usually strongly seasonal, with rainfall of less than 50 mm/month in June to October. Average annual rainfall is 1450–1900 mm in southern New Guinea, and 2100 mm in northern Queensland. *A. mangium* appears to have a preference for slightly higher and drier sites than other *Acacia* species found in the same area, whereas *A. auriculiformis* prefers moister soils.

In their natural habitat the species are found in a wide variety of vegetation types, ranging from grassland, swamp grassland, savanna, savanna woodland, to dry evergreen monsoon forest. The timber-producing species native in South-East Asia and northern Australia occur at low altitudes, on well-drained sandy, stony, or limestone soils, or on poorly drained floodplains and on the margins of swamps and mangroves. *Acacia* species are often found associated with *Melaleuca*, *Eucalyptus*, *Tristania*, *Alstonia*, *Dillenia*, *Xanthostemon*, *Grevillea*, *Planchonia* and *Syzygium* spp.

In general, *Acacia* can grow on a variety of soils, including very infertile, clayey, acidic, or saline soils with impeded drainage. *A. mangium* has been successfully planted on abandoned areas of shifting cultivation colonized by *Imperata cylindrica* grass, but it does not tolerate waterlogging and soils derived from ultrabasic rocks. The optimum soil pH range is 4–6. *A. auriculiformis* performs well on extremely infertile sand tailings and on heath soils.

Propagation and planting *Acacia* can be propagated from seed (direct sowing or in the nursery), and by air layering, cuttings, grafting and tissue culture.

For the production of seedlings, the pods should be processed as soon as possible after harvesting. Pods and seeds should not be left to dry in the sun for too long, as temperatures exceeding 43°C reduce viability. It is difficult to extract the seed, but pods can be broken open by being tumbled in a cement mixer with heavy wooden blocks for 10 minutes or by beating in a commercial thresher. Threshing produces highly irritating dust and causes respiratory problems for some people; operators should wear protective gear. One kg of *A. mangium* pods yields (16–)56–86 g of seed.

The number of seeds/kg is 40 000–80 000 for *A. aulacocarpa*, 30 000–62 000 for *A. auriculiformis*, 15 000–40 000 for *A. catechu*, 35 000–50 000 for *A. crassicarpa*, 60 000–120 000 for *A. leptocarpa*, 32 500–37 500 for *A. leucophloea*, 63 000–189 000 for *A. mangium* and 66 000–80 000 for *A. mearnsii*. Seed can retain its viability for many years if stored cool (0–5°C) in airtight containers. The seed of all species except *A. catechu* needs to be pretreated before sowing. A good method is to pour seed into 5–10 times their volume of water at 100°C and stir for 30 seconds (2 minutes for *A. auriculiformis*). The hot water is then drained off, cold water is added, and the seed is left to imbibe for 24 hours. Manual scarification is another pretreatment used for *Acacia* species. Pretreated seed can be sown, or may be dried immediately after the hot water treatment and then stored and transported.

The germination rate is high, generally 75–90%, and germination is rapid, usually within one month (2–10(–35) days for *A. mangium*). Seed may be sown in seed beds and pricked out 6–10 days after sowing; however, the recovery rate for *A. mangium* is only about 37%. Sowing in germination trays ('wet-towel method'), and pricking out the seedlings 6–10 days after sowing when the radicle emerges, gives over 85% recovery. Another option is direct sowing in containers (polythene bags, open-ended hanging pots called 'root trainers' or other permanent pots) followed by pricking out to maintain one seedling per container. There are no specific requirements for the type of substrate; mixtures of topsoil, peat, old sawdust, rice husks, sand and vermiculite are used. Even pure peat with a pH of 3.1 presented no problems. A mixture of peat (70–80%) and rice husks (30–20%) has been used successfully for *A. mangium* in Sumatra. NPK fertilization is generally applied in the nursery, but fertilization is stopped when 'hardening off' the plants by reducing watering and exposing them to full sunlight. The appropriate height for planting is 25–40 cm, when seedlings have been in the nursery for 9–16 weeks. A direct seeding trial with *A. mangium* in Sabah gave 66% survival after 3 months and 30% after 6 months.

A. mangium can be propagated vegetatively through single-node stem cuttings 4–5 cm long and 0.5–1.5 cm in diameter, leaving 0.5–1 phyllodes. The application of 500–1000 ppm indolebutyric acid (IBA) or rooting powder enables 65–75% rooting to be achieved. However, rooting is reported to be slow. Air layering trials in Thailand gave a success rate of 80% in *A. aulacocarpa* and *A. auriculiformis*; promising results were also obtained for *A. crassicarpa* and *A. mangium*. The explants for tissue culture are 2–3 mm lengths of aseptically-germinated one-month-old seedlings and the optimum induction of multiple shoots is achieved in a Murashige and Skoog basal medium supplemented with 0.5 mg/l of benzylamino purine (BAP). Excised shoots longer than 0.5 cm root easily in a humidified rooting chamber. Plants in the nursery do not need to be inoculated with *Rhizobium*, because nodulation is prolific; however, the seedlings should be checked for the presence of active nitrogen-fixing root nodules prior to planting. There is little experience with bare-root planting stock, but in the Philippines plantations have been succesfully established using this technique. In Malaysia, plants are hardened off by wrenching them every 2–4 weeks and watering only once every 6 days. The spacing applied varies according to country and to the objective of the plantation, from 2 m × 2 m to 4 m × 4 m. Dense planting for the production of saw logs reduces the incidence of large branches and the inherent risk of infections.

Silviculture and management *Acacia* species are pioneers and demand full light for good development; in shade *A. mangium* grows stunted and spindly. *Acacia* trees are renowned for their robustness and adaptability, which makes them good plantation species. Survival after planting out is high: 60% for *A. mangium* planted in a windbreak in *Imperata* grassland, and over 90% when planted on more favourable sites. In *A. mangium* plantations canopy closure occurs after 9 months to 3 years, depending on soil fertility, weediness and initial spacing (e.g. in Sabah in a plantation with an initial spacing of 3 m × 3 m canopy closure was achieved in one year).

In the first year, the plantation should be protected from livestock as they browse the trees, and it should be weeded, taking particular care to remove climbers, creepers and vines. *Imperata cylindrica* is a strong competitor on relatively wet sites with heavier soils. *A. mangium* has been found to be very sensitive to herbicides.

As *A. mangium* has a strong tendency to produce multiple leaders from the base, 'singling' is carried out at 4–6 months after planting. Persistent branches are pruned out only in plantations where the objective is to produce quality saw or veneer logs. Usually, pruning is done twice; the second time, branches are pruned out further up the trunk, often to a height of 6 m. Pruning out branches with a diameter of 2 cm or more makes the trees susceptible to infections, especially heart rot.

A. mangium is very responsive to extra growing space. The thinning caried out in plantations for pulpwood production is aimed at achieving a final stock of 600–700 stems/ha from the 1250 trees/ha planted. It is executed after 18 months. These plantations are clear felled after 6–8 years. Thinnings in plantations for the production of quality saw logs generally reduce the initial number of trees from 900/ha to 100–200/ha in two or three thinnings. The first thinning is done when trees are about 9 m tall, i.e. before 2 years of age. The rotation here is 15–20 years. However, no definitive pruning and thinning schedules have yet been established for *A. mangium* and other schedules are also applied. In Papua New Guinea, plantations grown on a 7–8-year rotation for pulpwood are not thinned.

It is not possible to regenerate from coppice for the second generation, as the coppice shoots do not develop to tree size. Only *A. aulacocarpa* coppices well and suckers from its roots. *A. auriculiformis* coppices when cut more than 50 cm from ground level. *A. mangium* regenerates abundantly in clear-felled areas or where a light fire has occurred. However, there are no reports of experience in tending, pruning and thinning a crop grown from natural regeneration. Natural regeneration of *A. auriculiformis* is also profuse and rapid after the mature stand has been felled. For the production of tannin from *A. mearnsii* in Java the initial 3300 trees/ha are thinned heavily to the final stocking of 275 trees/ha at the age of 8 years, when the plantation is harvested. For *A. mearnsii* up to 8 short rotations have been harvested from the same site without apparent growth decline. Only *A. crassicarpa* and *A. leucophloea* are resistant to fire. Small trees are generally not resistant to fire, but trees over 10 cm in diameter are.

About 50 000 ha of *A. mangium* plantations have been established in Sabah, and about 42 000 ha in Peninsular Malaysia. In North Sumatra, one enterprise plants 16 000 ha annually and in South Sumatra 300 000 ha of forest land is planned to be planted, predominantly with *A. mangium*.

Diseases and pests Damping-off is the most serious disease in the nursery. It is caused by a wide variety of fungi, but can be overcome with the use of fungicide. Other common diseases in nurseries are also found on young plants of *A. mangium*.

Heart rot is the most serious disease of *A. mangium* in plantations. It invades through branch wounds (e.g. caused by pruning) and is also known as white rot, as the affected wood becomes whitish, spongy or fibrous and is surrounded by a dark stain. Heart rot is much less common in Sabah than in Peninsular Malaysia. Dead or broken branches, wounds, and cankers indicate its presence. Only *Phellinus noxius* has been positively identified as causal organism. In Peninsular Malaysia, the Forestry Department recently suspended the planting of *A. mangium*, pending an evaluation of the impact of heart rot. However, this suspension has now been lifted. Root rot is caused by *Phellinus* spp. (*P. noxius* in the Philippines) and by *Ganoderma* spp., causing 29% mortality in Papua New Guinea after 5 years. In Sarawak, 'pink disease' caused by *Corticium salmonicolor* is locally important and causes the crown to die.

About 48 groups of insects attack *A. mangium*. Only the pests of major economic importance are mentioned below. *Coptotermes curvignathus* (a termite found in Sumatra, Malaysia and Thailand) feeds on young seedlings' roots or stems near ground level and penetrates to the heartwood. Attack on trees is primary, regardless of wound or decay, and damage is greatest in dry plantation sites after the old forest has been cleared, and on low-lying moist sites. All affected wood at the site should be destroyed before replanting. The beetle *Sinoxylon anale* (a branch and twig borer) is found on *A. mangium*, *A. auriculiformis*, *A. catechu* and other *Acacia* species in Thailand. It primarily bores into sapwood of cut logs or into diseased and weak poles, but occasionally it tunnels into shoots and young stems to feed. Larvae of *Sternocera aequisignata* (the green-leg flat-headed borer) bore at root collars and can kill trees in the nursery; this pest is especially destructive during the first 2 years after planting. It attacks *A. mangium* and *A. auriculiformis* in Thailand. The larvae of *Zeuzera coffea* (the red coffee borer) tunnel in young twigs and stems and are found on *A. mangium* and *A. auriculiformis*. They are especially injurious to one-year-old seedlings or small saplings in nurseries and plantations. Many other pests may become locally important and deserve attention, including control measures.

Harvesting *A. mangium* plantations are felled for pulpwood 6–8 years after planting; for sawn timber the rotation is 15–20 years. In old trees and in *A. aulacocarpa* and *A. crassicarpa* the lower part of the bole is often fluted. *A. mearnsii* trees are harvested when 8 years old, with the main objective of collecting the bark for tannin production, whereas *A. auriculiformis* is harvested after 10–12 years and *A. leucophloea* after 12 years.

Yield The productivity of *A. mangium* in Kalimantan has been found to be closely related to 'total' soil potassium (K) levels (The latter accounted for 50% of the variation in the data). However, in Malaysia phosphorus (P) appears to be the most important nutrient.

Measurements of the diameter at breast height provide sufficiently accurate and reliable yield estimates in *A. mangium* plantations. Untended stands of 9-year-old *A. mangium* in Sabah had an annual increment of 46 m^3/ha. Even on poor sites a mean annual increment of 20 m^3/ha is often achieved. The performance of *A. mangium* in plantations in Malaysia, however, is variable and is below expectations. In Java, the mean annual increment of *A. auriculiformis* on relatively fertile soils is 15–20 m^3/ha and on less fertile soils it is 8–12 m^3/ha. The mean annual increment of an 8-year-old plantation of *A. mearnsii* in Java is 11 m^3/ha, and an additional 7 m^3/ha from thinnings. The final yield of undried bark in this plantation was 15 400 kg/ha, and an additional 8800 kg/ha was obtained from thinnings. In general, a mean annual increment of 10–25 m^3/ha can be expected for this species. The mean annual increment over the 12-year rotation period of *A. leucophloea* is 9 m^3/ha of stemwood (bole) and 11 m^3/ha for wood over 7 cm diameter.

Handling after harvest The observed *A. mangium* trees in Peninsular Malaysia have problems especially regarding early forking and damage by fungi and insects. Only a small portion of the total amount could be used as saw or veneer logs. The bulk, about 60%, is only fit for pulpwood.

Genetic resources Extensive seed collections have been made by CSIRO (Australia) from a range of *Acacia* species in Indonesia (Moluccas, Irian Jaya), Papua New Guinea and in northern Queensland. The natural stands are accessible but not threatened by logging. Moreover, several species are planted on a large scale.

Breeding A large international provenance trial has been set up for *A. mangium*, involving 24 provenances tested in 19 sites in 8 countries. Provenances from Papua New Guinea consistently show better growth in height and diameter, and stem form is also superior. In most countries in South-East Asia provenance trials for other species have been set up and preliminary results are available. *A. mearnsii* and *A. auriculiformis* are generally outcrossing, and have estimated outcrossing rates of 67–89% and 93%, respectively. *A. mangium* has a stronger tendency to selfing. Natural hybrids have been found between *A. auriculiformis* and *A. leptocarpa* and between *A. mangium* and *A. auriculiformis* (8% hybrids in an *A. mangium* research plot in Peninsular Malaysia). The tree form of the latter hybrid is satisfactory where it inherits the better stem straightness of *A. mangium* and the self-pruning ability and better stem roundness of *A. auriculiformis*. The hybrid's height and diameter increments are significantly better. Moreover, it has intermediate physical and mechanical wood properties (better than *A. mangium*) and it also appears to be more resistant to heart rot. Natural hybrids in Sabah, however, tend to inherit the poor stem form of *A. auriculiformis*. Hybridization techniques have been developed and the production of hybrid plants could be accelerated through tissue culture. *A. leptocarpa* is possibly very variable genetically, and selection of good provenances may easily raise the productivity in plantations. Straight-stemmed *A. auriculiformis* trees have been found in Papua New Guinea and Sabah, however, the trunks of most trees of this species are crooked. Selection and breeding of *A. auriculiformis* may considerably enhance its utilization in plantations. In Thailand, a programme for selection and breeding of *A. auriculiformis* started in 1983 with the selection of plus trees and the identification of plantations which can be transformed into seed stands. Many countries in South-East Asia have started research on breeding on a number of *Acacia* species.

Prospects The future for the increased utilization of *A. mangium* wood for the production of particle board and medium-density fibreboard is promising, and the quality of wood chips for pulp and paper is satisfactory. The wood quality observed in Peninsular Malaysia is less promising for general utility timber. Silvicultural schedules, especially those regarding the spacing, pruning and thinning and management of subsequent rotations, are not well known yet or at least are not well publicised. Present problems with heart rot may be overcome by carefully matching species to site, by selection and breeding, and by hybridization. The high incidence of heart rot in Peninsular Malaysia might be the result of the absence of high seasonality in rainfall. In Thailand, farmers are now planting *A. mangium* and selling the produce to industry. This interesting example of small-scale plantations of *A. mangium* deserves to be copied in other countries. Most *Acacia* species are fast growing and suitable for planting on *Themeda* and *Imperata cylindrica* grasslands (although the growth is not optimal under this condition) and sites degraded by logging. The hybrid *A. mangium* × *A. auriculiformis* appears to be very promising, as its characters and growth are superior to both parents. In Thailand, preliminary results from research indicate that *A. crassicarpa* may prove to be a very valuable species for industrial plantations.

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Selection of species

Acacia aulacocarpa A. Cunn. ex Benth.

Lond. Journ. Bot. 1: 378 (1842).

Synonyms *Racosperma aulacocarpum* (A. Cunn. ex Benth.) Pedley (1987).

Vernacular names Brown salwood, brown wattle, New Guinea wattle (En).

Distribution Eastern and northern Australia and southern New Guinea.

Uses The wood is used as wattle, e.g. for heavy construction, furniture, flooring, cabinet-making, boat-building and panelling. It has long been used for native building posts and has a reputation of being durable. It is also used for fuel.

Observations A medium-sized to fairly large tree up to 35(–39) m tall, bole branchless for up to 21 m, up to 90 cm in diameter, bark surface deeply vertically fissured and peeling in long strips, dark grey or brown, inner bark red to pink, branchlets angular; phyllodes straight or falcate, 7–15 cm × 0.6–3.5 cm, 4–12 times longer than wide, with 3–7 major longitudinal veins, secondary veins not anastomosing; flowers in spikes, 5-merous, corolla 1.5–1.9 mm long; pod straight but often twisted when old, up to 8 cm × (1–)2 cm, coriaceous to subwoody, with anastomosing venation. *A. aulacocarpa* has often been confused with *A. crassicarpa*. It is found in savanna, scrub forest, monsoon forest, light rain forest or secondary forest in periodically flooded areas, on stony or sandy soils, at 15–60 m altitude in New Guinea, but up to 1000 m in Australia. The density of the wood is 645–720 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 145, 162, 289, 297, 509, 649, 650, 672.

Acacia auriculiformis A. Cunn. ex Benth.

Lond. Journ. Bot. 1: 377 (1842).

Synonyms *Racosperma auriculiforme* (A. Cunn. ex Benth.) Pedley (1986).

Vernacular names Northern black wattle, Papua wattle (En). Indonesia: akasia (general), ki hia (Sundanese). Thailand: krathin-narong (Bangkok).

Distribution New Guinea, Kai Islands and Australia (Queensland and Northern Territory); also planted in plantations, and naturalized in western Malesia.

Uses The wood is used as wattle, e.g. as poles for house building, for furniture and veneer; it is also employed for pulp and a useful firewood. The bark is collected locally as tanning material. The tree is also planted as an ornamental wayside tree, especially in western Malesia, for erosion control, and as a shade tree.

Observations A medium-sized tree up to 20(–30) m tall, bole branchless for up to 12 m, up to 50 cm in diameter, bark surface deeply fissured, grey or dark grey, inner bark cream, branchlets angular; phyllodes curved or falcate, 10–16 cm × (1.2–)1.5–2(–3) cm, 4–8(–10) times as long as wide, with 3 or 4 major longitudinal veins, secondary veins somewhat anastomosing; flowers in somewhat interrupted spikes, 5-merous, corolla 1.7–2 mm long; pod contorted, c. 6.5 cm × 1–1.5(–2.5) cm, subwoody, with anastomosing venation. *A. auriculiformis* occurs in *Eucalyptus* savanna, is a main constituent of *Acacia-Melaleuca* woodlands, and is found on forest edges near swamps, in secondary growth, in monsoon forest, in grassland with *Melaleuca* spp., and is common in coastal savanna at the inner edge of mangrove, at 0–90 m altitude in New Guinea, but up to 400 m in Australia. The density of the wood is 490–840 kg/m^3 at 15% moisture content.

Selected sources 36, 119, 162, 289, 300, 451, 469, 474, 499, 509, 547, 649, 650, 672, 687, 737.

Acacia catechu (L.f.) Willd.

Sp. Pl. ed. 4, 4: 1079 (1806).

Synonyms *Acacia chundra* Willd. (1806).

Vernacular names Cutch tree, catechu tree (En). Acacie au cachou (Fr). Burma (Myanmar): sha. Thailand: sisiat-nua (central), sisiat (northern).

Distribution Pakistan, Nepal, India and Burma (Myanmar); sometimes planted in India, Burma (Myanmar), Thailand and Java.

Uses The wood is used as wattle, e.g. for posts, agricultural implements, wheels and carts; chips are used for the manufacture of hardboard. The wood is also used as firewood and yields excellent charcoal. More important is the 'cutch' or 'kath' obtained from the heartwood for tanning. This concentrated extract is also used for dyeing. Concentrated cutch is used for chewing with betel, and for medicinal purposes, especially for the treatment of coughs and sore throat.

Observations A small tree up to 15 m tall, bark surface peeling off in long stripes, or sometimes in rectangular plates, dark grey or greyish-brown, inner bark brown or red, branchlets with paired prickles just below the stipules; leaves bipinnate with 9–30 pairs of pinnae, these with (13-)18–50 pairs of leaflets, rachis glandular; flowers in spikes, 5-merous, corolla 1–1.5 mm long; pod strap-shaped, (1–)4–14 cm × (0.8–)1.1–2.4 cm, transversely veined. *A. catechu* occurs naturally in deciduous forest and savanna, usually on sandy soils along rivers, up to 1500 m altitude. It has been introduced in monsoon areas in Java. The wood is comparatively heavy with a density of 880–1000 kg/m^3 at 15% moisture content.

Selected sources 78, 115, 162, 234, 300, 369, 649.

Acacia crassicarpa A. Cunn. ex Benth.

Lond. Journ. Bot. 1: 379 (1842).

Synonyms *Racosperma crassicarpum* (A. Cunn. ex Benth.) Pedley (1987).

Vernacular names Northern wattle, red wattle (En).

Distribution South-western Papua New Guinea and Australia (coastal Queensland); also planted in plantations in Kalimantan.

Uses The wood is used as wattle, e.g. for heavy construction, furniture, flooring, cabinet-making, boat building, panelling, hardboard and veneer. It has long been used for native building posts and has a reputation of being durable.

Observations A medium-sized tree up to 25(–33) m tall, bole branchless for up to 13(–18) m, up to 50 cm in diameter, fluted or spurred at base, bark surface rough, deeply fissured, grey to grey-brown, inner bark reddish, branchlets angular; phyllodes falcate, 11–20 cm × 1–4.5 cm, 2.5–12 times as long as wide, with 3–5 yellowish main longitudinal veins and a yellowish margin, secondary veins not anastomosing; flowers in spikes, 5-merous, corolla 1.3–1.6 mm long; pod flat, up to 5 cm × 2–3.5 cm, woody, with transverse but hardly reticulate venation. *A. crassicarpa* has often been confused with *A. aulacocarpa*. It is found in savanna sometimes with *Banksia* spp., in woodland or burnt-over open forest, on flats dominated by *Melaleuca* and *Tristania* spp., at 10–30 m altitude in Papua New Guinea, up to 700 m in Australia. The density of the wood is 670–710 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 145, 162, 297, 509, 649, 650, 672.

Acacia leptocarpa A. Cunn. ex Benth.

Lond. Journ. Bot. 1: 376 (1842).

Synonyms *Racosperma leptocarpum* (A. Cunn. ex Benth.) Pedley (1987).

Distribution Lesser Sunda Islands (Wetar), southern New Guinea and Australia (coastal

Queensland and Northern Territory); also planted in trials in Thailand, Papua New Guinea and East Africa, as well as in industrial plantations in Kalimantan and Sumatra.

Uses The wood is used as wattle. Because of its decorative figure it is often used for turnery and cabinet work; it is also used for firewood and is suitable for pulp production.

Observations A small tree up to 12 m tall, bole branchless for up to 4 m, up to 25 cm in diameter, bark surface deeply longitudinally fissured, grey-black, inner bark dark red, branchlets only distally angular; phyllodes falcate, (10–)12–21(–26) cm × 1–2.6 cm, 6–15(–17) times as long as wide, with 3 major yellowish longitudinal veins, secondary veins anastomosing; flowers in spikes, 5-merous, corolla 1.6–2.4 mm long; pod somewhat coiled, 4–12 cm × 0.3 cm, subwoody, inconspicuously veined. *A. leptocarpa* occurs usually clustered in grassland and savanna woodland, and in monsoon scrub vegetation, often associated with *Banksia*, *Melaleuca* and *Tristania* spp., at 10–30 m altitude in Malesia, but up to 550 m in Australia.

Selected sources 162, 649, 350, 672.

Acacia leucophloea (Roxb.) Willd.

Sp. Pl. ed. 4, 4: 1083 (1806).

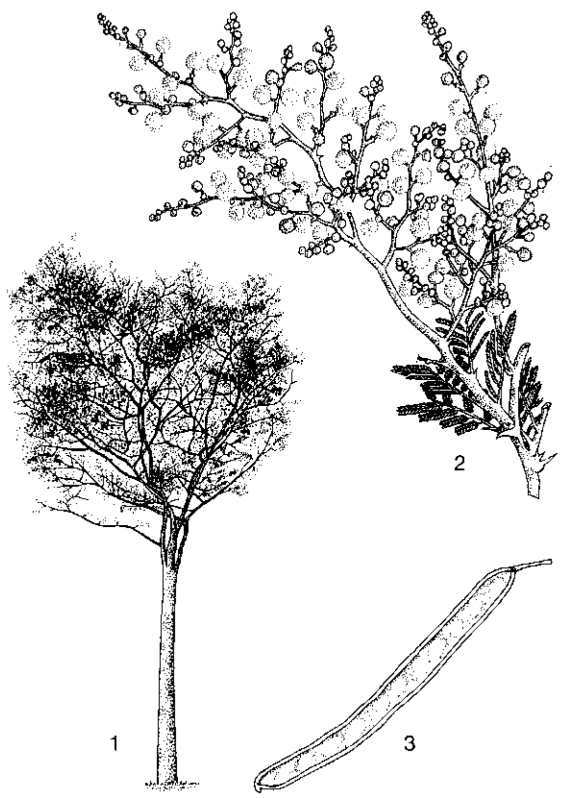
Synonyms *Acacia melanochaetes* Zoll. (1846), *Delaportea ferox* Gagnep. (1852), *Delaportea microphylla* Gagnep. (1852).

Vernacular names Indonesia: pilang (Javanese, Sundanese), opilan (Madura), pelang (Madura, Bali). Burma (Myanmar): ta-noung. Thailand: chalaep-daeng (central), phayamai (Kanchanaburi). Vietnam: a bu, a kawa (Thuân Hai).

Distribution Pakistan, Nepal, India, Sri Lanka, Burma (Myanmar), Vietnam, Thailand, Java, Madura, Timor and Sumbawa.

Uses The wood is used as wattle, e.g. for indoor construction, flooring and furniture. It is appreciated as firewood and very suitable for manufacturing charcoal. More important is the use of the bark for tanning leather, for which it was formerly cultivated. The strong fibres have been used locally to manufacture fishing nets. The germinated seeds can be cooked and eaten as a vegetable. The pods and foliage are eaten by cattle. Stem and roots produce a gum used medicinally.

Observations A medium-sized to fairly large deciduous tree up to 35 m tall, bole up to 100 cm in diameter, bark surface pale, lower branchlets with spinescent stipules; leaves bipinnate, with (4–)6–13 pairs of pinnae, each with 6–25 pairs of leaflets, with prominulous lateral veins below;



Acacia leucophloea (Roxb.) Willd. – 1, tree habit; 2, flowering branch; 3, pod.

flowers in pedunculate glomerules aggregated in terminal or axillary panicles, 5-merous, corolla 1.2–2 mm long; pod linear or strap-shaped, often falcate, 7–14 cm × 0.8–1 cm, thinly woody. *A. leucophloea* is found in savanna or scrub vegetation, dry forest and teak forest, on well-drained often calcareous or sometimes sandy clayey soils, at 50–750 m altitude. The density of the wood is 710–890 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 36, 162, 163, 261, 369, 474, 526, 575, 649.

Acacia mangium Willd.

Sp. Pl. ed 4, 4: 1053 (1806).

Synonyms *Racosperma mangium* (Willd.) Pedley (1987).

Vernacular names Brown salwood, black wattle, hickory wattle (En). Indonesia: tongke hutan, mangge hutan (general), nak (Moluccas). Malaysia: mangium (general). Thailand: krathin-thepha.

Distribution Sula Islands, Seram, Aru Islands, Irian Jaya, Western Province of Papua New Guinea and north-eastern Queensland; planted elsewhere in the Malesian region, especially in Sabah and Peninsular Malaysia, also as an ornamental.

Uses *A. mangium* is an important source of wattle timber; the wood is used for e.g. construction, boat building, furniture and cabinet-making, veneer, but it also makes excellent particle board. The pulp is readily bleached to high brightness levels and is excellent for paper making. The tree is also used for firewood, and is occasionally planted as an ornamental, for erosion control, or as firebreak or windbreak. The leaves may serve as forage for cattle.

Observations A medium-sized to fairly large tree up to 35 m tall, bole branchless for up to 15 m, up to 90 cm in diameter, bark surface fissured near the base, greyish-brown to dark brown, inner bark pale brown, branchlets acutely triangular; phyllodes straight or straight along one side and curved along the other, up to 25 cm × 3.5–9 cm, 2–5 times as long as wide, with 4 (or 5) main longitudinal veins, secondary veins finely anastomosing; flowers in spikes, 5-merous, corolla 1.2–1.5 mm long; pod linear, coiled, up to 10 cm × 0.3–0.5 cm, membranous to slightly woody, inconspicuously veined. *A. mangium* is found, sometimes dominant, in primary and secondary forest, forest margins, savanna, grassland, savanna woodland, on poorly drained floodplains and along fringes of mangrove forest where it is sometimes associated with *Melaleuca* and *Rhizophora* spp., up to 200 m altitude in Malesia, but up to 500(–800) m in Australia. In New Guinea, it often prefers slightly higher and drier sites than other *Acacia* species growing in the same area. The density of the wood is (450–)530–690 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 24, 29, 32, 33, 34, 35, 65, 118, 119, 162, 289, 300, 361, 362, 452, 474, 509, 630, 639, 640, 649, 650, 672, 687, 691, 692, 737.

Acacia mangium Willd. – 1, habit of young tree; 2, flowering twig; 3, pods.

Acacia mearnsii De Wild.

Pl. bequaert. 3: 61 (1925).

Synonyms *Acacia decurrens* (Wendl.) Willd. var. *mollis* Lindl. (1819).

Vernacular names Black wattle, late black wattle, tan wattle (En). Acacie noir (Fr). Indonesia: akasia (general).

Distribution Native to south-eastern Australia (New South Wales, Queensland, Victoria and Tasmania), but introduced throughout the tropics and often naturalizing. Commercial plantations have been established in montane areas of Java, on Madura, in southern Sulawesi, around Lake Toba on Sumatra and on Bali. Smaller plantations are found in Peninsular Malaysia, the Philippines and Papua New Guinea.

Uses The wood is used as wattle, e.g. for local construction, mine props, wooden tools, joinery, flooring and hardboard. It is also used for rayon and paper pulp. More important is the production of tannin from the bark used for tanning heavy leather. It is one of the principal sources of the world's tanbark of superior quality. The powdered bark extract is also used to prepare adhesives for plywood, particle board and laminated timber. The wood is commonly used as fuel for domestic purposes, small industries, and for charcoal production. Trees have also been planted for erosion control, soil improvement, in shelterbelts or as fire-breaks, as shade trees in tea plantations and as ornamentals. The leaves may be used as a fodder, but are best mixed with other feeds.

Observations A small to medium-sized tree up to 25 m tall, bole straight, up to 60 cm in diameter, bark surface longitudinally fissured, brownish-black, smooth and grey-brown in young trees, inner bark straw-coloured, branchlets angular, unarmed; leaves bipinnate with (8–)12–21 pairs of pinnae each with 16–70 pairs of leaflets, rachis glandular above; flowers in pedunculate glomerules arranged in axillary racemes or panicles, 5-merous; pod usually moniliform with 3–12 joints, flat, 3–10 cm × 0.5–0.8 cm. *A. mearnsii* occurs naturally in the understorey of tall open forest or scrub vegetation, at 0–200(–900) m altitude. Plantations in the tropics are generally at higher elevation (1000–2500 m). The density of the wood is 550–850 kg/m^3 at 15% moisture content.

Selected sources 155, 162, 369, 474, 560, 649, 650, 672, 687.

F. Arentz (general part, selection of species),
E. Boer (general part),
R.H.M.J. Lemmens (properties),
J. Ilic (wood anatomy)

Aglaia Lour.

Fl. Cochinch.: 173 (1790).
MELIACEAE

x = unknown; *A. edulis*: n = 40, *A. elliptica*: $2n$ = 68, *A. korthalsii* Miq.: $2n$ = 84, *A. leptantha*: $2n$ = 68, *A. odoratissima* Blume: $2n$ = 84, *A. perviridis*: n = 20, *A. spectabilis*: n = 20

Trade groups Aglaia: medium-heavy to heavy hardwood, e.g. *Aglaia cucullata* (Roxb.) Pellegrin, *A. lawii* (Wight) C.J. Saldanha ex Ramamoorthy, *A. leptantha* Miq., *A. pachyphylla* Miq., *A. silvestris* (M. Roemer) Merr., *A. spectabilis* (Miq.) Jain & Bennet.

Vernacular names Aglaia: amoora (general). Indonesia: parak (general), langsat (Kalimantan). Malaysia: bekak, pasak (Peninsular), segera (Iban, Sarawak), langsat-langsat (Sabah), lantupak (Dusun, Sabah). Philippines: guijo, makaasim (general), katong (Tagalog). Burma (Myanmar): thanatka-wa. Cambodia: chomnay poveang. Thailand: tasua (central), sangkhriat (Trang). Vietnam: g[ooj]i, g[ooj]i tia, g[ooj]i trang.

Origin and geographic distribution *Aglaia* currently consists of 105 species, but it is expected that more will be discovered. The species are distributed from southern India and Sri Lanka, through Burma (Myanmar), Thailand, Indo-China towards the Malesian area, northern Australia, New Caledonia, the Solomon Islands, Fiji and Samoa. In general, comparatively few species of *Aglaia* are endemic; high percentages of endemics are, however, present in New Guinea and Fiji. Within Malesia the largest number of species is found in Borneo (50), followed by Peninsular Malaysia (48), Sumatra (38), the Philippines (35) and New Guinea (33). There is a marked geographical division into species with a western distribution (52 species, confined to the Sunda shelf) and species with an eastern distribution (37 species, confined to Australasia and/or the Pacific).

Uses *Aglaia* wood is suitable for a wide range of purposes. The heavier timber is used where a good strength and durability are required, as in house and bridge building. The moderately heavy timber is used for light and interior construction. The attractive figure and good working properties of some species make their wood suitable for furniture, flooring, fine finishing, cabinets, turnery, rifle butts, decorative wall panelling, interior trim and face veneer as a substitute for mahogany (*Swietenia* spp.). The wood is also used for general construction (beams, joists, rafters, doors and door frames, windows, weatherboards, venetian blinds), joinery, boat building, billiard cue butts, soles, agricultural implements and tool handles. Smaller boles are often used for fences or poles in local house construction.
The fruit and the aril of the seed of some species are edible.
The flowers are aromatic and may be used in tea or to perfume household textiles. The leaves have a wide range of traditional medicinal applications.

Production and international trade Japan imports *Aglaia* timber mainly from Papua New Guinea and the Solomon Islands. It imports small amounts from other areas (e.g. Thailand). The bulk of the timber is sold in the domestic markets. In Papua New Guinea, *Aglaia* timber is ranked in the MEP (Minimum Export Price) group 3; in 1992 saw logs fetched a minimum price of US$ 50/m^3.

Properties *Aglaia* yields a medium-weight to heavy hardwood. The heartwood is pale red to dark reddish-brown, sometimes turning to walnut-brown or chestnut-brown, usually distinctly demarcated from the pale yellow to pale red-brown sapwood, but sometimes indistinctly defined. The density is 450–1120 kg/m^3 at 15% moisture content. The grain is interlocked, sometimes straight, texture moderately fine to moderately coarse. The wood is sometimes glossy, and often has a fragrant, sometimes even pungent, odour when fresh, resembling both cedar and camphor. A regular, diagonal and wavy ribbon figure is generally visible on radial surfaces, and tangential surfaces have an irregular curly figure, marked with characteristic fine zigzag lines formed by cutting through wavy concentric belts of soft tissue.

At 12% moisture content, the modulus of rupture is 81–145 N/mm^2, modulus of elasticity 11 660–15 780 N/mm^2, compression parallel to grain 46–55 N/mm^2, shear c. 12.5 N/mm^2, cleavage 68.5 N/mm tangential, and Janka side hardness 3785 N.

The rates of shrinkage are moderate to fairly high: from green to 15% moisture content 1.4–3.0% radial and 2.7–7.1% tangential, from green to 12% moisture content 2.5–2.9% radial and 4.4–6.9% tangential, and from green to oven dry 4.1–6.8% radial and 6.9–10.7% tangential. The wood usually dries without much degrade, but slight collapse and twisting may occur; stacks should be weighted down to prevent distortion. Boards 75 mm thick take about 6 months to air dry from green to 20% moisture content. The moisture content of green wood is often rather high (94–123% in *A. cucullata*, but only 71–79% in *A. lawii*), and mild kiln schedules are required in drying. Deformation on cross-section (collapse) may be severe during kiln drying (e.g. in *A. lawii*). Boards 75 mm thick can be kiln dried from 20% to 12% moisture content in about 4 days. Once dry, form stability is good.

In general, the workability of *Aglaia* wood is good. The wood machines and saws well, but the heavier wood requires much power in sawing (e.g. *A. lawii*). The often curly and wavy grain of the wood requires sharp and fine-set planes, however. Planed surfaces are smooth and lustrous, and finishing gives good results. The wood peels and slices satisfactorily. It has been suggested that only a limited number of species may be used for first grade face veneer, but this has not been confirmed. Veneer may warp severely during drying. Unbleached pulp is not very bright, but is very strong. The sawdust of several species may cause dermatitis.

The wood is rated as moderately durable to durable, even in contact with the ground, but for some species it is rated as non-durable and susceptible to *Lyctus* attack (e.g. *A. argentea*) and sometimes also to pinhole borer and termite attack. The wood may be susceptible to staining. The heartwood is often very difficult to treatment with preservatives, the sapwood moderately easy to easy. A test of *A. cucullata* heartwood showed a retention of 62 kg/m^3 using the pressure treatment method, and 407 kg/m^3 for sapwood; heartwood of *A. lawii* absorbed only 20 kg/m^3, and sapwood 327 kg/m^3. Treatment of green logs or sawn timber by the boron diffusion process is recommended.

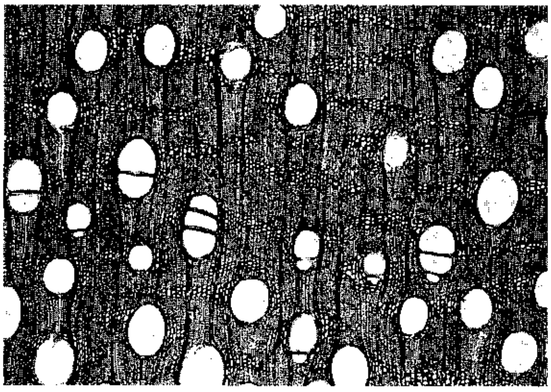
Aglaia wood contains 67.5–74% holocellulose, 46.5–50% α-cellulose, 32.5–37% lignin, c. 12% pentosan and 0.3–1.1% ash. The solubility is 1.1–3.6% in alcohol-benzene, 2.1–5.6% in hot water, and 8.8–19.6% in a 1% NaOH solution.

Description Dioecious, usually small or medium-sized trees, sometimes large and up to 40(–50) m tall, rarely shrubs; bole unbranched for up to 24 m, up to 160(–200) cm in diameter, often with small to tall (up to 3(–5) m high) buttresses; bark surface with scattered large lenticels and smaller ones in longitudinal rows, otherwise smooth or, in larger trees, often with deciduous squarish scales, inner bark yellowish-brown; latex rarely present in bole bark; in some species which become small trees only, twigs contain latex, sometimes abundantly; crown sympodial; apical bud consisting of 2–4 slender unexpanded leaves, without bud scales. Indumentum consisting of stellate hairs or stellate or peltate scales present, at least on the younger parts. Leaves arranged spirally, usually imparipinnate with 3–27 leaflets, rarely with a single leaflet, lacking stipules; leaflets entire, the apex acuminate to caudate with an obtuse to acute acumen. Inflorescence usually axillary, occasionally ramiflorous or cauliflorous; male inflorescence large, much divaricately branched, with up to several thousand flowers; female inflorescence similar but usually smaller, sometimes a narrow spike-like raceme. Flowers unisexual, with well developed rudiments of the opposite sex, 3(–4) or 5(–6)-merous; calyx cup-shaped, often thickened at base; petals free or united at base, subrotund, elliptical or obovate, often yellow, sometimes white or pink; stamens united to form a tube, anthers (3–)5–10(–21), usually in a single whorl, inserted on the inner face of the tube, usually glabrous; ovary superior, 1–3(–10)-locular, style short or absent, style-head small, capitate, conical or clavate; disk absent. Fruit a 1–4(–6)-seeded, more or less globose to pear-shaped berry, nut or less frequently a 1–3(–4)-valved capsule, each locule with 1(–2) seeds. Seeds large, usually with an aril nearly or completely covering the seed, without endosperm.

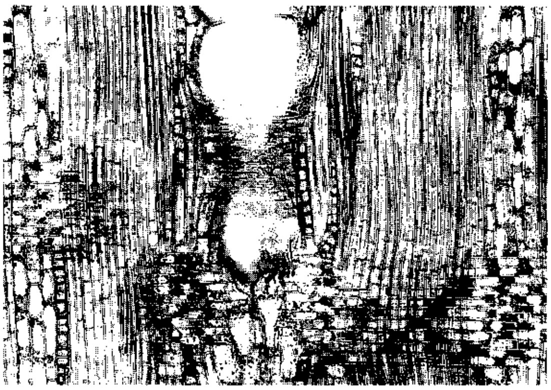
Wood anatomy

– Macroscopic characters:

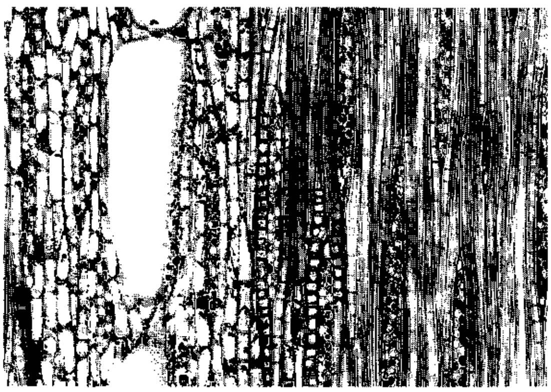
Heartwood usually dark brown or reddish-brown with purple tinge, occasionally pale brown or yellowish-brown; sapwood pale yellowish to greyish



transverse section (×25)



radial section (×75)



tangential section (×75)

Aglaia lawii

or pinkish-brown. Grain slightly to moderately interlocked. Texture moderately fine to moderately coarse; wood sometimes slightly lustrous; fresh wood often with fragrant odour. Growth rings indistinct; vessels visible to the naked eye; parenchyma in fine tangential bands, or invisible; rays almost invisible to the naked eye; ripple marks absent.

– Microscopic characters:

Growth rings absent. Vessels diffuse, 8–9(–11)/mm^2, solitary (25–60%) or in multiples of 2–4(–5), uniformly distributed, generally oval, average tangential diameter (75–)115–155 μm; perforation plates simple; intervessel pits dense and alternate, 3–4 μm in diameter; vessel-ray pits similar but half-bordered, brown deposits present; tyloses absent. Fibres 1.0–1.6 mm long, septate, thick-walled (c. 3 μm), 15–25 μm in tangential diameter, with minutely bordered to simple pits mainly in the radial walls. Axial parenchyma paratracheal, vasicentric and aliform to confluent; apotracheal parenchyma diffuse, in strands of 4–8 cells. Rays multiseriate (40% to more than 80%) or uniseriate, multiseriate rays 2–3 cells wide, up to 0.6 mm high, heterocellular with 1–2(–3) rows of square to upright marginal cells, uniseriate rays short, mostly less than 0.4 mm high. Prismatic crystals often present in non-chambered parenchyma cells (absent in *A. sapindina*). Silica bodies absent.

Species studied: *A. beccarii* C.DC., *A. edulis*, *A. lawii*, *A. malaccensis*, *A. odorata*, *A. odoratissima*, *A. rimosa*, *A. sapindina*.

Growth and development Germination is semi-hypogeal, with the hypocotyl undeveloped and with peltate cotyledons. When the shoot axis begins to grow, the cotyledons are forced apart, the testa splits, and the cotyledons are exposed. The cotyledons remain on the soil surface. The first 2 leaves are simple and opposite, subsequent leaves are arranged spirally, simple at first, later with 2–3 leaflets. The number of leaflets increases to or even exceeds the number of leaflets on the mature plant.

In trial plantations of *A. lawii* in Java the mean height 10 years after planting was 10 m and the mean diameter was 10–12 cm.

Growth is usually sympodial with orthotropic branching. Some of the smaller species are monopodial and belong to Corner's tree architecture model. When the apical shoot is damaged, an axillary bud grows to form a new apical meristem. *Aglaia* species usually flower around June and bear fruit in October to November. The bright-coloured perianth and the strong scent, especially in male flowers, attracts insects collecting pollen. Fruits did not develop when pollination was prevented. Small insects, probably mainly dipterans, are most likely the main pollinators of *Aglaia* flowers. Two main types of fruits can be distinguished: dehiscent fruits containing seeds with a red odourless aril which are dispersed by birds, and indehiscent fruits containing seeds with a white, yellow, orange or brown and sweet-tasting aril, which are dispersed by primates.

Other botanical information *Aglaia* belongs to the tribe *Aglaieae* and is most closely related to the genus *Lansium*. The latter differs from *Aglaia* by its indumentum of simple hairs, its 5-locular ovary and the structure of the style and style-head. *Aglaia* is divided into 2 sections on the basis of whether the fruits are dehiscent. Section *Amoora* (Roxb.) Pannell with dehiscent fruits was formerly regarded as a separate genus and coincides more or less with the timber trade group amoora, which is often kept separate from the trade group aglaia in Papua New Guinea. Amoora timber is slightly less heavy and paler in colour, but there is much overlap with aglaia timber. Several botanists disagree with the merging of *Amoora* into *Aglaia*, arguing that *Amoora* trees can be easily distinguished in the forest by their larger size and little latex. *Aglaia* sensu stricto consists mainly of small laticiferous trees.

The exact type of indumentum of stellate hairs and/or scales is an important, often diagnostic feature for identification of species.

Ecology *Aglaia* usually occurs scattered and is locally common but never dominant. It is found in both primary and secondary forest, generally in evergreen rain forest or sometimes in monsoon or deciduous forest. Larger adult individuals may become canopy trees but generally they are elements of the subcanopy layer. Most species prefer flat or slightly undulating land, often along rivers, or in swamp forest in periodically inundated locations, sometimes in kerangas. *Aglaia* is usually found from near the coast, on coastal plains, towards the lower montane zone up to 1500 m altitude, but occasionally individual species ascend as high as 2500(–3800) m. The preferred soils are usually sandy to loamy or clayey, but many species also occur on limestone or on granitic soils.

Propagation and planting Per kg there are about 380 green seeds of *A. lawii*. The seed does not need any pretreatment before being sown in full light and is sown as soon as possible after harvesting. There is no information on the longevity of the seed. Germination period and germination percentage have been determined for some species: seed of *A. forbesii* with pulp has nearly 100% germination in 30–81 days and seed without pulp has 30% in 31–40 days. Other germination rates are: 45% for *A. leucophylla* in 47–121 days, 22% for *A. macrostigma* King in 30–68 days, 85% for *A. malaccensis* in 13–44 days (seed in aril), 100% for *A. silvestris* in 27–43 days, and 76% for *A. spectabilis* in 8–46 days; *A. lawii* has 50% germination.

Silviculture and management *A. lawii* has been planted on an experimental scale in Java. The trees developed somewhat crooked stems, and branches developed very low along the stem; the latter was attributed to the wide spacing adopted. In natural forest in Papua New Guinea, *Aglaia* constitutes up to 5% of the gross timber volume. Natural regeneration in forest with a closed canopy is generally satisfactory. Survival of *A. argentea* seedlings in natural forest in Irian Jaya was very low due to its slow growth; the initial 480 seedlings/ha declined to 0.5 trees/ha.

Diseases and pests Seed of *Aglaia* is sometimes destroyed by larvae of various groups of insects, including moths, flies and beetles, developing from eggs laid in the young fruits.

Yield A clear bole of *A. cucullata* 24 m long, with a diameter of 78 cm at breast height and of 57 cm under the first branch, had a volume of 8.6 m^3. A bole of *A. lawii* 15 m long, with a diameter of 60 cm at breast height and of 51 cm under the first branch, had a volume of 3.6 m^3. In Papua New Guinea, the estimated timber volume of *A. cucullata* is up to 1.1 m^3/ha, and in New Britain up to 2.7 m^3/ha has been recorded. The estimated timber volume is up to 0.7 m^3/ha for all other *Aglaia* spp. in Papua New Guinea. In the *Elmerrillia ovalis* (Miq.) Dandy forest in North Sulawesi, the estimated timber volume of *Aglaia* spp. is 1.2–2.4 m^3/ha.

Genetic resources Several species of *Aglaia* show considerable morphological variation, which is often correlated with geographical distribution. Possible future germplasm collection activities should take this into account. Because of the comparatively high percentage of endemic species of *Aglaia* present in New Guinea, individual species may easily become endangered here as a result of selective logging and the conversion of natural forest into agricultural land or production forest.

Breeding For breeding purposes it is important to know that *Aglaia* is reported to have polyploid series.

Prospects As the wood of *Aglaia* is of great decorative value and often has good physical and mechanical properties which allow for wide utilization, it is probable that trials will be set up to test the species in plantations or enrichment planting.

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Selection of species

Aglaia agglomerata Merr. & Perry

Journ. Arn. Arb. 21: 322 (1940).

Synonyms *Aglaia doctersiana* Harms (1942), *Aglaia leeuwenii* Harms (1942).

Distribution New Guinea.

Uses The wood is thought to be used.

Observations A small to medium-sized tree up to 32 m tall, bole branchless for up to 19 m, up to 90 cm in diameter, buttresses up to 2.5 m high, bark surface pale grey, greyish-brown or brown, inner bark yellow or reddish-yellow; leaflets (7–)9–13, opposite or subopposite, with 11–19 pairs of secondary veins, upper surface with numerous pits, sometimes rugulose, lower surface and midrib above with numerous small, very dark reddish-brown peltate scales with a paler and irregular or fimbriate margin; flowers 5-merous, anthers 5, style-head ovoid, longitudinally ridged; fruit indehiscent, 2-locular. *A. agglomerata* occurs scattered in primary lowland to lower montane forest or in secondary forest, on river banks and clayey or volcanic soil, sometimes on limestone, up to 1800 m altitude. The density of the wood is about 770 kg/m^3 at 15% moisture content.

Selected sources 474, 481.

Aglaia argentea Blume

Bijdr. fl. Ned. Ind.: 170 (1825).

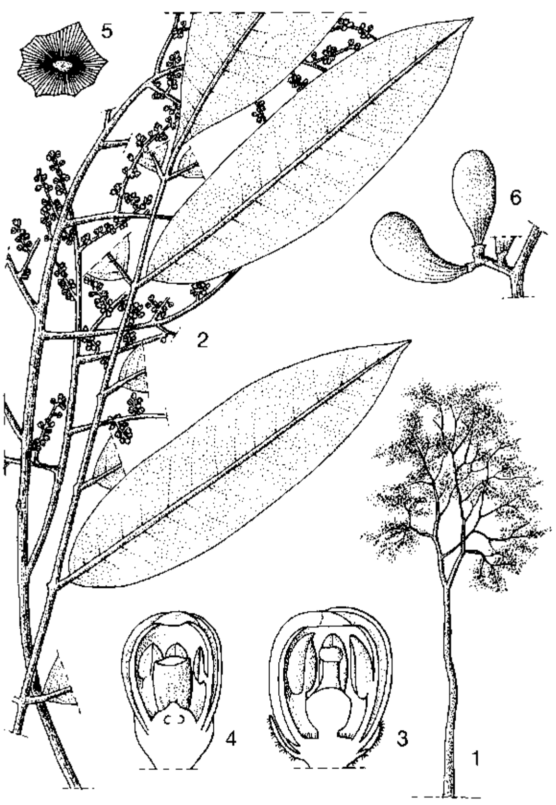
Synonyms *Aglaia splendens* (Koord. & Valeton) Koord. & Valeton (1897), *Aglaia multifoliola* Merr. (1915), *Aglaia discolor* Merr. (1929).

Vernacular names Indonesia: bayur (Sumatra), tanglar, selang (Java), luka-lukam (Moluccas). Malaysia: pasak (Peninsular), jalongan sasak (Sabah), lantupak (Dusun, Sarawak), jalongan sasak (Sarawak). Philippines: kansulud (Panay Bisaya). Burma (Myanmar): tagat-thitto. Thailand: sangkhriat-klong (Trang).

Distribution Burma (Myanmar), peninsular Thailand, throughout Malesia but rare in the Philippines, towards the Solomon Islands and northern Australia (Cape York Peninsula).

Uses *A. argentea* is a fairly important source of timber. The aril of the seed is edible.

Observations A small to medium-sized tree up to 30 m tall, bole branchless for up to 18 m, up to 60 cm in diameter, buttresses up to 1 m high, bark surface brown or greyish-green, inner bark white, yellow or brown; leaflets 9–19, subopposite, with 11–25 pairs of secondary veins, smooth, glabrescent above, below densely covered with white and some brown peltate scales, often having a short



Aglaia argentea Blume – 1, tree habit; 2, flowering twig; 3, sectioned male flower; 4, sectioned female flower; 5, peltate scale; 6, branchlet with fruits.

fimbriate margin; flowers 5-merous, anthers 5, style-head subglobose or ovoid, longitudinally ridged; fruit indehiscent, 2(–3)-locular. *A. argentea* is fairly common and occurs scattered in primary or secondary evergreen to semi-evergreen forest overlying granite, basalt, sandstone, clay or limestone, and also in peat-swamp forest, e.g. in Sarawak, together with ramin (*Gonystylus bancanus* (Miq.) Kurz) and sometimes alan (*Shorea albida* Sym.); from sea-level up to 1300 m altitude. The density of the wood is 660–960 kg/m^3 at 15% moisture content.

Selected sources 69, 77, 145, 282, 302, 303, 337, 414, 474, 481, 544, 705, 734.

Aglaia aspera Teijsm. & Binnend.

Natuurk. Tijdschr. Ned. Ind. 27: 42 (1864).

Synonyms *Aglaia acuminatissima* Teijsm. & Binnend. (1864), *Aglaia polyphylla* Miq. (1868), *Aglaia calelanensis* Elmer (1937).

Vernacular names Indonesia: duku (Java), tanglan peucang (Sundanese, Java), sepanas (Sumatra). Malaysia: bekak (Peninsular), segera (Iban, Sabah). Philippines: basinau (Lanao).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra, Java, Borneo and New Guinea.

Uses The wood is used e.g. in Papua New Guinea for house construction. The aril of the seed is edible.

Observations A small to medium-sized tree up to 29 m tall, bole branchless for up to 12 m, up to 50 cm in diameter, buttresses up to 1.8 m high, bark surface greyish-brown, yellowish-brown or reddish-brown, mottled with grey, green and pale brown, inner bark pink or brown; leaflets 7–13(–17), subopposite, with 7–14(–29) pairs of secondary veins, above with numerous pits and few stellate scales, below with numerous reddish-brown stellate scales and many-armed stellate hairs; flowers 5-merous, anthers 5, style-head ovoid, with 2 small apical lobes; fruit indehiscent, 2-locular. *A. aspera* occurs scattered to rather common in both primary and secondary forest, kerangas and monsoon forest, on sandy to loamy soils, from sea-level up to 1600 m altitude. The wood is reported as non-durable.

Selected sources 302, 303, 481, 544, 705.

Aglaia cucullata (Roxb.) Pellegrin

Lecomte, Fl. gén. Indo-Chine 1: 771 (1911).

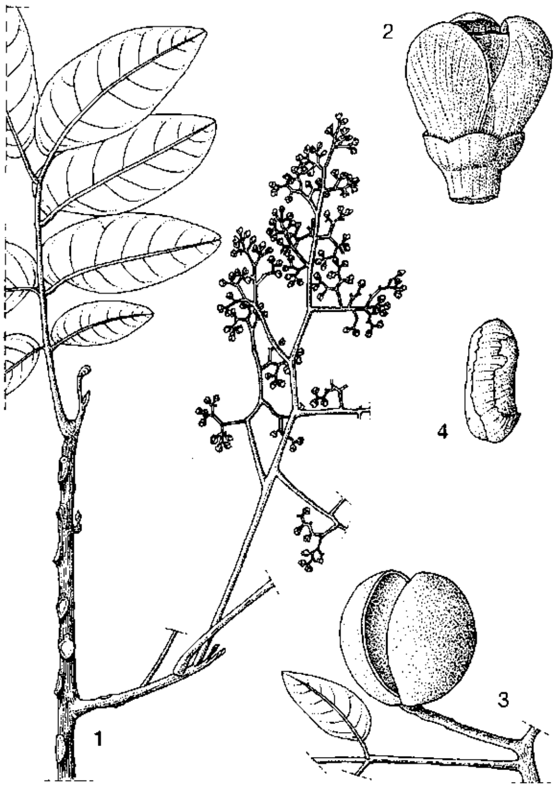
Synonyms *Amoora cucullata* Roxb. (1820), *Amoora aherniana* Merr. (1904), *Aglaia tripetala* Merr. (1917).

Vernacular names Pacific maple (En). Brunei: nyireh batu. Malaysia: bengang (Iban, Sabah). Papua New Guinea: amoora (general). Philippines: kato, katong-tiklop (Tagalog), malakamote (Tayabas). Burma (Myanmar): myauk-le-seik. Thailand: tasua (central), che (Karen-Mae Hong Son), daeng-nam (Phitsanulok).

Distribution Bangladesh, Burma (Myanmar), Thailand, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Java, Borneo, the Philippines and New Guinea.

Uses *A. cucullata* is an important source of timber; the wood is used for e.g. house and boat building, flooring, furniture, bridges and wharves. The timber is sometimes traded separately as 'Pacific maple'.

Observations A small to medium-sized, sometimes large tree up to 30(–45) m tall, bole branchless for up to 24 m, up to 100 cm in diameter, buttresses up to 3 m high, bark surface brown, pinkish-grey or pale orange-brown, inner bark pink;



Aglaia cucullata (Roxb.) Pellegrin – 1, flowering twig; 2, flower; 3, branchlet with fruit; 4, seed.

leaflets 5–9, subopposite, with 8–13 pairs of secondary veins, glabrous above, below rugulose and faintly pitted, with a few pale peltate scales with a darker centre and a sometimes fimbriate margin on the midrib and sometimes on the surface; flowers 3-merous, anthers 6, style-head ellipsoid, with 3 apical lobes and 6 longitudinal ridges; fruit dehiscent, (2–)3-locular. *A. cucullata* is scarce to rather common in riverine forest, estuaries, mangrove and nipah (*Nypa fruticans* Wurmb) swamp forest, near sea-level. The density of the wood is 450–830 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 12, 60, 145, 232, 282, 414, 474, 481, 482, 526, 527, 544, 574, 626, 731.

Aglaia edulis (Roxb.) Wallich

Calcutta Gard. Rep.: 26 (1840).

Synonyms *Aglaia sulingi* Blume (1825), *Aglaia latifolia* Miq. (1868), *Aglaia acida* Koord. & Valeton (1896), *Aglaia minahassae* Koord. (1898), *Aglaia diffusa* Merr. (1912).

Vernacular names Indonesia: balik-balik (Sumatra), langsatan (Java), langsat-lotung (Bali). Philippines: kaniue, curran kaniue (Tagalog), malasaging (Filipino). Thailand: khangkhao (north-eastern, eastern), kholaen (Prachuap Khiri Khan), changkru (Khmer-Chanthaburi).

Distribution Western India, Bhutan, southern China, Hainan, Vietnam, Cambodia, peninsular Burma (Myanmar), peninsular Thailand, the Nicobar Islands, Peninsular Malaysia, Sumatra, Java, Bali, Borneo, Sulawesi, Halmahera, and the Philippines.

Uses The wood is used e.g. for boat, house and bridge building and agricultural implements, but supplies are limited. The aril of the seed is edible. The pericarp has medicinal properties, and is used against diarrhoea.

Observations A generally small to medium-sized tree up to 20 m tall, bole usually short, up to 50 cm in diameter, buttresses up to 1.5 m high, bark surface reddish-brown, yellowish-brown or greyish-green, flaking to expose the orange-brown bark beneath, inner bark pink or brown; leaflets 5–9(–11), subopposite to alternate, with 5–16 pairs of secondary veins, usually with numerous pits on both surfaces, glabrous above, below with few to numerous reddish or pale brownish stellate hairs and scales or peltate scales with an irregular or fimbriate margin; flowers with 5 calyx-lobes, petals 5(–7), anthers 5, style-head ovoid or depressed globose, longitudinally ridged; fruit indehiscent, 3-locular. *A. edulis* occurs scattered and is comparatively rare. It is found in primary evergreen forest along the seashore on sandstone or sandy loam, but also in secondary forest, from sea-level up to 1700 m altitude. The density of the wood is 775–990 kg/m^3 at 15% moisture content.

Selected sources 185, 234, 303, 414, 481, 527, 544, 574.

Aglaia elaeagnoidea (A.H.L. Juss.) Benth.

Fl. Austr. 1: 383 (1863).

Synonyms *Aglaia roxburghiana* (Wight & Arn.) Miq. (1868), *Aglaia wallichii* Hiern (1875), *Aglaia canariifolia* Koord. (1898).

Vernacular names Indonesia: kemubang, pancal kidang (Java), mata-mata (Bajau, Bali). Philippines: mata-mata (general), gupak (Cebu Bisaya). Thailand: kradukkhiat (Nakhon Ratchasima), khangkhao. Vietnam: cay gi, g[ooj]i nui.

Distribution India, Sri Lanka, Taiwan, Vietnam, Cambodia, Thailand, Peninsular Malaysia (rare), throughout the rest of Malesia except for Sumatra, towards northern Australia, New Caledonia, Vanuatu and Samoa.

Uses The wood is used e.g. for house construction, musical instruments, ship planking, poles and cart wheels. The aril of the seed is edible and sweet.

Observations A shrub or small to medium-sized tree up to 20 m tall, bole branchless for up to 9 m, up to 50(–75) cm in diameter, sometimes with small buttresses, bark surface flaking with stiff scroll-like scales, brown, greyish-brown or yellowish-grey, inner bark pink or reddish-brown; leaflets (1–)3–7, subopposite, with 5–10 pairs of secondary veins, with numerous pits and numerous pale brown or pale orange-brown peltate scales with a short fimbriate margin on both surfaces; flowers 5-merous, anthers 5, style-head ovoid, with 2 small apical lobes; fruit indehiscent, 2-locular. *A. elaeagnoidea* is rather common and often found in coastal areas, but also in primary or secondary, deciduous or evergreen inland forest, along rivers, often on sandy soils or limestone, up to 1100 m altitude. The density of the wood is 675–810 kg/m³ at 15% moisture content.

Selected sources 86, 116, 185, 234, 330, 481, 494, 544, 574.

Aglaia elliptica Blume

Bijdr. fl. Ned. Ind.: 171 (1825).

Synonyms *Aglaia oxypetala* Valeton (1901), *Aglaia harmsiana* Perk. (1903), *Aglaia havilandii* Ridley (1930), *Aglaia longipetiolata* Elmer (1937).

Vernacular names Indonesia: bajing talang (Sumatra), langsat-langsat (Kalimantan), pisek (Sulawesi). Malaysia: peler tupai (Peninsular), segera, bunyau (Iban, Sarawak). Philippines: malatumbaga (general), mata-mata (Bikol), malasaging (Filipino).

Distribution Southern Burma (Myanmar), peninsular Thailand, Peninsular Malaysia, Sumatra, Java, Bali, Flores, Borneo, Sulawesi and the Philippines.

Uses The wood is used e.g. for furniture, general construction and agricultural implements. Bathing in water boiled with the bark is used against tumours, whereas the leaves are applied to wounds.

Observations A small to medium-sized, sometimes fairly large tree up to 20(–40) m tall, bole branchless for up to 15 m, up to 60 cm in diameter, with steep buttresses up to 1.5 m high, bark surface dark reddish-brown or greenish-brown, inner bark magenta; leaflets (5–)7–11(–15), subopposite to alternate, with 6–19 pairs of secondary veins, sometimes pitted, with numerous reddish-brown to pale orange-brown stellate hairs or scales, especially on the veins below; flowers 5-merous, anthers 5, style-head ovoid or depressed globose, with 2 small apical lobes or a central depression; fruit indehiscent, 2-locular. *A. elliptica* is locally common in primary and secondary evergreen forest, swamp forest, along rivers or roads and in periodically inundated locations, on various soils, from sea-level up to 2000 m altitude. The density of the wood is 755–860 kg/m³ at 15% moisture content.

Selected sources 68, 414, 481, 527, 544, 626, 705.

Aglaia erythrosperma Pannell

Kew Bull., Add. Ser. 16: 7 (1992).

Vernacular names Indonesia: boka-boka, parak daun besar (Sumatra), bunyau (Kalimantan). Malaysia: bekak (Peninsular), segera (Iban, Sarawak), lantupak (Dusun, Sabah).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo.

Uses *A. erythrosperma* may provide a good timber.

Observations A medium-sized to fairly large tree up to 35 m tall, bole branchless for up to 23 m, up to 50 cm in diameter, with small buttresses, bark surface pale pinkish-brown with reddish-brown and grey patches, inner bark pinkish-brown, red or green; leaflets 7–19, opposite to subopposite, sometimes alternate, with 7–13 pairs of secondary veins, shiny above, below with few to numerous pale brown stellate scales especially on the veins; flowers 3-merous, anthers 6(–8), style-head obovoid with 6 longitudinal lobes; fruit dehiscent, 3-locular. *A. erythrosperma* sometimes occurs as an emergent tree in primary evergreen forest and kerangas on sandy or clayey soils, from sea-level up to 1300 m altitude.

Selected sources 481, 705.

Aglaia exstipulata (Griffith) W. Theob.

Mason, Burmah ed. 3, 2: 583 (1883).

Synonyms *Aglaia longifolia* Teijsm. & Binnend. (1864), *Aglaia griffithii* (Hiern) Kurz (1875), *Aglaia minutiflora* Bedd. var. *griffithii* Hiern (1875).

Vernacular names Malaysia: balun hijau, kerantai, gerenggong (Peninsular).

Distribution Southern Burma (Myanmar), peninsular Thailand, Peninsular Malaysia, Singapore and Borneo.

Uses The wood is thought to be used. The aril of the seed is edible.

Observations A small to medium-sized tree up to 25 m tall, bole branchless for up to 15 m, up to at least 30 cm in diameter, bark surface brown or greyish-brown, inner bark pale brown; leaflets 11–23, subopposite, usually oblong, with 7–16 pairs of secondary veins, sometimes with numerous pits on both surfaces, above with reddish-brown stellate hairs on the midrib, below with similar hairs all over the surface interspersed with smaller, paler, fewer-rayed hairs; flowers 5-merous, anthers 5, style-head ovoid to globose; fruit indehiscent, 2-locular. *A. exstipulata* is fairly common in Peninsular Malaysia and occurs in primary or secondary evergreen forest, often on hills and ridges, on sandy to clayey soils, at 50–1400 m altitude. The density of the wood is about 995 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 294, 481, 705.

Aglaia flavida Merr. & Perry

Journ. Arn. Arb. 21: 320 (1940).

Vernacular names Indonesia: amsam (Asmat, Irian Jaya).

Distribution New Guinea, New Britain and the Solomon Islands.

Uses The wood is used for house construction, paddles, tool handles and canoes.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 95 cm in diameter, buttresses up to 3 m high, bark surface dark brown or reddish-brown, grey or even white; leaflets 7–15, subopposite, with 6–20 pairs of secondary veins, smooth, glabrous above, below with numerous orange to pale brown peltate scales with a darker centre on the midrib, the intervenal parts below scattered with these scales; flowers 3-merous, anthers 6, style-head with 3 apical lobes; fruit dehiscent, 3-locular. *A. flavida* is fairly common and occurs in primary or secondary lowland and hill forest on well-drained or occasionally inundated locations, from sea-level up to 1300 m altitude.

Selected sources 481.

Aglaia forbesii King

Journ. As. Soc. Beng. 64: 68 (1895).

Synonyms *Aglaia humilis* King (1895).

Vernacular names Indonesia: langsat burung (Kalimantan). Malaysia: langsat (Peninsular), lantupak (Dusun, Sabah), segera (Iban, Sarawak).

Distribution Peninsular Burma (Myanmar), peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is thought to be used. The aril of the seed is edible and sweet.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 60 cm in diameter; leaflets 9–15, usually alternate, with 9–24 pairs of secondary veins, rugulose and pitted but glabrous above, below with few to numerous white, pale brown or reddish-brown stellate hairs or scales; calyx with 5 lobes, petals 5–6, anthers 5, style-head ovoid, with 2 small apical lobes, longitudinally ridged; fruit indehiscent, 2-locular. *A. forbesii* is found in primary and secondary evergreen forest, along rivers, on sandy or clayey soils and on ultrabasic soils, up to 1000 m altitude.

Selected sources 465, 481, 705.

Aglaia foveolata Pannell

Kew Bull., Add. Ser. 16: 211 (1992).

Vernacular names Malaysia: bekak, memberas (Peninsular), segera (Iban, Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sabah, Sarawak).

Uses The wood is thought to be used.

Observations A small to medium-sized tree up to 25 m tall, bole up to 65 cm in diameter, buttresses up to 75 cm high, bark surface reddish-brown or greyish-brown, inner bark pale brown or reddish-brown; leaflets (11–)13–17(–27), subopposite, with 9–15(–24) pairs of secondary veins, shiny and with numerous pits above, below rugulose and often with numerous pits, with sparse to dense indumentum of reddish-brown stellate hairs or scales on the midrib above and below; flowers 5-merous, anthers 5, style-head narrowly ovoid or ellipsoid with longitudinal ridges and 2 apical lobes; fruit indehiscent, 1(–2)-locular. *A. foveolata* occurs in primary or secondary lowland and hill forest, in swamps, or in riverine forest, on sand, silty clay or clay, from sea-level up to 1000 m altitude.

Selected sources 481, 705.

Aglaia grandis Korth. ex Miq.

Ann. Mus. Bot. Ludg.-Bat. 4: 56 (1868).

Synonyms *Aglaia lanuginosa* King (1895), *Aglaia hemsleyi* Koord. (1898), *Aglaia merostela* Pellegrin (1911).

Vernacular names Indonesia: purisihula (Sulawesi). Malaysia: pasak lingga (Peninsular). Philippines: barongisan-dilau (Tagalog), lambunau (Tagbanua).

Distribution Southern Vietnam, peninsular Thailand, Peninsular Malaysia, Borneo, northern Sulawesi and the Philippines.

Uses The wood is used.

Observations A medium-sized tree up to 27 m

tall, bole branchless for up to 17 m, up to at least 30 cm in diameter, bark surface grey, inner bark brown or dark brown; leaflets 11–21(–25), subopposite, with 14–46 pairs of secondary veins, shiny and glabrous above, below densely covered with pale brown hairs with a central rachis and several whorls of arms radiating from it; flowers 5-merous, anthers 5, style-head cylindrical, narrowed slightly to the obtuse apex; fruit indehiscent, 3-locular. *A. grandis* is found in primary forest, sometimes on ultrabasic soils or limestone, from sea-level up to 1700 m altitude. The density of the wood is 770–860 kg/m^3 at 15% moisture content.

Selected sources 140, 465, 474, 481, 544, 705.

Aglaia hiernii King

Journ. As. Soc. Beng. 64: 71 (1895).

Synonyms *Aglaia curtisii* King (1895), *Aglaia caudatifoliolata* Merr. (1929), *Aglaia ochneocarpa* Merr. (1934).

Vernacular names Indonesia: balik-angin, madang palapah (Sumatra), jalungang sasak (Kalimantan). Malaysia: segera (Iban, Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is thought to be used.

Observations A medium-sized tree up to 30 m tall, bole up to 35 cm in diameter, bark surface greenish-brown or grey, inner bark green; leaflets (7–)9(–13), opposite, with 12–25 pairs of secondary veins, smooth, glabrescent above, below with reddish-brown stellate hairs densely covering the midrib and numerous on the intervenal parts, in addition interspersed with numerous pale brown stellate scales or hairs; calyx with 4 or 5 lobes, petals 5, anthers 5; fruit indehiscent, 1-locular. *A. hiernii* is found in primary or secondary forest or old wasteland, on sandy to clay-loamy soils, from sea-level up to 1700 m altitude.

Selected sources 481, 705.

Aglaia lawii (Wight) C.J. Saldanha ex Ramamoorthy

C.J. Saldanha & Nicolson, Fl. Hassan Distr.: 392, pl. 76 (1976).

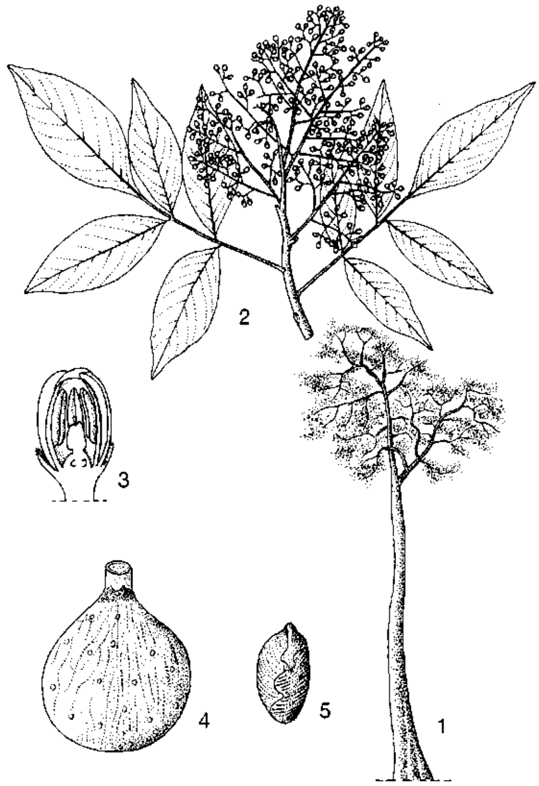
Synonyms *Aglaia littoralis* Zippelius ex Miq. (1868), *Amoora korthalsii* Miq. (1868), *Amoora lawii* (Wight) Beddome (1871), *Aglaia eusideroxylon* Koord. & Valeton (1896).

Vernacular names Indonesia: lasih (Sumatra), kayu jangan (Sulawesi), langsat lutung (Java), aisnepapir (Biak, Irian Jaya). Malaysia: bekak (Peninsular), lasat-lasat (Dayak, Sabah), segera (Iban, Sarawak). Philippines: talisaian (Ibanag), salotoi (Ibanag), sulmin (Tagalog). Burma (Myanmar): tagat-thitto. Thailand: sang katong (peninsular).

Distribution From India through Burma (Myanmar), Thailand, Indo-China and throughout Malesia towards the Solomon Islands.

Uses *A. lawii* is an important source of timber. In the Philippines the leaves are used against headache.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 15 m, up to 200 cm in diameter, fluted or with buttresses up to 1.8 m high, bark surface reddish-brown to yellowish-brown or pale pinkish-brown, sometimes grey or greenish-brown, inner bark green; leaflets (1–)2–7(–11), alternate to subopposite, with 5–21 pairs of secondary veins, with numerous pits on both surfaces, glabrous on both surfaces or with numerous pale brown or pale orange-brown peltate scales with an irregular to fimbriate margin on the lower surface; flowers 3–4(–6)-merous, anthers (5–)6–10(–11), style-head



Aglaia lawii (Wight) C.J. Saldanha ex Ramamoorthy – 1, tree habit; 2, flowering twig; 3, sectioned flower; 4, fruit; 5, seed.

ovoid with (2–)3 apical lobes or columnar with a truncate apex; fruit dehiscent, (2–)3(–4)-locular. *A. lawii* is locally common and occurs in primary or secondary evergreen to deciduous forest, sometimes in peat-swamp or riverine forest, on sandy to clayey soils or limestone, from sea-level up to 1650 m altitude. The wood is reported as hard and durable and has a density of 590–995 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 12, 63, 140, 180, 218, 228, 302, 303, 481, 544, 731.

Aglaia leptantha Miq.

Ann. Mus. Bot. Ludg.-Bat. 4: 51 (1868).

Synonyms *Aglaia glabriflora* Hiern (1875), *Aglaia laevigata* Merr. (1906), *Aglaia gamopetala* Merr. (1929).

Vernacular names Indonesia: bomberang, langadai delok (Sumatra), kayu lilin (Kalimantan). Malaysia: pasak beras-beras (Peninsular), lantupak (Dusun, Sabah), segera (Iban, Sarawak). Philippines: gisihan, kagatongan (Tagalog), agai (Negros).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, Java, Flores, Borneo and the Philippines.

Uses The wood is used e.g. for furniture, house and fence posts, and house building. The aril of the seed is edible but sour.

Observations A medium-sized, occasionally fairly large tree up to 30(–40) m tall, bole branchless for up to 16 m, up to 60 cm in diameter, fluted at base or with small buttresses up to 30 cm high, bark surface pale grey or greenish-brown to reddish-brown with greyish-green patches, inner bark green, pale orange-brown or reddish-brown; leaflets 7–11(–12), alternate, with 4–14 pairs of secondary veins, smooth or occasionally rugulose and glabrous or with few scales on the veins above, the midrib and veins below with few to numerous reddish-brown, pale brown or grey peltate scales with fimbriate margin and a darker centre, the intervenal parts almost glabrous; flowers 5-merous, anthers 5, style-head ovoid, with 2 small apical lobes; fruit indehiscent, 1–2-locular. *A. leptantha* is locally common in primary forest, sometimes in kerangas or seasonal swamp, ridge or lower montane forest, on sandy or clayey soils or limestone, up to 1700 m altitude. The density of the wood is about 915 kg/m^3 at 15% moisture content.

Selected sources 78, 414, 481, 527, 544, 705.

Aglaia leucophylla King

Journ. As. Soc. Beng. 64: 66 (1895).

Synonyms *Aglaia heteroclita* King (1895), *Aglaia kunstleri* King (1895), *Aglaia agusanensis* Elmer ex Merr. (1937).

Vernacular names Indonesia: ganggo bareh, letung (Sumatra), perumpong hutan (Kalimantan). Malaysia: bekak kedongong, pasak lingga (Peninsular), lantupak (Dusun, Sabah). Philippines: bubunau (Manobo), agusan bulog (Panay Bisaya).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra, Borneo, Sulawesi and the Philippines.

Uses The wood is used e.g. for house poles.

Observations A small to medium-sized tree up to 20 m tall, bole up to 20 cm in diameter, sometimes fluted at base, bark surface grey to brown, inner bark pale yellow; leaflets 9–15(–17), alternate to subopposite, with 8–14 pairs of secondary veins, rugulose on both surfaces and pitted below, glabrous above, below with few to numerous tiny golden-brown stellate scales, sometimes interspersed with darker peltate scales or stellate hairs; flowers 5-merous, anthers 5(–7), style-head depressed globose; fruit indehiscent, 2-locular. *A. leucophylla* is found in primary but more often in secondary evergreen forest, sometimes in riverine or moss forest, on sandy to clayey soils or limestone, from sea-level up to 1300 m altitude.

Selected sources 465, 481, 544, 705.

Aglaia luzoniensis (S. Vidal) Merr. & Rolfe

Philipp. Journ. Sci., Bot. 3: 105 (1908).

Synonyms *Aglaia unifoliolata* Koord. (1898), *Aglaia brevipetiolata* Merr. (1916), *Aglaia rizalensis* Merr. (1918).

Vernacular names Indonesia: pisek-rintek (Sulawesi). Philippines: kuling-manuk (general), kansulud-pugot, Rizal kaniue (Tagalog).

Distribution Borneo, Sulawesi and the Philippines.

Uses The wood is sometimes used e.g. for house posts, window sills and general construction.

Observations A small tree up to 10 m tall, bole short, up to 40 cm in diameter, with prominent buttresses, bark surface brown or red, inner bark red or reddish-brown; leaflets 1, with 5–18 pairs of secondary veins, smooth and glabrous above, below with numerous orange-brown or reddish-brown peltate scales sometimes with fimbriate margin on the midrib and less dense on the intervenal parts; calyx 5-lobed, petals 5(–6), anthers 5, style-head ovoid or depressed globose, sometimes with a central depression at the apex; fruit indehiscent, 1–2-locular. *A. luzoniensis* occurs scattered in primary or secondary forest, on sandy to clayey soils or on limestone, from sea-level up to 1400 m altitude. The density of the wood is 535–1085 kg/m^3 at 15% moisture content.

Selected sources 414, 474, 481, 527, 544.

Aglaia macrocarpa (Miq.) Pannell

Kew Bull., Add. Ser. 16: 65 (1992).

Synonyms *Amoora rubescens* Hiern (1875), *Amoora trichanthera* Koord. & Valeton (1896), *Aphanamixis trichanthera* (Koord. & Valeton) Koord. (1912), *Aglaia rubescens* (Hiern) Pannell (1982).

Vernacular names Indonesia: balam pelapah, kayu tenu, manehwuh bungo (Sumatra). Malaysia: kasai, bekak (Peninsular), lantupak (Dusun, Sabah).

Distribution Peninsular Malaysia, Singapore, Sumatra, Java, Borneo and Sulawesi; possibly on the Moluccas and Palawan.

Uses The wood is used.

Observations A medium-sized to fairly large tree up to 35 m tall, bole branchless for up to 22 m, up to 50 cm in diameter, bark surface reddish-brown and grey or pale, inner bark dark red or pinkish-brown; leaflets 11–15, subopposite, with 6–11 pairs of secondary veins, both surfaces rugulose, above shiny and glabrous, below with few to numerous pale grey or reddish-brown peltate scales on the midrib and veins; flowers 3-merous, anthers 6–10, style-head ovoid, with longitudinal ridges; fruit probably dehiscent, 3-locular. *A. macrocarpa* has been found in primary and secondary lowland, hill and ridge forest, sometimes along rivers and paths, on sandstone, sandy clay, loam, basalt and limestone, from sea-level up to 1750 m altitude. The density of the wood is 650–725 kg/m^3 at 15% moisture content.

Selected sources 140, 302, 303, 481, 705.

Aglaia malaccensis (Ridley) Pannell

Mal. Forester 45: 455 (1982).

Synonyms *Amoora malaccensis* Ridley (1917).

Vernacular names Indonesia: guls, palangkutan (Sumatra), parak keluwang (Kalimantan). Malaysia: kasai memberas, kalbang (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Borneo and the Philippines (Mindanao).

Uses The wood is used.

Observations A medium-sized tree up to 27 m tall, bole up to 53 cm in diameter, buttresses up to 50 cm high, bark surface flaking in large scales, pale brown; leaflets 11–15, subopposite, smooth, glabrous above, below with small pale brown or almost white stellate hairs or scales, especially on the midrib; calyx with 3(–4) lobes, petals 3, anthers 6(–7), style-head ovoid, with 3 apical lobes and 6 longitudinal ridges; fruit dehiscent, 3–4-locular. *A. malaccensis* is locally common and occurs in primary and secondary forest on sandy to clayey soils, from sea-level up to 700 m altitude. The density of the wood is 660–870 kg/m^3 at 15% moisture content.

Selected sources 140, 456, 465, 481, 705.

Aglaia multinervis Pannell

Kew Bull., Add. Ser. 16: 84 (1992).

Synonyms *Amoora lanceolata* Hiern (1875).

Vernacular names Indonesia: parak, parek api (Sumatra), embunjau (Kalimantan). Malaysia: lantupak, manggi (Dusun, Sabah).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses The wood is used.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 70 cm in diameter, bark surface pale brown, reddish-brown or pinkish-grey, with deciduous scales exposing reddish-brown patches; leaflets 15–25, subopposite, with 20–50 pairs of secondary veins, glabrous and smooth above, below rugulose with peltate or stellate scales, especially on the midrib; calyx with 3(–4) lobes, petals 3, anthers 6, style-head ovoid, with 3 apical lobes and 6 longitudinal ridges; fruit dehiscent, 3-locular. *A. multinervis* occurs in forest, often on slopes, up to 400 m altitude. The density of the wood is about 795 kg/m^3 at 15% moisture content.

Selected sources 140, 481, 705.

Aglaia odorata Lour.

Fl. Cochinch. 1: 173 (1790).

Synonyms *Aglaia chaudocensis* Pierre (1896), *Aglaia duperreana* Pierre (1896), *Aglaia oblanceolata* Craib (1926).

Vernacular names Indonesia: pacar cina (Sumatra, Java), bunga maniran (Kalimantan), pacar culam (Java, Moluccas). Malaysia: me shui lan (Chinese, Peninsular), chulan, pokok telur belangkas (Peninsular). Burma (Myanmar): thanatka-wa. Cambodia: trayang. Laos: 'khai[1] pou. Thailand: homklai (peninsular), khayong (northern), prayong (central).

Distribution Hainan (China), Burma (Myanmar), Vietnam, Cambodia and Thailand; possibly in Laos and the Moluccas. Cultivated in India, Sri Lanka, Peninsular Malaysia, Sumatra and Java.

Uses The wood is reported to be excellent for turnery. More important is the use as an ornamental, e.g. in hedges. The flowers are used for scenting tea and applied externally to the body after childbirth or internally against fever.

Observations A shrub or small tree up to 10 m tall; leaflets 3–5(–7), opposite, with 5–9 pairs of secondary veins, usually smooth and glabrous or occasionally with few yellowish-brown stellate scales with a fimbriate margin below; flowers 5-merous, anthers 5, style-head ovoid or narrowly ovoid, longitudinally ridged and with 2 small apical lobes; fruit indehiscent, 1-locular. *A. odorata* occurs scattered but is locally common and found in evergreen primary and secondary forest, sometimes along the coast, up to 700 m altitude.

Selected sources 78, 104, 185, 234, 302, 481, 574, 676.

Aglaia pachyphylla Miq.

Ann. Mus. Bot. Lugd.-Bat. 4: 57 (1868).

Synonyms *Aglaia barbatula* Koord. & Valeton (1896), *Aglaia clarkii* Merr. (1905), *Aglaia megistocarpa* Merr. (1929).

Vernacular names Indonesia: siluwar (Sundanese, Java), singkok (Kalimantan). Malaysia: semeliang (Peninsular), langsat-langsat, koping-koping (Sabah). Philippines: tukang-kalau (Tagalog), guijo, makaasim (general).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra, western Java, Borneo, south-eastern Sulawesi and the Philippines (Burias).

Uses The wood is used e.g. for furniture, bridges, planks and temporary construction.

Observations A medium-sized to large tree up to 43 m tall, bole branchless for up to 20 m, up to 90 cm in diameter, sometimes with buttresses up to 3 m high, bark surface brown, greyish-brown or greenish-grey, inner bark dark brown to pale yellowish-brown; leaflets 13–23, subopposite, with (15–)20–45 pairs of secondary veins, shiny and glabrous above and with numerous small pits, below densely covered with pale reddish-brown tree-shaped hairs or with pale to dark brown stellate hairs or scales; flowers 5-merous, anthers 5, style-head cylindrical, truncate at apex; fruit indehiscent, 2(–4)-locular. *A. pachyphylla* occurs frequently to very commonly along rivers, in primary or secondary forest and forest margins, on sandstone, clay or limestone, from sea-level up to 1350 m altitude. The wood is reported to be hard and durable and has a density of about 855 kg/m^3 at 15% moisture content.

Selected sources 77, 302, 303, 414, 481, 527, 544, 626, 705.

Aglaia parviflora C.DC.

Bull. Herb. Boiss., Sér. II, 3: 176 (1903).

Synonyms *Aglaia forbesiana* C.DC. (1903), *Aglaia procera* C.DC. (1913), *Aglaia acariaeantha* Harms (1942).

Vernacular names Indonesia: lai, lasaba (Moluccas), mansaambree (Biak, Irian Jaya).

Distribution The southern Moluccas, New Guinea, New Britain and the Solomon Islands.

Uses The wood is used e.g. for house construction in Papua New Guinea.

Observations A small to medium-sized tree up to 20 m tall, bole branchless for up to 16 m, up to 30 cm in diameter, bark surface yellowish-brown or pale greyish-brown, inner bark pinkish-brown; leaflets 5–7(–9), subopposite, with 7–17(–26) pairs of secondary veins, smooth and glabrous above, below sometimes pitted, with few to numerous orange-brown or yellowish-brown peltate scales with a fimbriate margin, more densely scaly on the midrib; flowers 5-merous, anthers 5, style-head flattened and with shallow marginal lobes; fruit indehiscent, 2-locular. *A. parviflora* is locally common and occurs in primary and secondary forest, sometimes on ridges, in riverine forest or along the coast, on sandy or sandy clay soils, volcanic loam or limestone, up to 1700 m altitude.

Selected sources 481.

Aglaia penningtoniana Pannell

Kew Bull., Add. Ser. 16: 94 (1992).

Distribution Papua New Guinea.

Uses The wood is thought to be used.

Observations A medium-sized to large tree up to 45 m tall, bole branchless for up to 20 m, up to 150 cm in diameter, buttresses up to 3 m high, bark surface brown or pale greyish-brown, inner bark pinkish-brown; leaflets 11–13, subopposite, with 13–21 pairs of secondary veins, rugulose on both surfaces, shiny and glabrous above, below with few to numerous white stellate scales on the midrib and occasionally elsewhere; calyx with 3(–4) lobes, petals 3, anthers 17–21, style-head small, with 3 narrow longitudinal lobes at the apex; fruit dehiscent, 1-locular. *A. penningtoniana* occurs in lowland and montane rain forest, up to 1550 m altitude.

Selected sources 481.

Aglaia perviridis Hiern

Hook.f., Fl. Brit. India 1: 556 (1875).

Synonyms *Aglaia maiae* Bourd. (1899), *Aglaia canarensis* Gamble (1915), *Aglaia kingiana* Ridley (1920).

Vernacular names Malaysia: tengkorak lang, tenkohalang (Peninsular). Vietnam: g[ooj]i xanh.

Distribution South-western India, Bhutan, Bangladesh, the Andaman Islands, southern China, northern Vietnam, Thailand and Peninsular Malaysia.

Uses The wood is used, e.g. for general construction, ship and boat planking, and agricultural tools. The fruit is reported to be edible. *A. perviridis* is also used as a shade and wayside tree.

Observations A small to medium-sized tree up to 25 m tall, bole up to 50 cm in diameter; leaflets 11–13, subopposite, with 12–18 pairs of secondary veins, usually pitted and sometimes rugulose on both surfaces, generally glabrous above, below with few small reddish-brown peltate scales having a dark centre and an irregular fimbriate margin, more densely scaly on the midrib; flowers 5-merous, anthers 5, style-head ovoid; fruit indehiscent, 1-locular. *A. perviridis* is common, occurring scattered in primary and secondary evergreen forest on limestone, at 100–1500 m altitude. Wood samples of seasoned timber from India have a density of 895–1120 kg/m^3.

Selected sources 78, 86, 116, 185, 481, 494.

Aglaia rimosa (Blanco) Merr.

Sp. Blanc.: 212 (1918).

Synonyms *Aglaia llanosiana* C.DC. (1878), *Aglaia lanceolata* Merr. (1910), *Aglaia subviridis* Elmer ex Merr. (1923).

Vernacular names Indonesia: hitang mararu (Moluccas), mansaambra (Biak, Irian Jaya). Philippines: bayanti (Tagalog), botgo (Bikol, Tagalog), gasatin (Iloko).

Distribution Taiwan, the Philippines, the Moluccas, New Guinea and New Britain.

Uses The wood is used for house construction.

Observations A shrub to medium-sized tree up to 30 m tall, bole up to 50 cm in diameter, buttresses up to 50 cm high, bark surface dark brown to greenish-grey, inner bark pink to dull red; leaflets (3–)9–11(–15), subopposite, sometimes alternate, with 7–17(–20) pairs of secondary veins, above glossy and often rugulose, sometimes pitted and glabrescent, below sometimes pitted and with few to numerous radiating peltate scales with a dark orange-brown or dark reddish-brown centre and a paler, entire to ragged margin, sometimes interspersed with few darker scales; calyx with (4–)5 lobes, petals 4–5, anthers 5, rarely 6, style-head broadly ovoid or subglobose, with 2 small apical lobes; fruit indehiscent, 2-locular. *A. rimosa* is locally common in secondary forest, along rivers and along the coast, on sandy clay or limestone, up to 1350 m altitude.

Selected sources 330, 414, 481, 544.

Aglaia rivularis Merr.

Univ. Calif. Publ. Bot. 15: 125 (1929).

Vernacular names Malaysia: lambunan (Dusun Labuk, Sabah).

Distribution Borneo (West Kalimantan and Sabah).

Uses The wood is used for fence posts in Sabah.

Observations A small tree up to 15 m tall, bole branchless for up to 10 m, up to 50 cm in diameter, bark surface brown or whitish-brown, inner bark reddish-brown or pale brown; leaflets 1, with 10–17 pairs of secondary veins, smooth, glabrous above, below with reddish-brown to pale brown peltate scales often having a short fimbriate margin, densely scaly on the midrib, few elsewhere; calyx (4–)5-lobed, petals 5, anthers 5, style-head ovoid or depressed globose, with an apical depression; fruit indehiscent, 1-locular. *A. rivularis* is a rheophyte of riverine forest on sand, and occurs from sea-level up to 500 m altitude.

Selected sources 481.

Aglaia rubiginosa (Hiern) Pannell

Mal. Forester 45: 455 (1982).

Synonyms *Amoora rubiginosa* Hiern (1875), *Aglaia ignea* Valeton ex K. Heyne (1917).

Vernacular names Indonesia: parak api (Belitung), parak talang (Sumatra), parak merah (Bangka). Malaysia: bekak (Peninsular), lantupak (Dusun, Sabah).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses The wood is used e.g. for beams in house building and for boat building.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 50 cm in diameter, branchless for up to 20 m, buttresses up to 1 m high, bark surface pale pinkish-brown or greyish-brown, inner bark pale pinkish-brown; leaflets 15–21, subopposite, with 11–24 pairs of secondary veins, above pitted, glabrous and shiny, below densely covered with reddish-brown stellate scales having a darker centre, the veins less densely scaly; calyx shallowly 3-lobed, petals 3, anthers 6, style-head ellipsoid with 3 apical lobes and 6 longitudinal ridges; fruit dehiscent, 3-locular. *A. rubiginosa* is common, occurring most frequently in freshwater peat-swamp forest and kerangas, sometimes in primary lowland or hill forest, from sea-level up to 300 m altitude. The density of the wood is 835–1025 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 140, 234, 474, 481, 705, 734.

Aglaia rufinervis (Blume) Bentvelzen

Acta Bot. Neerl. 11: 19 (1962).

Synonyms *Aglaia trichostemon* C.DC. (1878), *Aglaia montana* C.DC. (1912), *Aglaia borneensis* Merr. (1917).

Vernacular names Indonesia: kawauk (Java). Malaysia: bekak, rim, chiang lima (Peninsular). Thailand: sangkhriat-lai (Trang).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, western Java and Borneo.

Uses The wood is used only locally, e.g. for ladders and poles, as it seems to split easily. The fruit is reported to be edible.

Observations A small tree up to 15 m tall, bole branchless for up to 10 m, up to at least 20 cm in diameter, bark surface brown or grey, inner bark pale orange-brown; leaflets 15–19, subopposite, with 9–18 pairs of secondary veins, above rugulose, pitted and glabrous, below with numerous pits and densely covered with reddish-brown stellate scales on the midrib and brown or pale brown stellate scales on the intervenal parts; flowers 5-merous, anthers 5, style-head narrowly ovoid; fruit indehiscent, 1-locular. *A. rufinervis* is common in primary and secondary forest and has been found on sandy loam, clay and limestone, from sea-level up to 1330 m altitude.

Selected sources 78, 481, 705.

Aglaia sapindina (F. v. Mueller) Harms

Engl. & Prantl, Nat. Pflanzenfam. 3(4): 298 (1896).

Synonyms *Aglaia ermischii* Warb. (1891), *Aglaia novaguineensis* (C.DC.) C.DC. (1903), *Aglaia rudolfi* Harms (1942).

Vernacular names Indonesia: luka luka ma (Moluccas).

Distribution The Moluccas and New Guinea to the Solomon Islands and northern Australia.

Uses The wood is used.

Observations A small to medium-sized tree up to 30 m tall, bole branchless for up to 18 m, up to 75 cm in diameter, buttresses up to 2 m high, bark surface greenish-brown, greyish-brown or reddish-brown, inner bark pink or white; leaflets (3–)5–9, subopposite, with 8–20 pairs of secondary veins, smooth and glabrous above, below pitted on the veins and there with few to numerous pale brown to reddish-brown peltate scales having a fimbriate margin, sometimes few of these scales on the intervenal parts; calyx 5(–6)-lobed, petals 5, anthers 5, style-head ovoid with 2 small apical lobes; fruit indehiscent, 2-locular. *A. sapindina* is common, occurring in primary and secondary forest, in riverine forest, swamps, along rivers and the beach, on limestone or sandy clay with granite, from sea-level up to 3800 m altitude. In Papua New Guinea, it is a tree of the understorey and does not reach the canopy. The density of the wood is about 530 kg/m^3 at 15% moisture content.

Selected sources 12, 232, 282, 330, 481.

Aglaia silvestris (M. Roemer) Merr.

Interpr. Herb. amboin.: 210 (1917).

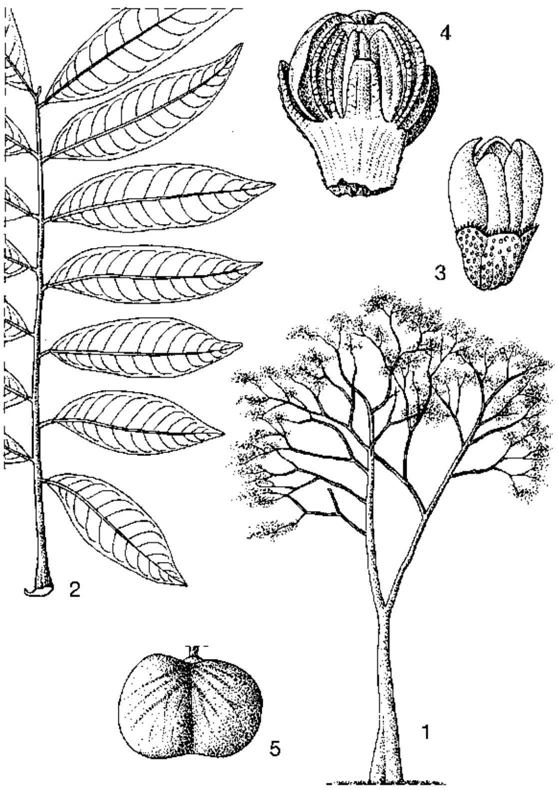
Synonyms *Aglaia ganggo* Miq. (1861), *Aglaia cedreloides* Harms (1942), *Aglaia mannii* (King ex Brandis) Jain & Gaur (1986).

Vernacular names Indonesia: ganggo (general), pacar kidang (Sumatra), kayu wole (Sulawesi). Malaysia: bekak (Peninsular), segera (Sarawak), lantupak (Dusun, Sabah). Philippines: salamingai (Tagalog), panuhan (Negrito). Thailand: chanchamot (Chanthaburi).

Distribution The Andaman and Nicobar Islands, southern Vietnam, Cambodia, peninsular Thailand, throughout Malesia (except for the Lesser Sunda Islands) towards the Solomon Islands.

Uses *A. silvestris* is an important source of timber; the wood is used for e.g. house building, furniture, tool-handles, spears and boards.

Observations A medium-sized to sometimes large tree up to 30(–50) m tall, bole branchless for up to 13 m, up to at least 50 cm in diameter, buttresses L-shaped, up to 120 cm high, bark surface pale greyish-brown or reddish-brown, inner bark reddish-brown or dark orange-brown; leaflets (5–)13–19, alternate, with 12–21 pairs of secondary veins, smooth and glabrescent above, below sparsely to densely set with peltate scales having a dark brown centre and pale margin; calyx 5-lobed, petals 5(–6), anthers 5, style-head ovoid, with 2 small lobes and longitudinally ridged; fruit indehiscent, 1–2(–3)-locular. *A. silvestris* is locally common in primary and secondary evergreen to semi-deciduous forest, in swamps, kerangas, and even forest-savanna vege-



Aglaia silvestris (M. Roemer) Merr. – 1, tree habit; 2, leaf; 3, flower; 4, sectioned flower; 5, fruit.

tation, on clayey loam, sandstone or limestone, from sea-level up to 2100 m altitude. The density of the wood is 620–930 kg/m^3 at 15% moisture content.

Selected sources 234, 465, 474, 481, 705.

Aglaia smithii Koord.

Meded. 's Lands Plantent. 19: 383, 635 (1898).

Synonyms *Aglaia badia* Merr. (1909), *Aglaia bicolor* Merr. (1909), *Aglaia ramosii* Quisumb. (1930).

Vernacular names Indonesia: monjowojan (Sulawesi), alawe (Moluccas), duren (Irian Jaya). Philippines: batukanag (Iloko), masaleng (Negrito).

Distribution The Philippines, Sulawesi, the Lesser Sunda Islands, the Moluccas and New Guinea (Irian Jaya).

Uses The wood is used in the Philippines for temporary construction, and in Irian Jaya for poles.

Observations A small to medium-sized tree usually less than 10 m tall; leaflets (5–)9–15, subopposite, with 9–13 pairs of secondary veins, with numerous pits or scales above, below densely set with peltate dark reddish-brown scales and a few larger and darker scales; calyx 5-lobed, petals 5, anthers 5, style-head depressed-globose; fruit obovoid. *A. smithii* is locally common in primary forest and coastal forest on clayey soils, up to 40 m altitude. The wood is reddish-brown and comparatively hard and heavy.

Selected sources 414, 481.

Aglaia speciosa Blume

Bijdr. fl. Ned. Ind.: 171 (1825).

Vernacular names Indonesia: ganggo udang, setur padi (Sumatra). Malaysia: bekak, memberas (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Borneo (Sabah, Kalimantan) and Sulawesi (Sula).

Uses The wood is thought to be used.

Observations A medium-sized to fairly large tree up to 35 m tall, bole branchless for up to 20 m, up to 60 cm in diameter, buttresses up to 5 m high, bark surface reddish-brown, inner bark magenta or pink; leaflets (5–)7–11, subopposite, with 12–15 pairs of secondary veins, smooth and glabrous above, below sometimes pitted and with numerous peltate scales having a dark reddish-brown centre and a pale, barely or shortly fimbriate margin; flowers 5-merous, anthers 5, style-head columnar or obovoid with a central depression at the apex; fruit indehiscent, (1–)2-locular. *A. speciosa* is found in primary or secondary forest, on loam with lime, from sea-level up to 2200 m altitude.

Selected sources 481.

Aglaia spectabilis (Miq.) Jain & Bennet

Indian Journ. Forestry 9: 271 (1987).

Synonyms *Amoora gigantea* Pierre (1886), *Amoora ridleyi* King (1895), *Aglaia gigantea* (Pierre) Pellegrin (1911), *Aglaia ridleyi* (King) Pannell (1982).

Vernacular names Indonesia: mokken (Biak, Irian Jaya). Malaysia: bekak, surian batu (Peninsular), lantupak (Dusun, Sabah). Laos: n[oox]k k[oox]k. Thailand: tasua-bailek (Chon Buri). Vietnam: g[ooj]i, g[ooj]i nep, g[ooj]i nui.

Distribution From north-eastern India through Indo-China towards Peninsular Malaysia, Sumatra, Borneo, Sulawesi, Sumba, New Guinea, the Solomon Islands and northern Australia (Cape York).

Uses The wood is used e.g. for house building, planking, and the manufacturing of rifle butts.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 18 m, up to 150 cm in diameter, buttresses up to 4 m high, bark surface shaggily flaky, greyish-white, pale yellowish-brown or brown, inner bark pink, reddish-orange or brown; leaflets (3–)11–21, subopposite, with 9–19 pairs of secondary veins, above rugulose and sometimes pitted, glabrous, below pitted and sparsely to densely covered with pale brown or reddish-brown stellate hairs and scales, sometimes interspersed with few darker peltate scales having a fimbriate margin, indumentum most dense on the veins; flowers 3-merous, anthers (5–)6(–10), style-head ellipsoid with 3 apical lobes and 6 longitudinal ridges; fruit dehiscent, 3(–4)-locular. *A. spectabilis* is locally common and occurs in primary and secondary rain forest, gallery forest, coastal riverine forest or deciduous forest dominated by vines, on sandy to clayey or coral soils, from sea-level up to 700 m altitude. The wood is reported to be of excellent quality and has a density of 610–790 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 78, 86, 116, 140, 465, 481, 494, 526, 574, 676, 705, 734.

Aglaia subcuprea Merr. & Perry

Journ. Arn. Arb. 21: 324 (1940).

Synonyms *Aglaia versteeghii* Merr. & Perry (1940), *Aglaia boanana* Harms (1942).

Distribution New Guinea and New Ireland.

Uses The wood is thought to be used.

Observations A medium-sized tree up to 30 m tall, bole up to 160 cm in diameter, bark surface brown or black, mottled with grey, inner bark pale brown or reddish-brown; leaflets (3–)7–9(–11), subopposite, with 6–15 pairs of secondary veins, above glabrescent leaving the surface wrinkled or pitted, below sometimes glabrescent but usually densely covered with pale brown to reddish-brown peltate scales having a darker centre and a fimbriate margin; flowers 5-merous, anthers 5(–10), style-head ovoid to fusiform with 2 small apical lobes; fruit indehiscent, 2-locular. *A. subcuprea* is locally common in primary or secondary lowland or montane rain forest, sometimes in periodically inundated locations, on sandy clay or granitic soils, from sea-level up to 2600 m altitude. The density of the wood is 800–950 kg/m^3 at 15% moisture content.

Selected sources 474, 481.

Aglaia tomentosa Teijsm. & Binnend.

Natuurk. Tijdschr. Ned. Ind. 27: 43 (1864).

Synonyms *Aglaia cordata* Hiern (1875), *Aglaia dyeri* Koord. (1898), *Aglaia glomerata* Merr. (1906).

Vernacular names Indonesia: awa saelu saelu datan, kayu si rah-rah batu (Sumatra), malasot (Sulawesi). Malaysia: buah patung (Temuan, Peninsular), medang belulu (Peninsular), lambunau burong (Dusun, Sabah). Philippines: karamiras (Tagalog), arangnang (Dumagat), maybosug (Yakan). Thailand: sangkhriat-langsat (Trang).

Distribution Southern India, Vietnam, Laos, Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo, Sulawesi, the Philippines, New Guinea and northern Australia.

Uses The wood is used.

Observations A usually small, sometimes medium-sized tree up to 15(–23) m tall, bole branchless for up to 9 m, up to at least 20 cm in diameter, bark surface pale reddish-brown or grey with green patches, inner bark yellow; leaflets 5–11(–13), opposite or subopposite, with 5–25 pairs of secondary veins, above smooth and glabrous or the midrib densely covered with reddish-brown or orange-brown stellate hairs, below with numerous stellate hairs and interspersed with smaller paler hairs; flowers 5-merous, anthers 5, style-head subglobose, longitudinally ridged; fruit indehiscent, 1–2-locular. *A. tomentosa* is fairly common, occurring in primary and secondary evergreen forest, on hills and ridges, along rivers or in periodically inundated locations, on sandy to clayey soils or on lateritic or limestone soils, from sea-level up to 2000 m altitude. The wood is reported as non-durable and has a density of 800–905 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 414, 474, 481, 574, 705.

Nguyen Ba (general part),
Nguyen Nghia Thin (general part),
S.I. Wiselius (properties),
S. Noshiro (wood anatomy),
M.S.M. Sosef (selection of species)

Ailanthus Desf.

Mém. Acad. Sci., Paris 1786: 265 (1788).

SIMAROUBACEAE

x = unknown; *A. altissima*: $2n$ = 64, 80, *A. integrifolia* subsp. *calycina*: n = 31, 32

Trade groups White siris: lightweight hard-

wood, *Ailanthus integrifolia* Lamk, *A. triphysa* (Dennst.) Alston.
The timber is sometimes traded together with similar timbers as 'mixed light-coloured hardwood'. Sometimes the wood of *Albizia procera* (Roxb.) Benth. is also traded as white siris.

Vernacular names White siris (En). Indonesia: kayu langit.

Origin and geographic distribution *Ailanthus* consists of 5 species and its natural distribution is from Turkestan and India to China, through Malesia towards the Solomon Islands and north-western Australia. Two species occur naturally within Malesia. They have large areas of distribution, but are rare in most regions; *A. integrifolia* is locally common in New Guinea and the Bismarck Archipelago.

Uses White siris is used for parts of furniture, laminated wood, drawers, ceilings, wooden shoes, moulding, toys, shingles, matchsticks, matchboxes, core of plywood, weatherboards, interior trim, brush stocks, pattern making, paper pulp, fuel and charcoal.
The leaves, bark, roots and resin have medicinal properties; they are used to prepare tonics, as febrifuge and against indigestion. In Vietnam, the leaves are used to dye silk black. The resin is burned for its pleasant fragrance (gaharu).

Production and international trade Japan imports small amounts of white siris timber, mainly from Papua New Guinea, little from other areas. White siris accounts for about 1% of the total amount of timber imported in Japan from Papua New Guinea. In Papua New Guinea the wood is ranked in MEP (Minimum Export Price) group 4; logs fetched a minimum price of US$ 43/m^3 in 1992.

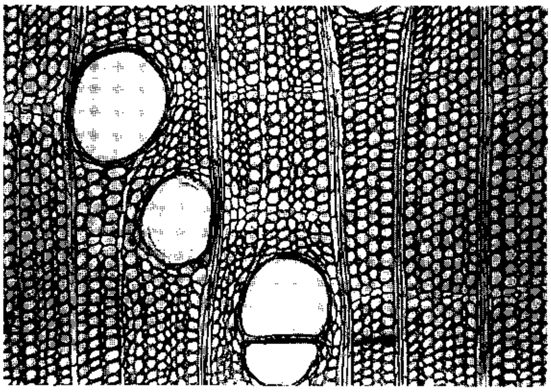
Properties White siris is a lightweight and comparatively soft wood. The heartwood is yellowish-white to pale brown and not distinctly demarcated from the sapwood. The density is 330–435 kg/m^3 at 12% moisture content. The grain is straight to shallowly interlocked, texture moderately coarse.
At 12% moisture content, the wood of *A. integrifolia* has the following mechanical properties: the modulus of rupture 54.5–62 N/mm^2, modulus of elasticity c. 9175 N/mm^2, compression parallel to grain 36 N/mm^2, shear 5.5 N/mm^2, cleavage 29.5 N/mm radial and 23 N/mm tangential, and Janka side hardness 1715 N.
The rates of shrinkage are fairly low to moderate: from green to 15% moisture content 1.0–1.5% radial and 2.3–4.0% tangential, from green to 12% moisture content c. 2.1% radial and 3.7–4.7% tangential, and from green to oven dry 2.8–4.2% radial and 5.2–8.1% tangential. The wood is easy to air dry and kiln dry, although sometimes liable to develop fine long surface cracks.
White siris wood is difficult to split but easy to saw, work and polish. It holds nails well. Veneer made from white siris may have a very fuzzy surface.
The wood is non-durable. It is often liable to staining. However, white siris is easy to treat with preservatives. The retention by the pressure treating method is 600 kg/m^3 in the heartwood, and 665 kg/m^3 in the sapwood of *A. integrifolia*.
Wood of *A. integrifolia* contains 74% holocellulose and 51% α-cellulose (calculated on an ash- and lignin-free basis), 31% lignin and 0.8% ash. The solubility is 0.9% in alcohol-benzene, 0.8% in cold water, 1.5% in hot water and 10.5% in a 1% NaOH solution. The inner bark tastes very bitter.

Description Large, dioecious, evergreen or sometimes deciduous trees up to 60 m tall; bole cylindrical, up to 85(–175) cm in diameter, buttresses absent; bark surface smooth or with irregular fissures, grey-white to pale brown or greenish-brown, outer bark 1.5–2 cm thick, inner bark fibrous, grey-white or grey-brown; branches thick, with large leaf scars. Leaves more or less tufted at the end of twigs, arranged spirally, paripinnate or imparipinnate; stipules absent; leaflets opposite or subopposite, stalked, generally with some glands below or at the base. Inflorescence an axillary panicle. Flowers unisexual, 5(–6)-merous, zygomorphic; calyx small, 5(–6)-lobed or closed in bud and later irregularly splitting to the base (often in two parts), rarely cupular; petals 5(–6), free, induplicate-valvate in bud, concave, oblong or narrowly oblong; stamens 10, in female flowers either subnormal but without pollen, or vestigial, or absent; carpels 2–5, free, flat, in male flowers vestigial or absent, ovule 1 per locule, styles 2–5, free or united. Fruit a linear or oblong-lanceolate samara. Seed flat, orbicular or obovate or somewhat triangular, without endosperm, with a thin testa. Seedling with epigeal germination.

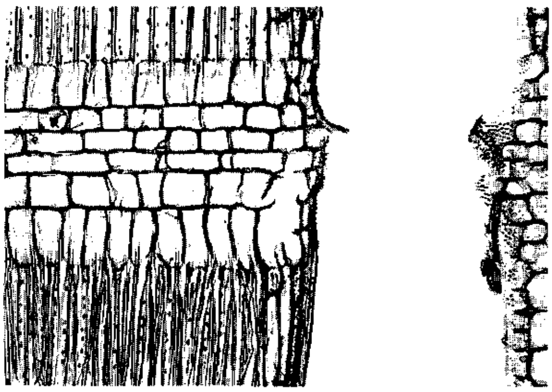
Wood anatomy

– Macroscopic characters:

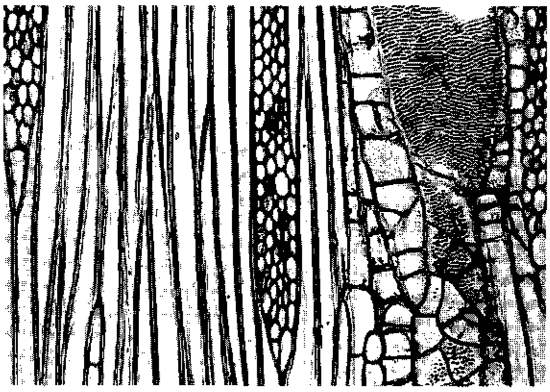
Heartwood yellowish-white to pale brown-yellow, not clearly demarcated from the pale yellow sapwood. Grain straight to shallowly interlocked. Texture moderately coarse; fiddleback figure sometimes present. Growth rings indistinct; vessels visible to the naked eye, tyloses sparse to rather frequent; parenchyma usually not distinct



transverse section (×25)



radial section (×75)



tangential section (×75)

Ailanthus integrifolia

without a lens; rays conspicuous; ripple marks absent.

– Microscopic characters:

Growth ring boundaries indistinct. Vessels diffuse, 2–3/mm^2, solitary and in radial multiples of 2–3(–4), rarely in clusters, generally oval, average tangential diameter 100–270 μm; perforation plates simple; intervessel pits numerous, alternate, polygonal, c. 6 μm, often with coalescent apertures; vessel-ray and vessel-parenchyma pits half-bordered, c. 6 μm; pronounced reticulate thickenings sometimes present on the inner face of vessel walls; tyloses sparse to rather frequent. Fibres 600–2000 μm long, non-septate, very thin-walled, with rather numerous, minutely bordered pits with vertical slit-like inner apertures, entirely confined to the radial walls. Axial parenchyma winged-aliform to confluent; paratracheal parenchyma rather abundant, on the radial sides of the vessels usually passing into short, sometimes long, tangential bands 1–4 cells wide; parenchyma strands 2–4(–8)-celled. Rays 3–4/mm, 1–8-seriate (mostly 5–6-seriate), uniseriate rays few, 4–60 cells high, almost entirely composed of square or procumbent cells, only 1(–2) rows of marginal cells regularly shorter in radial direction or composed of upright cells in narrow rays. Prismatic crystals rarely present in upright ray parenchyma cells and axial parenchyma cells, usually one large crystal per cell; yellowish-brown deposits sometimes present in axial and ray parenchyma cells. Axial intercellular canals of the traumatic type present in long tangential bands, 160 μm in average diameter.

Species studied: *A. integrifolia*, *A. triphysa*.

Growth and development *A. integrifolia* is a fast-growing tree. In Java, the mean height of planted *A. integrifolia* was 1.8 m 2 years after planting and 4.0 m 3 years after planting, and the corresponding mean diameters were 2.9 cm and 5.3 cm, respectively. In India, 10- and 50-year-old trees of *A. integrifolia* were 5 m and 39 m high, respectively, and their corresponding diameters at breast height were 18 cm and 60 cm, respectively. Pollination is probably by insects. The fruits are dispersed by wind. Natural regeneration of planted trees of *A. integrifolia* has been observed after only four years, but annual seed production varies greatly and seems unpredictable. Early flowering and early profuse production of seed is reported for *A. triphysa* too, although there are reports from India that every other year is a good seed year.

Other botanical information The genus *Ai*-

lanthus belongs to the subfamily *Simarouboideae*, which is by far the largest subfamily within the family; it is the only genus of importance concerning timber within this subfamily in New Guinea.

A. altissima (Miller) Swingle (synonym: *A. glandulosa* Desf.), a native of China known as 'tree of heaven', is widely planted as an ornamental and for shade, in shelterbelts and for erosion control in subtropical and temperate countries. The wood is ring-porous and is heavier (up to 650 kg/m^3 at 12% moisture content) and more durable than white siris; it is especially used for furniture and utensils. The wood of *A. excelsa* Roxb. is used locally in India and Sri Lanka.

Ecology White siris occurs in humid rain forest and in monsoon forest, and in Bengal (India) even in dry mixed forest. The individual species are fairly uncommon and occur scattered, but never gregariously, in valleys, along streams and in open locations below 1000 m altitude. The observed variation in mean annual rainfall is large and ranges from 1600 mm to 4560 mm. White siris is most often found on well-drained deep soils like fertile sandy loams, and usually in association with *Duabanga, Chukrasia, Erythrina, Garuga, Gmelina, Terminalia* and *Tetrameles*.

Propagation and planting *A. integrifolia* is propagated by seed; it has about 1800 wingless seeds per kg and germination of fresh seed is about 60% but varies greatly. No pretreatment is required. Germination starts 3–6 weeks after sowing. Seeds of *A. triphysa* remain viable for three months and germination takes place within 1–3 weeks; up to 100% germination has been observed. Seeds are broadcast and need only sparse watering, as they are susceptible to rot and damping-off. Seedlings of *A. triphysa* develop better when provided with partial shade, although the species is light demanding. When 8–10(–30) cm tall they are planted in fertile, well-drained sites at spacings of 1–2 m × 1–2 m. Seedlings are susceptible to damage by transplanting; the root system is especially vulnerable. In Papua New Guinea there are no plantations of white siris and it is harvested only from natural forest.

Silviculture and management In Java, a stand of *A. integrifolia* planted at 1 m × 3 m was thinned three years after planting. Natural pruning of this species stimulates the development of a long (up to 35 m in Papua New Guinea) branchless bole. Natural regeneration is poor in the shade of the natural forest, but is reasonably successful in open weed-free locations where mineral soil is exposed. The establishment of a plantation of *A. integrifolia* may benefit from a taungya system, in which a low annual crop, such as chili or eggplant, may be planted the first year.

Diseases and pests No serious diseases and pests have been reported for white siris, although *A. triphysa* seedlings are liable to attack by a fungus and a defoliator.

Harvesting On suitable sites, *A. integrifolia* may be harvested at the age of 35–40 years.

Yield White siris is considered to grow very fast. The mean annual increment in the first ten years of a plantation of *A. integrifolia* in Java was 15 m^3/ha, and on favourable sites in India even 20 m^3/ha. *A. integrifolia* tree yields about 8.5 m^3 of timber.

Handling after harvest The wood should be sawn as soon as possible after harvest as it is susceptible to blue stain (*Ceratocystis* sp.).

Genetic resources In India *A. integrifolia* has been taken up in a germplasm bank.

Prospects White siris grows very fast and shows several desirable characters in habit and behaviour (long straight bole, restricted crown, natural pruning etc.). It may, therefore, become more important for wood production in plantations. In Papua New Guinea it is classified as a minor hardwood, but with plantation potential. However, further studies on mechanisms controlling seed output are needed as a basis for further development.

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Selection of species

Ailanthus integrifolia Lamk

Dict. 3(2): 417 (1792).

Synonyms *Ailanthus moluccana* DC. (1825), *Ailanthus blancoi* Merr. (1918), *Ailanthus peekelii* Melch. (1930).

Vernacular names Indonesia: ai lanit (Moluccas), kayu ruris (Minahassa), pohon langit (Ambon). Philippines: malasapsap (general), balokas, makaisa (Tagalog).

Distribution Western India (Assam), southern Vietnam, throughout Malesia (except for the Lesser Sunda Islands) towards the Bismarck Archipelago and the Solomon Islands.

Uses The wood is used as white siris; it is also used for local house building and furniture manufacture.

Observations A large tree up to 60 m tall, bole branchless for up to 35 m, up to 85(–175) cm in diameter, bark surface smooth or irregularly fissured, pale brown or greyish; leaves with 2–9 entire leaflets 10–40 cm long, lower surface sometimes pubescent and with a few large black glands; petals puberulous, carpels 5; fruit 11–22 cm long. *A. integrifolia* is divided into two subspecies: subsp. *integrifolia* and subsp. *calycina* (Pierre) Nooteboom. The former has up to 15 mm long pedicels and 6–10 mm long petals and occurs in primary rain forest up to 900 m altitude throughout Malesia except for Java and the Lesser Sunda Islands and on the Bismarck Archipelago and the Solomon Islands. The latter has pedicels up to 5 mm long and petals c. 4 mm long and occurs in mixed seasonal primary forest in western India, southern Vietnam and Java. The density of the wood is 330–390 kg/m^3 at 12% moisture content. See also the table on wood properties.

Ailanthus integrifolia Lamk – 1, flowering twig; 2, male flower; 3, fruit.

Selected sources 12, 53, 60, 145, 162, 227, 228, 233, 426, 527, 705, 731.

Ailanthus triphysa (Dennst.) Alston

Handb. Fl. Ceylon 4, Suppl.: 41 (1931).

Synonyms *Ailanthus malabarica* DC. (1825), *Ailanthus imberbiflora* F. v. Mueller (1862), *Ailanthus philippinensis* Merr. (1906).

Vernacular names Indonesia: kayu langit (general), ki pahit, selangke (Java), kirontasi (Sulawesi). Philippines: malakamias (general), kalauag (Bikol). Burma (Myanmar): o-dein. Thailand: makkom (Chiang Mai), mayom-pa (central), mayom-hom (south-eastern). Vietnam: b[us]t, c[af]ng hom th[ow]m.

Distribution India, Sri Lanka, Burma (Myanmar), Indo-China, southern China, Thailand, Peninsular Malaysia, Java, Borneo (Sabah, East

Kalimantan), Sulawesi, the Philippines, and northern Australia (Queensland and northern New South Wales). It is planted in the arid zones of Africa.

Uses The wood is used as white siris. The resin is used medicinally in India and as incense in India and Indo-China. The bark and leaves are renowned as a tonic, especially in debility after childbirth, possess febrifuge properties and are useful in dyspeptic complaints. In Vietnam, the leaves are used to dye silk black.

Observations A large tree up to 45 m tall, bole up to 75(–150) cm in diameter, bark surface greenish-brown with grey patches, dippled; leaves with 6–17(–30) entire leaflets of (5–)9–15(–26) cm long, covered with velvety hairs below and with many glands scattered over the lower surface; petals glabrous, carpels (2–)3(–4); fruit 4.5–8 cm long. *A. triphysa* is comparatively rare and occurs in evergreen and seasonal forests up to 600 m altitude. The density of the wood is about 435 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 162, 233, 297, 426, 521, 527, 574, 575, 648, 705.

E. Boer (general part),
M.S.M. Sosef (general part, selection of species),
W.C. Wong (properties),
R.H.M.J. Lemmens (properties),
R.W. den Outer (wood anatomy)

Artocarpus J.R. Forster & J.G. Forster

Charact. gen. pl.: t. 51 (1775).
MORACEAE
$x = 14$; *Artocarpus altilis*: $2n = 27, 28, 54, 56$, *A. chaplasha, A. gomezianus*: $2n = 28$, *A. heterophyllus*: $n = 28$, $2n = 28, 56$, *A. lakoocha*: $n = 28$, $2n = 28, 56$

Trade groups

- Terap: lightweight hardwood, e.g. *Artocarpus elasticus* Reinw. ex Blume, *A. scortechinii* King. Timber of *Parartocarpus* spp. and *Antiaris toxicaria* (Pers.) Lesch. is also traded as terap; it is similar in properties and uses.
- Keledang: medium-weight hardwood, e.g. *A. anisophyllus* Miq., *A. dadah* Miq., *A. lanceifolius* Roxb.

Vernacular names

- Terap. Indonesia: teureup (sundanese). Malaysia: pudau (Sarawak). Philippines: antipolo. Thailand: ka-ok.
- Keledang. Indonesia: selangking, tambang, basang. Malaysia: selangking (Sarawak), beruni (Sabah). Papua New Guinea: kapiak (general), hang, ham (Wewak). Philippines: anubing. Laos: 'hat, mi^2, 'hat mi^2. Thailand: khanun, hat, mahat (general).

Origin and geographic distribution *Artocarpus* consists of about 50 species and is distributed from Sri Lanka, India, Pakistan and Indo-China towards the Malesian archipelago and the Solomon Islands. The greatest diversity is in the western Malesian area. The species are distributed as follows within Malesia: Peninsular Malaysia 16 species, Sumatra 17, Borneo 23, the Philippines 15, Sulawesi 6, Java 4, the Lesser Sunda Islands 3, the Moluccas 8 and New Guinea 6. Two well-known fruit tree species (breadfruit and jackfruit) are cultivated throughout the tropics.

Uses Terap is used for light construction, boxes and crates, wooden pallets and veneer (especially for core layers in plywood). The wood is sometimes nicely figured and suitable for decorative purposes, e.g. for furniture, joinery and panelling.

Keledang timber is used for light construction or, when under cover, for construction, house and bridge building, beams, poles, flooring, furniture, joinery, cabinet work, household utensils, musical instruments, telegraph poles, wharves, large canoes, boat building, tool handles, turnery, veneer and plywood. It is the favoured timber for expensive hewn coffins in the Chinese community in Malaysia.

The roots of older *A. heterophyllus* Lamk trees are highly prized for carving and picture framing.

Many species of *Artocarpus* are very important fruit producing trees, of which breadfruit (*Artocarpus altilis* (Parkinson) Fosberg), jackfruit (*A. heterophyllus*), chempedak (*A. integer* (Thunb.) Merr.) and marang (*A. odoratissimus* Blanco) are the most important; their wood is sometimes used. Apart from the fruits, which may be prepared in different ways, seeds are roasted and eaten. Some species yield a yellow dye and the bark of *A. heterophyllus* yields tannin. The bark of other species yields fibres, used for example, to manufacture cloth and rope. The latex, bark, leaves and roots of some species have medicinal properties and latex may be used for the production of birdlime, as a substitute for milk in sauces, as cooking oil, to mix with wax for batik manufacture or to mix with turpentine and paint. The bark and roots of a few species may be chewed with betel (*Areca catechu* L.). In Papua New Guinea, the leaves of *Artocarpus* are used traditionally to scour dirty pots and plates. The leaves of *A. lakoocha* Roxb. are used as fodder in Nepal and India. Some species are used for reforestation.

Production and international trade Only comparatively small amounts of terap and keledang timber are traded internationally. The export of terap from Sabah in 1992 was about 9000 m^3, mainly as logs, with a total value of US$ 630 000. Small amounts of terap and keledang are imported to Japan, mainly from Sarawak and Papua New Guinea.

Properties Terap and keledang are not well separated and show much overlap. The arbitrary limit is at a density of 640 kg/m^3 at 15% moisture content and the heartwood of keledang is moreover darker and more clearly defined from the sapwood than terap.

Terap is a lightweight hardwood. The heartwood is yellow to pale yellow-brown and usually indistinctly demarcated from the paler sapwood. The density is (310–)365–640(–780) kg/m^3 at 15% moisture content. The grain is interlocked, texture coarse but even.

At 15% moisture content, the modulus of rupture is 36–68 N/mm^2, modulus of elasticity 7410–12 000 N/mm^2, compression parallel to grain 27–35 N/mm^2, compression perpendicular to grain 3 N/mm^2, shear 5–9 N/mm^2, cleavage 32 N/mm radial and 36 N/mm tangential, Janka side hardness 2070–2650 N and Janka end hardness 3760 N.

The rates of shrinkage are fairly high: from green to 15% moisture content 1.5–2.0% radial and 2.9–4.4% tangential, from green to oven dry 3.2% radial and 7.7% tangential. Terap seasons rapidly to fairly slowly with moderate to slight tendency to bow, cup and check. It takes 1–3 months to dry 15 mm thick boards to air-dry condition, and 2.5–4 months for 40 mm thick boards.

Terap is easy to work. It can be sawn, planed, bored and turned easily, but the quality of finish is often rough, especially on radial surfaces due to grain picking up because of the interlocked grain. It can be peeled satisfactorily and is suitable for plywood production, having good gluability.

Terap is classified as non-durable under tropical conditions when exposed to the weather or in contact with the ground (with a service life of 1–1.5 years). The sapwood absorbs preservatives easily, but the heartwood is moderately difficult to treat, with an absorption of about 75 kg/m^3 of creosote using an open tank treatment. A retention of 12.5 kg/m^3 has been reported in Indonesia for *A. kemando* wood using CCA preservative.

Terap wood contains 59–71% holocellulose, 41–45% α-cellulose, 22.5–27.5% lignin, 13–14% pentosan and 0.6–1.4% ash. The solubility is 2.5–6.4% in alcohol-benzene, 1.5–6.2% in hot water and 11.6–16.9% in a 1% NaOH solution.

Keledang is a medium-weight hardwood. The heartwood is orange yellowish-brown, sometimes with an olive-green tinge, generally darkening considerably on exposure and usually well defined from the paler sapwood. The density is (420–) 640–875(–945) kg/m^3 at 15% moisture content. The density of the wood of the well-known fruit trees *A. altilis*, *A. heterophyllus*, *A. integer* and *A. odoratissimus* is 505–645 kg/m^3, 420–710 kg/m^3, 545–790 kg/m^3 and 580–780 kg/m^3 respectively at 15% moisture content. The grain is often deeply interlocked, texture moderately coarse and even.

At 15% moisture content, the modulus of rupture is 53–107 N/mm^2, modulus of elasticity 8700–15 500 N/mm^2, compression parallel to grain 45–65 N/mm^2, compression perpendicular to grain 5–10 N/mm^2, shear 9.5–12.5 N/mm^2, cleavage 45 N/mm radial and 47.5 N/mm tangential, Janka side hardness 4865–5830 N and Janka end hardness 5780–7560 N.

The rates of shrinkage of keledang are moderate: from green to 15% moisture content 0.8–1.2% radial and 1.7–2.6% tangential. The timber seasons moderately slowly with slight degrade; boards of 15 mm thick take about 3.5 months to air dry, boards of 40 mm thick about 4.5 months. The recommended kiln schedule in Malaysia is F.

Keledang is often difficult to saw; saw teeth are severely blunted. This is probably partly a result of the presence of tension wood, and sometimes a result of the presence of silica. The wood can be planed to a smooth surface, but there is some picking up on radial surfaces, boring is moderately easy to difficult and turning is easy. The nailing properties are good. Keledang is of less value than terap for the production of plywood because of its higher density.

Keledang is non-durable to moderately durable; the average service life in contact with the ground under tropical conditions varies between the species from 1.2–3.3 years. The wood is generally comparatively resistant to termite attack but it is more susceptible to powder-post beetle attack. Wood of *A. lanceifolius* showed some resistance to marine borers. The heartwood is very difficult to impregnate, absorbing only about 16 kg/m^3 of preservative using an open tank process.

Keledang wood contains 63–71% holocellulose, 40–44% α-cellulose, 16–25% lignin, 13–14% pentosan and 0.3–1.9% ash. The solubility is 4.6–9.6%

in alcohol-benzene, 5.9–13.3% in hot water and 15.6–23.1% in a 1% NaOH solution.

Description Small to fairly large or sometimes large evergreen or deciduous monoecious trees up to 40(–60) m tall, exuding thick white latex from all parts; bole straight and cylindrical or sometimes irregular, branchless for up to 20 m, up to 150(–300) cm in diameter, sometimes buttressed; bark surface brown or grey to dark grey, inner bark pale brown or yellow-brown to red or pink; sapwood pale yellow or straw-coloured. Leaves arranged spirally (subgenus *Artocarpus*) or alternate and distichous (subgenus *Pseudojaca*), simple, entire to pinnatifid or pinnate, pinnately veined, coriaceous, glabrous to pubescent; stipules large, amplexicaul (subgenus *Artocarpus*) or non-amplexicaul (subgenus *Pseudojaca*), often covering the conical bud. Inflorescence a unisexual, cylindrical to globose head, pedunculate, solitary or paired in leaf axils or rami- or cauliflorous; numerous flowers densely packed together, embedded in the receptacle, the perianths enclosing a single ovary or stamen, usually mixed with abundant stalked interfloral bracts; male head with perianths tubular and bilobed or perforate above, to 2–4-partite, stamens short- to long-exserted; female head with tubular perianths, thin-walled below, thick-walled above, with a narrow lumen containing the style, perianths partially or completely fused with one another to form a syncarp, ovary unilocular, style apical to lateral, simple or bifid. Aggregate fruit (syncarp) formed by the enlargement of the entire female head; mature ovary thin-walled to fleshy or horny, or developing an indurated endocarp. Seeds large, without endosperm; embryo straight. Seedling usually with hypogeal germination (semi-hypogeal in e.g. *A. integer*).

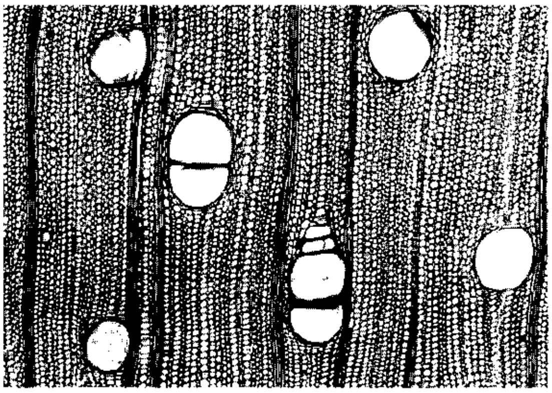
Wood anatomy

– Macroscopic characters:

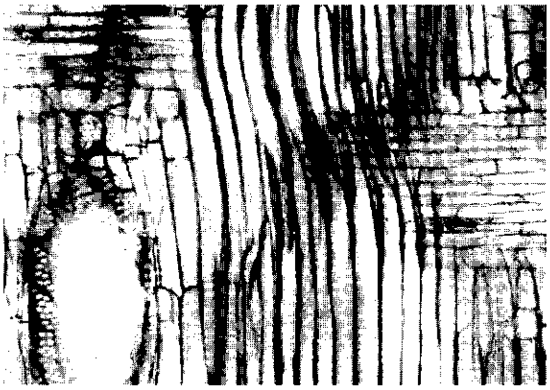
Heartwood yellow to yellowish-brown or golden brown, often turning darker upon exposure, usually distinctly demarcated from the sapwood in keledang but not in terap. Grain interlocked. Texture coarse. Growth rings indistinct, with sporadic short and fine light-coloured bands; yellowish or whitish chalky substance occasionally present in vessels and orange-coloured substance in ray cells and axial parenchyma, often visible with hand lens, yellowish-brown fine streaks sometimes visible with hand lens in rays on the radial surface.

– Microscopic characters:

Growth rings usually indistinct, but when present generally marked by long wings of parenchyma



transverse section (×25)



radial section (×75)

tangential section (×75)

Artocarpus altilis

and smaller pores. Vessels diffuse, usually 3–6(–9)/mm^2, solitary and in radial multiples of 2–3(–4), the percentage of solitary vessels varying from 45–80% even within a sample, 160–370 μm in tangential diameter; perforations simple; intervessel pits alternate, 8–13 μm in diameter; vessel-ray and vessel-parenchyma pits enlarged, round to oval and sometimes elongated, with or without borders; yellowish or whitish chalky substance occasionally present; tyloses often abundant and infrequently sclerotic. Fibres 1.2–2.6 mm long, non-septate, thin- to thick-walled, with fairly distinct but small and comparatively few, simple pits. Parenchyma vasicentric to aliform, usually with longer wings at ring boundaries, and apotracheal, in diffuse and often interrupted fine lines, in strands of 3–4 cells. Rays 3–7/mm, 1–8(–10)-seriate, 240–1000 μm high, heterocellular with one or more rows of upright marginal cells (mostly Kribs type heterogeneous II or III); sheath cells sometimes present but not well developed. Vitreous silica reported in fibres of some species. Latex tubes often present in rays; the occurrence of axial latex tubes has also been reported.

Species studied: *A. altilis*, *A. chaplasha* Roxb., *A. integer*, *A. lanceifolius*, *A. ovatus*, *A. sepicanus*.

Growth and development Early growth is rapid; for *A. elasticus* trees the average height is 6–7 m after 2 years and 11–12 m after 7 years with an average diameter of 15.4 cm, i.e. a mean annual diameter increment of over 2 cm. For *A. heterophyllus* the average height is 3–4 m after 2 years and 10 m after 6 years, whereas the average diameter after 6 years is 12 cm.

Mean annual diameter increment of *Artocarpus* trees (diverse species) over 10 cm in diameter at breast height is only 0.4–1.9 mm in primary forest in Sarawak. In selectively logged forest this value increases to 1.6–5.2 mm during the first 4 years after logging. Removal of relicts and further liberation thinning yields figures of up to 10.5 mm. For *A. scortechinii* in natural forest in Peninsular Malaysia a mean annual diameter increment of 1.2–1.6 cm has been recorded and for *A. ovatus* in natural forest on Mount Maquiling (Luzon) 1.8 cm for the diameter class 10–20 cm, which is very high for trees in natural forest.

Species restricted to the monsoon climate may be evergreen or deciduous. *A. heterophyllus* and *A. altilis* demonstrate the architectural growth model of Rauh determined by a monopodial trunk which grows rhythmically and so develops tiers of branches with flowers developing laterally. *A. sepicanus* represents the model of Roux characterized by a monopodial orthotropic trunk which shows continuous growth and with plagiotropic branches. *A. integer* also grows continuously and it is probably also a representative of Roux's model.

Annual flowering and fruiting of *Artocarpus* has been reported and flowering and fruiting may be more or less continuous for the major fruit-producing species, but it may be quite variable per region and per year. During 7 years of observations in Sarawak, *A. kemando* did not flower at all, *A. anisophyllus* flowered in one year only, *A. odoratissimus* in 3 years and *A. integer* in 4 years. For *A. heterophyllus* in India it is reported that alternate years have heavy bearing of fruits. Pollination is variable, by small flies and beetles attracted by the sweet scent, but is in other species probably by wind, given that the male flowers are scentless and give off clouds of pollen. Pollination by bats is very likely and may play an important role, as over 25% of guano samples from one bat species (*Eonycteris spelaea*) in Peninsular Malaysia contained pollen of *Artocarpus* species. Fruit dispersal is by arboreal mammals and fruit bats, but some of the smaller fruits may be eaten by birds. Fruits borne on the tree trunk may be eaten by herbivores such as elephants, or pigs.

Other botanical information *Artocarpus* is most closely related to the genus *Prainea* and is divided into 2 subgenera, subgenus *Artocarpus* and subgenus *Pseudojaca* Trécul, on the basis of whether the leaves are spirally arranged or distichous and whether or not the stipules are amplexicaul.

A. chaplasha and *A. lakoocha* are fairly well-known timber trees in India and Indo-China.

Ecology The species of *Artocarpus* are generally restricted to evergreen forest of the humid tropics or occur in areas with a comparatively mild monsoon climate. They occur commonly as scattered elements of lowland mixed dipterocarp forest and are usually found below 1000 m altitude, but some occur up to 1700 m. The only exception to the scattered occurrence is *A. altilis*, which acts as a dominant member of riverine swamp forests of New Guinea. Most of the species prefer a clayey soil.

Propagation and planting Seed weight for some species is as follows: for *A. elasticus* 1200–1900 seeds/kg and for *A. heterophyllus* about 430 seeds/kg. Generally, fresh seeds germinate easily: about 85% for *A. altilis*, 70% for *A. anisophyllus*, 90% for *A. heterophyllus*, 95% for *A. integer*, 40–70% for *A. lanceifolius*, 80–98% for *A. nitidus*, almost 100% for *A. odoratissimus* and 85–95% for

A. rigidus. Seeds are usually rated as recalcitrant and lose their viability very rapidly; *A. elasticus* seeds germinate readily (85%) when sown fresh, but germination decreases to 60% for seeds stored for 1 week and to 0% for seeds stored for 2 weeks. Seeds remain viable when kept inside the fruit, thus storage may be slightly prolonged. Seeds of *A. heterophyllus* can be stored in a moist condition for one month with final viability of 80%. Heavier seeds remain viable for a longer period.

Germination usually starts 9–40(–60) days after sowing. It starts after 2–4 weeks for *A. anisophyllus*, 6–9 weeks for *A. gomezianus*, 3–8 weeks for *A. lanceifolius* and about 5 weeks for *A. lowii*.

It has been reported that to promote germination the seeds of *A. heterophyllus* are heaped and covered with straw. Seedlings should be raised under shade, at 50–70% of full light intensity. *A. heterophyllus* seedlings soon develop a long taproot, which makes transplanting difficult as disturbance of the roots may be fatal. Transplanting of seedlings with adhering soil is advisable. Root suckers produced by *A. altilis* can be used for air layering, whereas taking root cuttings is the more common method of propagation. Excised embryos of *A. heterophyllus* can be kept viable for 4 years in liquid nitrogen (cryopreservation), with a recovery percentage of 60%.

Spacings in trial plantations in Java ranged from 1 m × 1 m to 1 m × 3 m. The denser spacing improved the form of the stem.

A. altilis, *A. hirsutus* Lamk, *A. integer*, *A. rigidus* and *A. sericicarpus* serve as rootstock for air layering, budding and grafting of other major fruit-producing species of *Artocarpus*.

Silviculture and management *Artocarpus* requires good soil conditions and can grow rather fast. Partial shade should be provided until the plants are well established (e.g. for *A. altilis*). In mixed plantations of *Artocarpus* (e.g. *A. heterophyllus*), the formation of heavy branches is considerably reduced by partial shading and close spacing (1 m × 1 m). In plantations *Artocarpus* soon forms a closed canopy. Natural pruning is satisfactory, as *Artocarpus* species are characterized by dense crowns, which also greatly reduces the development of weeds in a plantation. The large amount of litter, which easily decomposes, also reduces weed development. Thinning should be done carefully and only when trees have developed a stem branchless for some length (e.g. 8 m). The mortality of different *Artocarpus* species over 10 cm diameter in Sarawak was much higher (5–8%) in logged than in undisturbed forest (less than 3%). Trees should not be pruned, as the wounds may cause wood rot and woodboring insects attack the pruned trees. Excellent coppicing is reported from India for *A. heterophyllus* and *A. hirsutus*.

Diseases and pests In *A. heterophyllus* a serious attack of the fungus *Corticium salmonicolor* has been observed causing branches and sometimes trees to die. Brown root rot, *Phellinus lamaoensis*, may develop on stumps of latex-containing species such as *Ficus* spp. and *Artocarpus* spp., which may restrict future use of the terrain. However, this fungus is presently believed to be entirely saprophytic. The larva of the moth *Glyphodes caesalis* bores into tender shoots, flower buds and young fruits of *A. heterophyllus* and *A. rigidus* and also feeds on the leaves. *Erwinia carotovora* causes serious bacterial dieback in *A. integer* and may eventually kill the tree.

Yield The formation of heartwood starts only at a late stage: an *A. elasticus* tree of 40 cm diameter and 17 years old had just started to form heartwood. In a 15-year-old tree of *A. heterophyllus*, 5–6 cm of sapwood was found.

The mean annual increment of *A. elasticus* is 20 m^3/ha at an age of 17.5 years. For *A. heterophyllus* the total yield of bole timber is 75 m^3/ha at an age of 15.5 years.

Genetic resources South-East Asia is the main centre of distribution of cultivated *Artocarpus* fruit trees. Germplasm collections of the main cultivated fruit-producing *Artocarpus* species are found in several countries inside and outside the region. However, concerning wood characteristics and production no selection has been done nor germplasm collections established.

Prospects Several *Artocarpus* species are potentially economically important for use in timber plantations; they are fast-growing and the wood can be used for various purposes.

The use of *Artocarpus* species as rootstocks to adapt the major fruit-producing species to specific conditions deserves consideration.

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Selection of species

Artocarpus altissimus (Miq.) J.J. Smith

Icon. Bogor. 3: 79, t. 233 (1907).

Vernacular names Indonesia: lempato, kelutum, kelutum ketan (Sumatra).

Distribution Sumatra and West Kalimantan.

Uses The timber has been used as terap or keledang for large canoes, house and bridge building and wharves.

Observations A medium-sized deciduous tree up to 30 m tall, bole straight, branchless for up to 20 m, up to 300 cm in diameter, with prominent buttresses; leaves ovate to ovate-oblong or obovate-oblong, base shallowly cordate, with a glandular-crenate margin, puberulent above, sparsely pubescent on the veins below, with 5–9 pairs of secondary veins, stipules amplexicaul; male head ellipsoid or cylindrical, 2–3 mm across, on a 5–7 mm long peduncle; styles in female head deeply bifid; syncarp unknown. *A. altissimus* occurs in evergreen forest up to 550 m altitude. The wood is reported to be resistant to teredos. The density of the wood is 370–490 kg/m^3 at 15% moisture content.

Selected sources 234, 263, 474, 577.

Artocarpus anisophyllus Miq.

Fl. Ind. Bat., Suppl.: 422 (1861).

Synonyms *Artocarpus klidang* Boerl. (1900), *Artocarpus superbus* Becc. (1902).

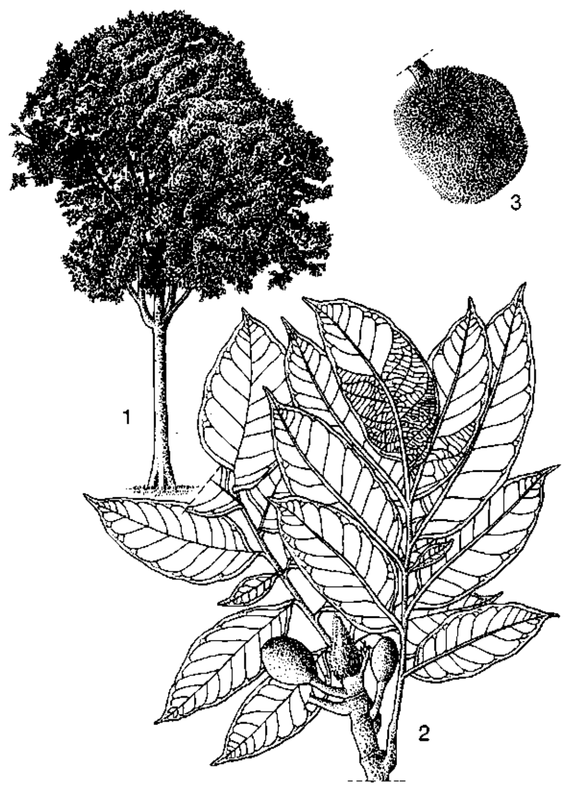
Vernacular names Brunei: tarapikal. Indonesia: bakil (Sumatra, Kalimantan), mentawa, pupuan (Kalimantan). Malaysia: keledang babi (Peninsular), bintawak (Sarawak).

Distribution Peninsular Malaysia, Sumatra, Borneo and intervening islands.

Uses *A. anisophyllus* is an important source of keledang timber in Borneo and is used for e.g. tool handles. The fruits are reported to be edible.

Observations A medium-sized to large evergreen tree up to 45 m tall, bole up to 60 cm in diameter, with buttresses up to 2.5 m high; leaves imparipinnate with 5–12 pairs of oblong to ovate-lanceolate leaflets, these with a rounded base, glabrous, with 7–20 pairs of secondary veins, stipules amplexicaul; male head ellipsoid-oblong, 15–20 mm across, on a 50–65 mm long peduncle; styles in female head simple; syncarp subglobose, c. 8 cm across, with cylindrical, rigid, shallowly fluted, minutely punctate processes, glabrous. *A. anisophyllus* occurs scattered in evergreen forest up to 1200 m altitude. The density of the wood is 560–920 kg/^{3} at 15% moisture content.

Selected sources 69, 77, 234, 262, 465, 474, 595, 705, 734.



Artocarpus anisophyllus Miq. – 1, tree habit; 2, flowering twig; 3, fruit (syncarp).

Artocarpus blancoi (Elmer) Merr.

Enum. Philipp. fl. pl. 2: 40 (1923).

Synonyms *Artocarpus communis* J.R. Forster & J.G. Forster var. *blancoi* Elmer (1909).

Vernacular names Philippines: antipolo, tipolo (general).

Distribution Throughout the Philippines.

Uses The wood is locally used as terap for light construction. Probably more important is the use as a fibre plant for the production of pulp and paper. An extract of the bark has high antimicrobial activity.

Observations A medium-sized evergreen tree up to 30 m tall, bole up to 100 cm in diameter; leaves entire or pinnatifid with 1–3(–4) pairs of lateral lobes, base cuneate to rounded, almost glabrous above, pubescent throughout below, with c. 12 pairs of secondary veins, stipules amplexicaul; male head cylindrical, 12–20 mm across, on a 17–37 mm long peduncle; styles in female head bifid; syncarp ellipsoid, 6.5 cm across, with flexuous, tapering and obtuse processes, hirsute. *A. blancoi* occurs in lowland forest and thickets, in areas with a distinct dry season and an annual rainfall of 2000 mm or more.

Selected sources 52, 175, 262, 544, 634.

Artocarpus dadah Miq.

Fl. Ind. Bat., Suppl.: 420 (1861).

Synonyms *Artocarpus rufescens* Miq. (1861), *Artocarpus tampang* Miq. (1861), *Artocarpus inconstantissimus* (Miq.) Miq. (1867).

Vernacular names Indonesia: dadah (general), tampang dadak, tampang telor (Sumatra). Malaysia: tampang, chempedak ayer (Peninsular), merubi (Sarawak). Burma (Myanmar): ta-mal. Thailand: thangkhan (Yala), hat-rum, hat-lukyai (Trang).

Distribution Peninsular Burma (Myanmar), Thailand, Peninsular Malaysia, Sumatra and Borneo.

Uses *A. dadah* is a fairly important source of keledang timber; the wood is used especially for poles, bridges and flooring. The latex is reported to have purifying properties when applied to wounds. The fruit is edible but sour.

Observations A medium-sized to fairly large deciduous tree up to 35 m tall, bole up to 100 cm in diameter; leaves obovate-oblong to ovate-elliptical, base rounded, entire, the veins puberulent above, densely to sparsely pubescent below, with 10–20 pairs of secondary veins, stipules not amplexicaul; male head globose or pulvinate, 8–15 mm across; styles in female head simple; syncarp subglobose, to c. 5 cm across, with an almost smooth surface, velutinous. *A. dadah* occurs in evergreen and deciduous forest but also in open country, up to 1000 m altitude. The wood is reported to be durable, resistant to insect attack and to alternating wet and dry conditions. The density is 650–880 kg/m^3 at 15% moisture content.

Selected sources 69, 77, 104, 234, 263, 474, 574, 705, 734.

Artocarpus elasticus Reinw. ex Blume

Bijdr. fl. Ned. Ind.: 481 (1825).

Synonyms *Artocarpus blumei* Trécul (1847), *Artocarpus kunstleri* King (1888).

Vernacular names Indonesia: benda (Javanese, Java), teureup (Sundanese, Java), mengko (Sumatra). Malaysia: terap nasi (Peninsular), terap (Sarawak). Thailand: oh, ka-oh, tuka (peninsular).

Distribution Peninsular Burma (Myanmar), peninsular Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, Palawan and the Lesser Sunda Islands.

Uses The timber is used as terap for light construction. The seeds are eaten roasted or fried. The latex is used for birdlime and aboriginal tribes prepare cloth and rope from the bark. The fruit is edible but often has a bad taste and smell.

Observations A medium-sized evergreen tree rarely reaching 45(–65) m tall, bole branchless for up to 30 m, up to 125(–210) cm in diameter, buttresses up to 3 m high; leaves ovate-elliptical, base rounded or cuneate, very shortly appressed hispid above, subappressed hispid below, with 12–14 pairs of secondary veins, stipules amplexicaul; male head cylindrical, 15–25 mm across, on a 40–75 mm long peduncle; styles in female head bifid; syncarp cylindrical, up to 5.5 cm across, with fleshy, shortly hispid processes of 2 lengths, the longer flexuous and solid, the shorter conical and perforate. *A. elasticus* occurs in evergreen and semi-deciduous forest, both primary and secondary, up to 300(–1500) m altitude. The wood is reported to be non-durable and has a density of 365–545 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 68, 69, 77, 78, 104, 234, 235, 261, 262, 294, 331, 458, 465, 474, 507, 526, 574, 577, 631, 684, 705.

Artocarpus fretessii Teijsm. & Binnend.

Hassk., Abh. Naturf. Ges. Halle 9: 189 (1866).

Synonyms *Artocarpus dasyphyllus* Miq. (1867), *Artocarpus paloensis* Elmer (1908), *Artocarpus leytensis* Elmer (1909).

Vernacular names Indonesia: kelembi, maumbi (Sulawesi), cempedak utan (Ambon). Philippines: bayuko (Bikol).

Distribution Eastern Borneo, the Philippines, Sulawesi, the Moluccas and Irian Jaya.

Uses The wood is locally used as terap or keledang, e.g. for bridges and light construction. The fresh bark is reported to have weak contracting properties. The latex tastes like coconut milk.

Observations A fairly large evergreen tree up to 40 m tall, bole sometimes with small buttresses; leaves obovate-oblong to elliptical, base broadly cuneate to shallowly cordate, veins pubescent above, moderately to sparsely pubescent below, with 9–13 pairs of secondary veins, stipules non-amplexicaul; male head subglobose or obovoid, 3–7 mm across, on a 3–7 mm long peduncle; styles in female head simple; syncarp with 1 to several lobes, up to 4 cm across, papillate between the lobes, smooth elsewhere, puberulent. *A. fretessii* is locally common in forest up to 600 m altitude. The density of the wood is about 640 kg/m^3 at 15% moisture content.

Selected sources 234, 263, 544, 577.

Artocarpus fulvicortex Jarrett

Journ. Arn. Arb. 41: 116 (1960).

Vernacular names Malaysia: tampang, tampang gajah (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Bangka.

Uses The wood is reputed to be used as terap or keledang.

Observations A medium-sized to fairly large deciduous tree up to 35 m tall, bole up to 75 cm in diameter, buttresses up to 2 m high, bark orange-brown or reddish-brown; leaves broadly ovate to rounded, base cuneate to rounded and unequal, glabrous above, densely hairy below, with 6–10 pairs of secondary veins, stipules non-amplexicaul; male head globose to obovoid, 4–6 mm across, almost sessile; styles in female head simple; syncarp rounded, 5–7 cm across, smooth, velvety. *A. fulvicortex* is uncommon in lowland forest up to 75 m altitude.

Selected sources 104, 235, 263, 474, 705.

Artocarpus glaucus Blume

Bijdr. fl. Ned. Ind.: 483 (1825).

Synonyms *Artocarpus glaucescens* Trécul (1847), *Artocarpus zollingerianus* Miq. (1847), *Artocarpus denisonianus* King (1888).

Vernacular names Indonesia: tiwu landu (Sundanese, Java), sembir (Java), tampang buwah (Palembang, Sumatra). Malaysia: nangka pipit (Peninsular), pudau paya (Sarawak).

Distribution Peninsular Malaysia, Sumatra, Borneo, Java and the Lesser Sunda Islands.

Uses The wood is used as terap or keledang, e.g. for house building.

Observations A fairly large evergreen tree up to 40 m tall, bole up to 115 cm in diameter, buttresses prominent or absent; leaves ovate to obovate, base cuneate to rounded, glabrous above, venation appressed puberulent below, with 8–15 pairs of secondary veins, stipules non-amplexicaul; male head narrowly oblong or clavate, 5–6 mm across, on a 1–3 mm long peduncle; styles in female head simple; syncarp subglobose, often shallowly lobed, up to 3 cm across, nearly smooth to papillate, shortly pubescent. *A. glaucus* is generally uncommon and occurs in evergreen lowland and hill forest, sometimes along rivers or in peat swamps, up to 750(–1200) m altitude. The density of the wood is 610–950 kg/m^3 at 15% moisture content.

Selected sources 69, 234, 235, 263, 474, 705.

Artocarpus gomezianus Wallich ex Trécul

Ann. Sci. Nat. Bot. III, 8: 118 (1847).

Synonyms *Artocarpus petiolaris* Miq. (1861), *Artocarpus pomiformis* Teijsm. & Binnend. (1863), *Artocarpus masticatus* Gagnep. (1926).

Vernacular names Indonesia: gajaman, sampang (Sumatra), penangkaan (Java). Malaysia: tampang hitam, tampang besi, medang sampang (Peninsular). Philippines: bagli (Sulu). Thailand: ta pang, tam-pang (peninsular), hat nun (northern).

Distribution From Burma (Myanmar) and Thailand through Indo-China towards Peninsular Malaysia, Sumatra, Java and the Philippines (Sulu).

Uses The wood is used as keledang. The fruit is recorded as edible and the roots are chewed with betel.

Observations A large evergreen tree up to 42 m tall, bole up to 65 cm in diameter, buttresses absent; leaves oblong to elliptical, base cuneate to subcordate, glabrous, with 10–15(–20) pairs of secondary veins, stipules non-amplexicaul; male head obovoid to subglobose, 10–25 mm across, on a 7–17 mm long peduncle; styles in female head simple; syncarp subglobose, up to 8 cm across, smooth, velutinous. *A. gomezianus* is divided into

2 subspecies; within the Malesian region only subspecies *gomezianus* occurs. It is uncommon and occurs in evergreen and semi-evergreen forest up to 600(–1000) m altitude. The wood is fairly durable and dark brown.

Selected sources 78, 234, 235, 263, 458, 474, 544, 574, 705.

Artocarpus horridus Jarrett

Journ. Arn. Arb. 40: 306 (1959).

Synonyms *Artocarpus communis* J.R. Forster & J.G. Forster var. *pungens* J.J. Smith ex K. Heyne (1927).

Vernacular names Indonesia: dinga, pongo (Moluccas).

Distribution The Moluccas (Halmahera group).

Uses The wood is reputed to be used as terap or keledang. The roots have been used as a styptic. The latex is used for birdlime and the seeds are sometimes roasted and eaten but regarded as inferior to those of other species.

Observations A fairly large evergreen tree up to 35(–40) m tall, bole up to 65 cm in diameter, with prominent buttresses; leaves ovate-elliptical, base rounded to cuneate, sparsely appressed puberulent above, veins below appressed puberulent, stipules non-amplexicaul; inflorescences arising from older branches and the trunk, male head cylindrical, 15–23 mm across, on a 20–35(–50) mm long peduncle; styles in female head bifid; syncarp cylindrical to subellipsoid, 3(–4.5) cm across, with solid, cylindrical, blunt processes, glabrous to sparsely hairy. *A. horridus* occurs in evergreen forest up to 350 m altitude.

Selected sources 234, 262.

Artocarpus kemando Miq.

Fl. Ind. Bat., Suppl.: 418 (1861).

Synonyms *Artocarpus brunneifolius* S. Moore (1925).

Vernacular names Indonesia: antarodan (Batak, Sumatra), puduk pereti (West Kalimantan), temedak ayer (Bangka). Malaysia: pudu, kudu, chempedak ayer (Peninsular), pudau (Sarawak).

Distribution Peninsular Malaysia, Sumatra, Borneo and intervening islands.

Uses The wood is locally used as terap or keledang, especially for household utensils and door frames. Limited amounts of the milky latex can be used as a substitute for milk in cold sauces. It tastes like coconut milk. When reduced by evaporation the latex has been mixed with wax and used for the manufacture of candles or used pure as birdlime. The fruits are edible.

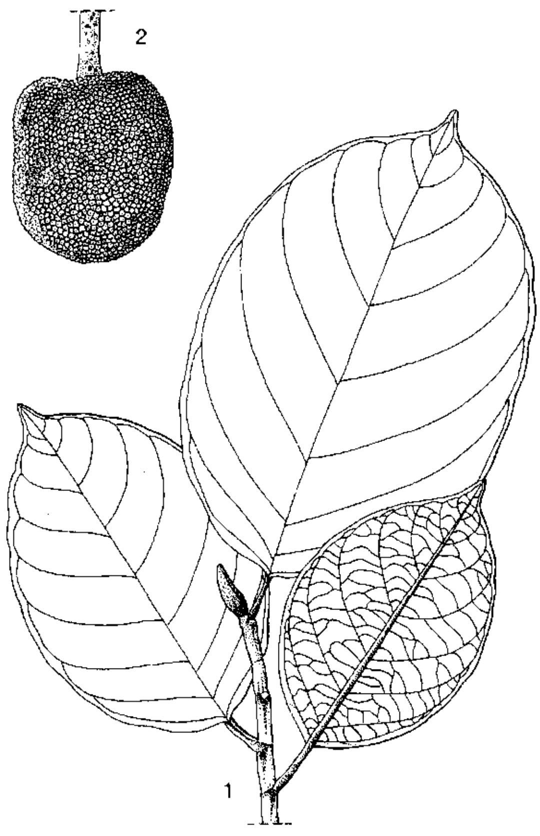
Observations A fairly large evergreen tree up to 40 m tall, bole up to 75 cm in diameter, with buttresses up to 2.5 m high; leaves elliptical to elliptical-oblong, base rounded to cuneate, glabrous above, main veins below appressed pubescent, stipules amplexicaul; male head cylindrical, 3–5 mm across, on a 7–13 mm long peduncle; styles in female head simple; syncarp ellipsoid, up to 2.5 cm across, nearly smooth or with low, umbonate processes, shortly pubescent. *A. kemando* occurs in evergreen forest, often in swampy localities, up to 150(–450) m altitude. The density of the wood is 320–700 kg/m^3 at 15% moisture content.

Selected sources 69, 77, 78, 104, 234, 262, 401, 474, 577, 705.

Artocarpus lanceifolius Roxb.

Fl. Ind. 3: 527 (1832).

Vernacular names Indonesia: keledang (Malay, Sumatra, Kalimantan), simar naka (Batak, Sumatra), bangsal (Dayak, Kalimantan). Malay-



Artocarpus lanceifolius Roxb. – 1, twig with leaves; 2, fruit (syncarp).

sia: keledang (Peninsular). Thailand: khanun-pa.

Distribution Thailand, Peninsular Malaysia, Sumatra, Bangka, the Riau and Lingga Archipelago and north-eastern Borneo.

Uses *A. lanceifolius* is an important source of keledang timber; the wood is used for e.g. heavy construction, furniture, boat building, household utensils and coffins. It yields a dye and the fruit is edible.

Observations A medium-sized to fairly large evergreen tree up to 36 m tall, bole straight, branchless for up to 25 m, up to 85 cm in diameter, with short buttresses; leaves ovate-lanceolate to ovate or obovate, base cuneate, glabrous, with 9–14 pairs of secondary veins, stipules amplexicaul; male head ellipsoid to cylindrical, 12–18 mm across, on a 25–70 mm long peduncle; styles in female head bifid; syncarp subglobose, up to 7(–12) cm across, tessellated from cylindrical, truncate processes, appressed pubescent. Two subspecies are recognized: subsp. *lanceifolius* and subsp. *clementis* (Merr.) Jarrett, the latter endemic to north-eastern Borneo. *A. lanceifolius* is fairly common and found in evergreen lowland or hill forest up to 600(–1100) m altitude. The density of the wood is 510–855 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 75, 77, 78, 104, 234, 262, 294, 363, 458, 465, 474, 507, 577, 705, 734.

Artocarpus lowii King

Hook.f., Fl. Brit. India 5: 542 (1888).

Vernacular names Indonesia: bangsal (Kalimantan). Malaysia: miku (Peninsular).

Distribution Peninsular Malaysia and eastern Sumatra.

Uses The wood is used as keledang. The greasy latex is used as an ointment or as a cooking oil. The fruit can be candied after cutting off the rind and removing the seeds.

Observations A medium-sized evergreen tree up to 25 m tall, bole exuding an oily latex; leaves elliptical or narrowly elliptical, base cuneate, glabrous above, appressed puberulent on the main veins below, with 11–16 pairs of secondary veins, stipules amplexicaul; male head cylindrical, c. 5 mm across, on a c. 40 mm long peduncle; styles in female head simple; syncarp cylindrical, up to 3.5 cm across, with fleshy, conical processes with depressed apices, appressed puberulent. *A. lowii* occurs scattered in lowland evergreen forest. The density of the wood is c. 645 kg/m^3 at 15% moisture content. The oily latex of *A. lowii* is unique within this genus.

Selected sources 77, 78, 104, 262, 458, 465, 705.

Artocarpus maingayi King

Hook.f., Fl. Brit. India 5: 542 (1888).

Vernacular names Malaysia: pudu, chempedak ayer (Peninsular).

Distribution Peninsular Malaysia and Sumatra (including Simeuluë).

Uses The wood is used as terap or keledang, e.g. for house and boat building.

Observations A medium-sized or fairly large evergreen tree up to 40 m tall, bole up to 55 cm in diameter, buttresses up to 2 m high; leaves elliptical to obovate-elliptical, base rounded to cuneate, glabrous above, the main veins appressed pubescent below, with 9–13 pairs of secondary veins, stipules amplexicaul; male head cylindrical, 5–6 mm across, on a c. 5 mm long peduncle; styles in female head simple; syncarp subellipsoid, up to 2 cm across, tessellate with very low, truncate processes, velutinous. *A. maingayi* is fairly common in lowland evergreen forest up to 150 m altitude.

Selected sources 104, 234, 265, 705, 734.

Artocarpus nitidus Trécul

Ann. Sci. Nat. Bot. III, 8: 119 (1847).

Vernacular names Malaysia: tampang (Peninsular). Philippines: kubi (Filipino). Thailand: mahat-khoi (Surat Thani).

Distribution From Burma (Myanmar), Indo-China and southern China towards Peninsular Malaysia, Sumatra, Borneo and the Philippines; sometimes planted for its edible fruit.

Uses The wood is used as terap or keledang, e.g. in house building and light construction. The fruit is edible, but not very tasty. Bark and roots are sometimes added to betel.

Observations A medium-sized to fairly large evergreen tree up to 35 m tall, bole up to 65 cm in diameter, buttresses absent or up to 1 m high; leaves obovate-elliptical to ovate-oblong, base cuneate to rounded, glabrous or sometimes puberulent on the veins below, with 5–15 pairs of secondary veins, stipules not amplexicaul; male head obovoid or oblong, 2.5–7 mm across, on a 1–3 mm long peduncle; styles in female head simple; syncarp subglobose, 1.5–6 cm across, smooth, with a varying indumentum. Within *A. nitidus* 5 subspecies are recognized: subsp. *nitidus* (synonym: *A. lanceolatus* Trécul) occurring in the Philippines, subsp. *borneensis* (Merr.) Jarrett (synonym: *A. borneensis* Merr.) occurring in Borneo, subsp.

griffithii (King) Jarrett (synonyms: *A. eberhardtii* Gagnep., *A. gomezianus* auct. non Trécul, *A. griffithii* (King) Merr.) occurring in Indo-China, Peninsular Malaysia and Borneo, subsp. *humilis* (Becc.) Jarrett (synonym: *A. humilis* Becc.) occurring in Borneo and subsp. *lingnanensis* (Merr.) Jarrett (synonym: *A. lingnanensis* Merr.) occurring in Indo-China, southern China and Thailand. *A. nitidus* is frequent and found in evergreen forest or sometimes in semi-deciduous forest or even savannah woodland up to 1500 m altitude.

Selected sources 104, 175, 263, 294, 465, 544, 574, 705, 734.

Artocarpus ovatus Blanco

Fl. Filip.: 666 (1837).

Synonyms *Artocarpus cumingiana* Trécul (1847), *Artocarpus acuminatissimus* Merr. (1921).

Vernacular names Philippines: anubing (general), kubi (Cagayan), kili-kili (Samar, Leyte).

Distribution Throughout the Philippines.

Uses The wood is used as keledang for purposes requiring strength and durability such as house posts, telegraph poles and bridges. The bark has been applied against stomach-ache. The latex is a source of anubing gum.

Observations A medium-sized tree up to 30 m tall, bole up to 100(–125) cm in diameter; leaves oblong to obovate-oblong or elliptical, base cordate to rounded, glabrous or pubescent on the main veins above, sparsely to densely pubescent on the veins below, with 11–20 pairs of secondary veins, stipules not amplexicaul; male head obovoid, 10–15 mm across, on a (15–)20–40 mm long peduncle; styles in female head simple; syncarp subglobose and shallowly lobed, up to 3 cm across, smooth, shortly pubescent. *A. ovatus* is fairly common in lowland forest and shrubby vegetations up to 750 m altitude. The density of the wood is 550–970 kg/m^3 at 15% moisture content.

Selected sources 68, 175, 263, 330, 527, 544.

Artocarpus rigidus Blume

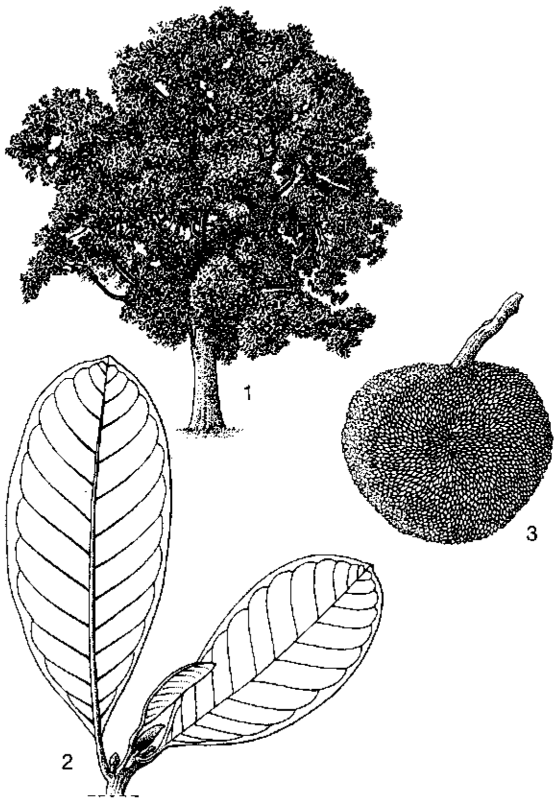
Bijdr. fl. Ned. Ind.: 482 (1825).

Vernacular names Indonesia: tempuni, kundang (general), pusar (Sundanese, Java), purian (Sumatra). Malaysia: temponek, nangka pipit (Peninsular), pala musoh (Sarawak). Burma (Myanmar): taung, peing, sone-padat. Cambodia: knor prey, dom knol prei. Thailand: khanun-pa (peninsular). Vietnam: c[aa]y mit nai, c[aa]y da x[os]p.

Distribution From Burma (Myanmar) and Indo-China to Peninsular Malaysia, Sumatra, western and central Java and Borneo; in Indonesia occasionally planted as fruit tree.

Uses The wood is used as keledang, e.g. for beams, furniture and boats. The fruit is edible and tasty. The seeds are also edible.

Observations A medium-sized to large evergreen tree up to 45 m tall, bole up to 115 cm in diameter, buttresses short or up to 3 m high; leaves oblong-elliptical to ovate-elliptical or obovate-elliptical, base cuneate to narrowly rounded, usually glabrous above except for the pubescent main veins, with appressed hispid veins below, with (9–)12–20 pairs of secondary veins, stipules amplexicaul; male head obovoid to globose, 13–20 mm across, on a 2–6 mm long peduncle; styles in female head simple; syncarp globose, up to 7(–13) cm across, with rigid, fluted, acute processes, hispid. *A. rigidus* is closely related to *A. hispidus* Jarrett and may even be conspecific with this species. It is highly variable and is divided into 2 subspecies: subsp. *rigidus* (synonyms: *A. cuspidatus* Griffith, *A. kertau* Zoll. ex Miq., *A. dimorpho-*



Artocarpus rigidus Blume – 1, tree habit; 2, twig with young inflorescences; 3, fruit (syncarp).

phyllus Miq., *A. varians* Miq.) occurring in southern Burma (Myanmar) and the Malesian region, and subsp. *asperulus* (Gagnep.) Jarrett (synonyms: *A. asperula* Gagnep., *A. calophylla* Kurz) occurring in Indo-China. It is not uncommon in evergreen forest on well-drained level and hilly locations, sometimes near streams, up to 900 m altitude. The density of the wood is 410–940 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 69, 75, 77, 78, 104, 234, 235, 262, 294, 363, 465, 474, 507, 553, 577, 705.

Artocarpus rubrovenius Warb.

Perkins, Fragm. Fl. Philipp.: 166 (1905).

Vernacular names Philippines: kalulot (general), anubing (Tagalog), anabling (Bikol).

Distribution The Philippines (Luzon).

Uses The wood is used as keledang for light construction. The bark has been used for the manufacture of cloth and is reported to have medicinal properties.

Observations A medium-sized tree up to 30 m tall, bole up to 40 cm in diameter; leaves ovate to elliptical, base broadly rounded to broadly cuneate, glabrous, with 8–13 pairs of secondary veins, stipules not amplexicaul; male head obovoid to clavate, 10–20 mm in diameter, on a 1.5–3 mm long peduncle; styles in female head simple; syncarp subglobose or shallowly lobed, up to 3 cm across, nearly smooth, shortly pubescent. *A. rubrovenius* occurs in forest up to 350 m altitude.

Selected sources 68, 175, 263, 544.

Artocarpus scortechinii King

Hook.f., Fl. Brit. India 5: 542 (1888).

Vernacular names Malaysia: terap hitam, nangka pipit (Peninsular).

Distribution Peninsular Malaysia, Sumatra and the Lingga Archipelago.

Uses The wood is used as terap. The bark has been used to obtain twine and the latex to adulterate that of *Willughbeia* spp.

Observations A medium-sized to fairly large evergreen tree up to 35 m tall; leaves elliptical to ovate-elliptical, base rounded to broadly cuneate, glabrous above, softly densely hairy below, with 12–14 pairs of secondary veins, stipules amplexicaul; male head cylindrical, 10 mm across, on a 35–50 mm long peduncle; styles in female head bifid; syncarp cylindrical, up to 5.5 cm across, covered by fleshy, cylindrical, obtuse or truncate processes, hispid pubescent. *A. scortechinii* occurs scattered in lowland evergreen forest up to 750 m altitude. The density of the wood is about 480 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 75, 78, 104, 262, 294, 363, 631, 703, 705, 734.

Artocarpus sepicanus Diels

Bot. Jahrb. Syst. 67: 176 (1935).

Distribution New Guinea.

Uses The wood is reputed to be used as terap or keledang.

Observations A fairly large tree up to 40 m tall; leaves elliptical or ovate-elliptical to ovate-oblong, base usually oblique and shallowly cordate, glabrous, with 9–16 pairs of secondary veins, stipules amplexicaul; male head cylindrical, 5–7 mm across, on a 15–30 mm long peduncle; styles in female head bifid; syncarp cylindrical, up to 1.5 cm across, areolate with fleshy, very short, truncate processes, velutinous. *A. sepicanus* occurs in lowland evergreen forest up to 200 m altitude.

Selected sources 216, 262.

Artocarpus sericicarpus Jarrett

Journ. Arn. Arb. 40: 350 (1959).

Vernacular names Malaysia: terap (Sarawak). Philippines: gumihan (Filipino), gomihan (Bikol).

Distribution Borneo, the Philippines, Sulawesi and the Moluccas.

Uses The wood is used as terap or keledang, e.g. for furniture, house and boat building. The fruit is edible and reported to be tasty; the seeds are roasted and eaten. The sticky latex is used in batik making.

Observations A fairly large tree up to 40 m tall, bole up to 100 cm in diameter; leaves elliptical to ovate, base rounded to cuneate, slightly scabrid above, pubescent below, with 11–16 pairs of secondary veins, stipules amplexicaul; male head cylindrical, 15–20 mm across, on a 55–100 mm long peduncle; styles in female head simple; syncarp ellipsoid to cylindrical, up to 5 cm across, with long, flexuous and solid processes, covered with long hairs. *A. sericicarpus* was formerly regarded as identical with *A. elasticus* but differs in e.g. the scabrid upper leaf surface and the long hairs on the syncarp. It occurs in evergreen lowland forest up to 300(–900) m altitude.

Selected sources 68, 175, 262, 544.

Artocarpus subrotundifolius Elmer

Leafl. Philipp. Bot. 1: 281 (1908).

Vernacular names Philippines: malakubi (Filipino).

Distribution The Philippines.

Uses The wood is reputed to be used as terap or keledang.

Observations A medium-sized tree up to 25 m tall; leaves broadly elliptical to obovate-oblong, base cordate, glabrous except for the pubescent main veins above, venation pubescent below, with 10–14 pairs of secondary veins, stipules not amplexicaul; male head obovoid to subglobose, 20–35 mm across, on a (7–)15–22 mm long peduncle; styles in female head simple; syncarp globose, up to 6 cm across, papillate or nearly smooth, pubescent. *A. subrotundifolius* is found in forest up to 300 m altitude.

Selected sources 263, 544.

Artocarpus tamaran Becc.

Nell. For. Borneo: 626 (1902).

Vernacular names Malaysia: tarap tempunan, tamaran, tembaran (Sarawak).

Distribution Borneo.

Uses The wood is used as terap. The bark has been used to prepare cloth.

Observations A fairly large tree up to 40 m tall, bole up to 90 cm in diameter; leaves ovate to ovate-elliptical, base rounded, glabrous above, the main veins appressed sericeous below, with (15–)17–23 pairs of secondary veins, stipules amplexicaul; male head cylindrical, 10–14 mm across, on a 35–55 mm long peduncle; styles in female head simple; syncarp cylindrical, up to 5 cm across, with both long, flexuous, filiform, solid and shorter, conical, perforate processes, rough from short recurved hairs. *A. tamaran* is fairly common and found in evergreen forest up to 550 m altitude. The density of the wood is 455–465 kg/m^3 at 15% moisture content.

Selected sources 77, 262.

Artocarpus teysmannii Miq.

Fl. Ind. Bat., Suppl.: 418 (1861).

Synonyms *Artocarpus peduncularis* Kurz (1875).

Vernacular names Indonesia: sali saling, tipulu (Sulawesi). Malaysia: chempedak ayer, miku, terbak kechil (Peninsular).

Distribution The Nicobar Islands, Peninsular Malaysia, Sumatra, Borneo, Sulawesi, the Moluccas and western New Guinea.

Uses The wood is used as terap or keledang, e.g. for boat building. The latex has been applied as birdlime on Sulawesi.

Observations A large evergreen tree up to 45 m tall; leaves ovate to ovate-elliptical, base rounded to broadly cuneate, glabrous or nearly so above, appressed puberulent on the main veins below, with 6–12 pairs of secondary veins, stipules amplexicaul; male head narrowly cylindrical, 5–7(–9) mm across, on a 20–80 mm long peduncle; styles in female head simple; syncarp cylindrical, up to 2.2 cm across, with fleshy, conical, mostly perforate processes, appressed puberulent. *A. teysmannii* occurs in lowland evergreen forest, often in swampy locations, up to 300 m altitude. The density of the wood is 310–730 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 234, 262, 474, 705.

Artocarpus treculianus Elmer

Leafl. Philipp. Bot. 2: 617 (1909).

Synonyms *Artocarpus nigrescens* Elmer (1909), *Artocarpus ovatifolia* Merr. (1914), *Artocarpus sorsogonensis* Elmer ex Merr. (1923).

Vernacular names Philippines: tugup, togop (Bisaya), pakak (Ibanag).

Distribution The Philippines.

Uses The wood is used as keledang, e.g. for flooring, and regarded as valuable; it is termite resistant. The latex is used in turpentine and paint. The fruit is edible.

Observations A medium-sized, sometimes fairly large, evergreen tree up to 20(–40) m tall, bole up to 100 cm in diameter, with small buttresses; leaves elliptical or ovate to rhomboid, base cuneate to rounded, entire to pinnatifid with 1–3 pairs of lateral lobes, glabrous above, the main veins appressed puberulent below, with 9–12 pairs of secondary veins, stipules amplexicaul; male head cylindrical, c. 7 mm across, on a 12–27 mm long peduncle; styles in female head bifid; syncarp ellipsoid to cylindrical, up to 5 cm across, with fleshy, cylindrical, obtuse processes, rough from the acute and deflexed tips of inflated hairs. *A. treculianus* occurs in lowland forest in regions with a rainfall of at least 1500 mm and a short or no dry season.

Selected sources 262, 544, 620.

T. Djarwaningsih (general part, selection of species),
D.S. Alonzo (properties),
S. Sudo (wood anatomy),
M.S.M. Sosef (selection of species)

Azadirachta A.H.L. Juss.

Mirb. & Cass. apud Guill., Bull. Sci. Nat. Géol. 23: 236 (1830).

MELIACEAE

x = unknown; *A. indica*: $n = 14$, $2n = 28$, 30

Trade groups

- Sentang: lightweight to medium-weight hardwood, *Azadirachta excelsa* (Jack) Jacobs.
- Neem: moderately heavy hardwood, *A. indica* A.H.L. Juss.

Vernacular names

- Sentang. Indonesia: kayu bawang (general), surian bawang, bawang kunyit (Kalimantan), nibwak (Irian Jaya). Malaysia: limpaga (Sabah), ranggu (Sarawak). Papua New Guinea: azadirachta. Philippines: maranggo (general), bird's-eye kalantas (En), danggo (Tag.). Thailand: thiam, sadao-thiam.
- Neem: nim, margosa, cornucopia (En), azadirac de l'Inde, margosier, margousier (Fr). Indonesia: imba, mimba (Java), membha, mempheuh (Madura), intaran (Bali). Malaysia: baypay, mambu, veppam (Peninsular). Singapore: kohumba, nimba, veppam. Burma (Myanmar): tamaka, bowtamaka, tamabin. Laos: ka dao. Thailand: khwinin (general), sadao (central), saliam (northern). Vietnam: s[aaf]u d[aa]u.

Origin and geographic distribution *Azadirachta* comprises 2 species. *A. excelsa* is native to Peninsular Malaysia, Sumatra, Borneo, Sulawesi, the Aru Islands, New Guinea, and the Philippines. *A. indica* is thought to be native to the dry forest areas of the Indo-Pakistan subcontinent and possibly also to Burma (Myanmar). It is widely cultivated, also as a plantation tree, and sometimes occurs naturalized throughout India, Pakistan, Sri Lanka, Thailand and Indonesia. More recently it has also been planted in Peninsular Malaysia and Singapore, the Philippines, Hawaii, Fiji, Australia, Saudi Arabia, tropical Africa, the Caribbean, Central and South America, and the southern United States.

Uses Sentang wood is valued for light construction (under cover) and is used for joinery, furniture, interior finishing, panelling, partitioning, sliced veneer, flooring, turneries, and matches. In the Philippines sentang is also used for piano cases, matches, decorative engraving and cigar boxes, while in Papua New Guinea other applications include louvred doors and canoe making. In Peninsular Malaysia the young shoots, leaves, and flowers are consumed as a vegetable.

Neem wood is appreciated for making carts, agricultural implements, doors, panels, window frames, poles and other building materials, toys and idols. The wood may be used for furniture. Neem is of limited value for construction, as the logs are too short. However, it is considered suitable for the manufacture of plywood and is used as a substitute for mahogany (*Swietenia*) in Central America. It is a promising, fast-growing source of fuelwood.

Neem seeds and leaves, and reputedly also the flowers and bark, yield azadirachtin which is used as insect and nematode repellent. The oil from the seeds is used for the manufacture of soap, as fuel for lamps and as a lubricant for machinery. The pulp surrounding the seeds is reputedly a promising substrate for generating methane gas. The oil extracted from the bark is industrially used in the manufacture of soap, toothpaste, and pharmaceutical and cosmetic products.

Various parts of neem have medicinal properties used against a wide variety of illnesses. Neem oil has contraceptive properties and is used in local medicine against e.g. malaria, skin diseases, stomach ulcers, worms and rheumatism. Neem is planted as a wayside tree for shade, and in windbreaks. In addition, the young leaves and young flowers are sometimes used as vegetable and the leaves and twigs are used as fodder for sheep and goats, and for mulching and fertilizing. Neem cake, the residue left after extracting oil from the seeds, is reportedly an excellent fertilizer and has potential as an insecticide. The bark contains tannin. Neem is regarded as a highly valuable multipurpose tree with great potential.

Production and international trade Most *Azadirachta* timber is used locally. Japan imports small amounts of sentang from Papua New Guinea, Sabah and Sarawak. Sentang accounts for about 1% of the total timber import in Japan from Papua New Guinea. In 1987, the export of sentang round logs from Sabah was about 2000 m^3 with a value of US$ 135 000 (US$ 68/m^3). At present, sentang is often traded in Sabah together with the wood of other *Meliaceae* genera, such as surian (*Toona*). The sawn timber export of this combined trade group was slightly less than 100 m^3 in 1992, with a value of US$ 33 000 (US$ 360/m^3).

Properties Sentang is a lightweight to medium-weight hardwood. The heartwood is pale reddish-brown to dark reddish-brown and distinctly demarcated from the yellowish-white, greyish-white or sometimes grey-pink sapwood. The density is 550–780 kg/m^3 at 15% moisture content. The grain is slightly to moderately interlocked, texture moderately coarse to coarse and often uneven.

The following mechanical properties are the result of testing the wood of 5-year-old trees that were 4–6 m tall and 10–12 cm in diameter and had been grown in Thailand, at 10.5% moisture content: the modulus of rupture 94 N/mm², modulus of elasticity 9770 N/mm², compression parallel to grain 52 N/mm², shear 16 N/mm² and Janka side hardness 3980–4050 N.

The rates of shrinkage of sentang reportedly vary from low to moderately high: in Malaysia it is reported to shrink only c. 0.5% radial and 0.5% tangential from green to 15% moisture content, but in the Philippines shrinkage from green to 15% moisture content is reported as c. 2.2% radial and 4.3% tangential, and from green to oven dry 4.5% radial and 7.5% tangential. The timber air dries fairly rapidly with little degrade. Air drying takes approximately 2 months for boards 15 mm thick, and about 4 months for boards 40 mm thick.

Sentang wood is generally easy to work, taking a good finish. The boring properties are rated as good, and planing and shaping as moderately good. Tests in Sabah showed that the timber peels well without pretreatment; the veneer dried well without serious degrade.

The heartwood of sentang is rated as non-durable to moderately durable. The sapwood is susceptible to dry-wood termites and powder-post beetles, and also to fungal attacks.

Sentang wood contains 45% cellulose, 27% lignin, 16% pentosan and 1.0% ash. The solubility is 2.3% in alcohol-benzene, 2.4% in cold water, 6.6% in hot water and 21.4% in a 1% NaOH solution.

Neem is a moderately heavy hardwood. The heartwood is reddish, becoming reddish-brown upon exposure, distinctly demarcated from the greyish-white sapwood. The density is 720–930 kg/m³ at 12% moisture content. The grain is interlocked, texture coarse.

Tests on trees planted in India and Sudan showed the following mechanical properties at 12% moisture content: the modulus of rupture 79–99 N/mm², modulus of elasticity 6960–8765 N/mm² and compression parallel to grain 46–51 N/mm².

The rates of shrinkage are moderate: from green to oven dry c. 4.5% radial and 6.2% tangential. The timber seasons well with little degrade. Preboring is necessary when nailed.

Neem is generally stronger and more durable than sentang; it is more resistant to termite, powder-post beetle and fungal attacks and even durable under exposed conditions. The energy value of neem wood is 20 830 kJ/kg.

Neem seeds contain up to 40% oil. The bark contains 12–15% tannins. The insecticidal substance is probably azadirachtin.

Description Small to medium-sized or fairly large, deciduous or evergreen trees, up to 40(–50) m tall; bole cylindrical, buttresses absent or minor, up to 125(–150) cm in diameter; bark surface smooth, becoming fissured and shaggily flaky, pinkish-brown or pinkish-grey, becoming pale brownish or greyish buff in old trees, inner bark orange-red. Indumentum of simple hairs. Leaves alternate, imparipinnate, with 2 pairs of glands at the base of the petiole; leaflets alternate below and opposite to subopposite above, lanceolate to elliptical, reduced in size towards each end of the rachis, with an entire or serrate margin, glabrous. Flowers in axillary, many-flowered panicles, bisexual and male flowers on the same individual, actinomorphic, 5-merous, fragrant; calyx with imbricate lobes; petals free, imbricate; stamens 8(–)10, filaments united to form a cylindrical staminal tube with (8–)10 small apical appendages, anthers sessile, free, 2-celled, basifixed, inserted opposite to the appendages; disk annular, fused to the base of the ovary; ovary superior, 3-locular, with (1–)2(–3) axillary ovules in each cell, style single, stigma capitate, 3-lobed. Fruit drupaceous, ellipsoid, 1(–2)-seeded, green turning yellow when ripe. Seed ovoid, with a thin membranous testa, with a small adaxial sarcotesta, smelling of garlic when cut; cotyledons unequal. Seedling with phanerocotylar germination, eophylls opposite, trifoliolate; leaflets deeply incised, pinnatifid, or partite.

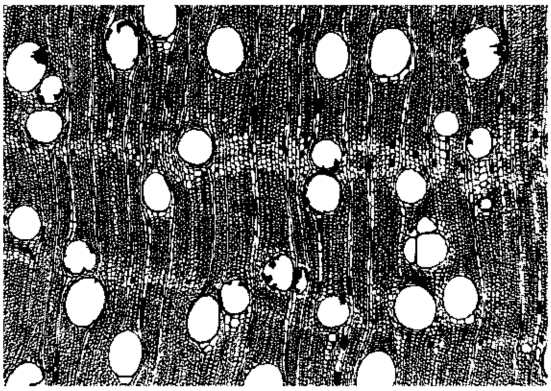
Wood anatomy

– Macroscopic characters:

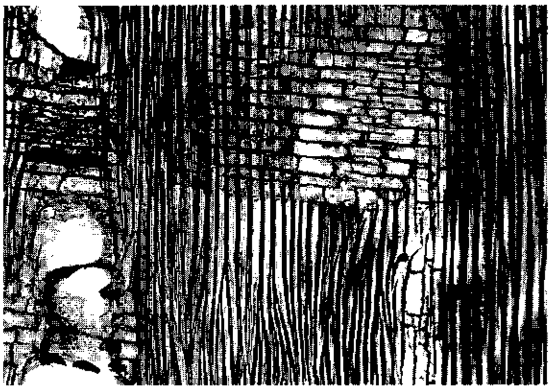
Heartwood pale to medium-brown or reddish-brown, sapwood greyish-white, pale brown to slightly yellowish-brown. Grain slightly to strongly interlocked. Texture moderately coarse; wood usually lustrous. Growth rings indistinct or sometimes distinct (*A. indica*); vessels medium-sized, visible to the naked eye, often occluded with dark deposits, tyloses indistinct; tangential bands of parenchyma indistinct; rays almost invisible to the naked eye; ripple marks absent.

– Microscopic characters:

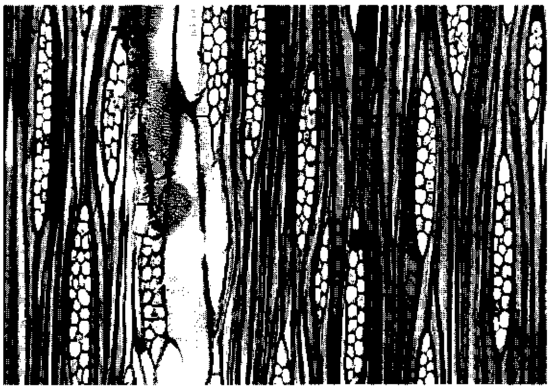
Growth rings absent or occasionally distinct (*A. indica*) and then defined by differences in pore size, fibre wall thickness and initial parenchyma. Vessels diffuse, 4–17(–60)/mm², of 2 sizes, small vessels vasicentric or in terminal clusters in wood specimens having growth rings, larger vessels



transverse section (×25)



radial section (×75)



tangential section (×75)

Azadirachta excelsa

4–10/mm², solitary or in multiples or clusters of 2–4 to more than 10, uniformly distributed or occasionally in loose tangential series, generally oval, polygonal in clusters, average tangential and radial diameter of large vessels 105–140 μm and 90–165 μm, respectively (maximum tangential and radial diameter 175–230 μm and 175–285 μm, respectively), average tangential and radial diameter of small vessels 20–35 μm; walls 2–6 μm thick; perforation plates simple; intervessel pits dense and alternate, 3–5 μm; vessel-ray pits similar but half-bordered, 3–4 μm; brown or blackish deposits present; tyloses absent. Fibres 0.8–1.5 mm long, non-septate, 7–25 μm in tangential diameter, thick-walled (3–4 μm), with sparse slit-like pits mainly in the radial walls. Axial parenchyma paratracheal, vasicentric; apotracheal parenchyma in irregularly spaced tangential bands of 3–8 cells wide, strand length 4–20 cells or more. Rays mostly (more than 85%) multiseriate, 2–3 cells wide, up to 550 μm high, heterocellular with 1(–2) rows of square to upright marginal cells, uniseriate rays few, short, mostly less than 150 μm high. Prismatic crystals present in non-chambered apotracheal parenchyma cells. Silica bodies absent. Intercellular canals absent.
Species studied: *A. excelsa*, *A. indica*.

Growth and development Sentang trees in Indonesia were 19–24 m tall after 9 years with a bole diameter of 22–27 cm. In Thailand, planted trees reached a diameter of up to 30 cm in 5 years. The growth of neem trees varies greatly, depending on site conditions and provenance. At first, seedlings grow slowly, reaching 15–25 cm tall after one year, but thereafter growth is much faster and trees may reach a height of 4–7 m after 3 years and 5–11 m after 5 years. Under moderate conditions mean annual diameter growth is 0.7–1.0 cm, but under optimal conditions 2 cm may be reached. In irrigated plantations in India, 16-year-old trees reached a diameter of 40 cm.
Neem trees may already start flowering and fruiting at the age of 4–5 years. They can live for over 200 years. The flowering and fruiting season varies greatly with location and habitat. In Thailand, *A. indica* trees flower in December to February and fruit in March to May, whereas *A. excelsa* flowers in February to March. Fruits ripen in about 12 weeks after anthesis and are eaten by bats and birds.

Other botanical information *Azadirachta* belongs to the subfamily *Melioideae* and the tribe *Melieae*, and is closely related to the genus *Melia*. It is sometimes confused with the latter but is easily distinguished by its simple pinnate leaves with a pair of orbicular glands and a pair of elongated glands at the base and by the 3-locular ovary, whereas *Melia* possesses 2–3-pinnate leaves with one pair of orbicular glands and a 4–8-locular ovary.

Ecology Sentang usually grows in secondary forest, but is also found in dipterocarp rain forest where it is associated with *Durio*, *Palaquium*, *Calophyllum* and *Agathis* species. It occurs scattered in lowland forest, up to 350 m altitude.

Neem has a wide climatic adaptability. It grows in tropical and subtropical regions, from sea-level up to 1500 m altitude. In its natural habitat in India it is generally found in mixed forest in association with *Acacia* spp. and *Dalbergia sissoo* Roxb. ex DC. In Indonesia, where it occurs widely naturalized, it is usually found in lowland monsoon forest and is associated with e.g. *Acacia leucophloea* (Roxb.) Willd., *Albizia chinensis* (Osbeck) Merr., *Butea monosperma* (Lamk) Taubert, and *Cassia fistula* L. Optimal growth is observed in areas with an annual precipitation of around 1000 mm, but neem plantations can be established in areas with only 450–750 mm of rain. Neem tolerates some frost. It does not like inundation and does not tolerate waterlogging. Neem is a light demander, but tolerates fairly heavy shade during the first few years. It grows on a wide variety of neutral to alkaline soils, but performs better than most species on shallow stony, sandy soils, or in places where there is a hard calcareous or clay pan not far below the surface. It grows best on soils with a pH of 6.2–7.0.

Propagation and planting Sentang and neem are generally propagated by seed, but can also be propagated by air layering, root and shoot cuttings, grafting and tissue culture.

Fruits should be collected off the trees to avoid contamination by soilborne pathogens and should not be placed directly on the ground. Fruits can be depulped by washing and seeds are air dried for 3–7 days in a dry and shaded area before being stored. Depulped fruits should be 'density graded' by being put in water; any 'floaters' should be discarded. Neem seeds remain viable for about 4–8 weeks only, but storage of dried seeds at 15 °C will prolong this period up to 4 months. Depulped fruits stored at -20 °C retained their viability for as long as 10 years. The germination rate for neem and sentang is 75–80% when seeds are sown directly after being harvested, and 50–60% when sown after being stored. However, when stored for 3 months under ambient conditions the germination rate of neem seed is only 8%. *A. excelsa* has about 470 seeds/kg and *A. indica* 3700–5400 seeds/kg. No seed treatment is required, although speed and rate of germination are increased when seeds have passed through the intestines of ruminants.

Seeds are sown in seedbeds, polybags or root-trainers. Spacing in seedbeds is 20 cm between the rows and 5 cm within the row, and seeds are covered with 0.5–1 cm soil. Germination starts 1–3 weeks after sowing. During germination, light shade is recommended; it should be maintained for about 2 months. Seedlings can be transferred to containers (polybags) when two pairs of leaves have developed. The seedlings should be provided with at least 50% shade at first and gradually exposed to full sunlight when about 30 cm tall.

Seedlings can be planted out in the field 12 weeks after sowing when the stem is 7.5–10 cm long with a taproot of 15 cm, either as bare-rooted plants or as plants from polybags. The taproot of bare-rooted seedlings should be pruned before planting. Stumps and striplings are generally made from one-year-old seedlings; for stumps the roots are pruned to 20 cm and the shoot to 5 cm. Seedlings with a well developed root system, such as those raised in root-trainers or through fertilization in the nursery, can withstand drought better and show a higher survival rate.

In Thailand, wildlings of *Azadirachta* spp. had a survival rate of 85% when planted out immediately after collection.

Vegetative propagation by cuttings is possible and over 90% rooting was obtained when cuttings were taken from coppicing shoots. However, this is not recommended for semi-arid areas, as the taproot will not develop. This also holds true for air layering, where mainly lateral roots are formed. Rootlets of 0.3–0.5 cm diameter and 3–5 cm long have been used successfully in Thailand as propagules.

Direct seeding in well prepared soil on well-drained sites is possible by sowing the seeds at a depth of 1.5 cm and at a spacing of 3 m × 3 m. In taungya systems spacing may be as close as 1.3 m × 1.3 m. The seedlings that issue from direct sowing, however, develop more slowly than those raised in the nursery.

Sentang is planted at a spacing of 2–4 m × 4 m; in Sumatra the local population has planted sentang using seedlings collected from the forest. Sentang and rubber are often mixed in plantations.

Silviculture and management Natural regeneration of neem is usually profuse, as the seeds are widely distributed by bats and birds. In dry areas, it is essential to weed neem plantations, as neem cannot withstand competition, especially from grasses. Rotation of neem plantations for firewood in West Africa is 7–8 years at a final spacing of 5 m × 5 m. In Haiti, on good soils and with adequate moisture, it is planted at 2.5 m × 2.5 m and managed with a rotation of only 4 years.

As neem coppices well, no replanting is necessary after harvesting. Coppicing is also preferred from the point of view of fuelwood production, as it facilitates the harvesting and managing of the plantation. Neem withstands pollarding well, a valuable asset for its use in windbreaks. Sentang also coppices well and coppice shoots grow faster than shoots from seedlings.

Leaf litter of neem is reported to raise the pH of the soil surface from 5 to 7.

Diseases and pests There are no records of fungi attacking neem in South-East Asia.

Hypsipyla robusta, a shoot borer and a serious pest in many *Meliaceae* has not been recorded for *Azadirachta*. Neem has few serious pests, but several scale insects have been reported to infest it, e.g. *Aonidiella orientalis* (feeding on sap of young branches and young stems), which is the most important pest, and *Pulvinaria maxima* (feeding on sap, and covering tender shoots and stems). The nymphs of *Helopeltis antonii* are also found to feed on sap. It has been observed that rats and long-spine porcupines attack and occasionally kill neem seedlings and trees, by gnawing the bark around the base.

Mistletoes infesting neem are *Dendrophtoe falcata* and *Tapinanthus* sp.

A serious decline of neem has been observed in West Africa recently. Older foliage is shed, leaving crowns with an open appearance. Tufts of leaves remain at the branch apices, for which the disorder is now known as 'giraffe neck'. Preliminary conclusions indicate that neem decline is not caused by a biotic agent, but is due to site-related stress such as inadequate soil moisture, soil compaction, competition, and intercropping.

Harvesting In Thailand, the first harvest of sentang is usually 5 years after planting, when the stem is 20–30 cm in diameter.

Yield Plantations of sentang on Java with a spacing of 2.5 m × 4 m yielded 12 m^3/ha of wood annually in the first 10 years. The form factor was assessed at 0.4. Plantations of neem in Thailand with spacings of 2–4 m × 4 m yielded 6–7.5 m^3/ha annually in the first 10 years on poor sites and 33–36 m^3/ha annually on favourable sites, the slightly lower yields being recorded for the wider spacing. In West Africa, fuelwood plantations managed with a rotation of 8 years and with an initial spacing of 2.4 m × 2.4 m yielded 2.5–21 m^3/ha annually.

Handling after harvest Sentang wood is subject to fungal attack and needs to be treated when used outdoors. Neem wood is very resistant to insects and fungi and does not require treatment with preservatives.

Genetic resources As neem and sentang are widely distributed, considerable genetic variation may be expected. Neem is much planted and naturalized throughout South-East Asia, but sentang is more rarely planted; the latter is only locally cultivated in botanical gardens and experimental gardens, e.g. in West Java (especially provenances from Sulawesi). In Thailand, 42 seed provenances of neem have been identified throughout the country.

Breeding Phenotypically superior neem trees have been clonally propagated in India and Thailand. Fresh cotyledons were found to be the best source of material for tissue culture.

Prospects Sentang and neem seem to have good prospects for use in timber plantations, e.g. as a substitute for mahogany (*Swietenia* spp.) for plywood and cabinet making. Neem is also interesting as a multipurpose tree in agroforestry and for reforestation purposes especially on critical soils and in drier areas. More research is needed on the silviculture of sentang, which is a very fast-growing tree.

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Ruskin, F.R., 1992. Neem: a tree for solving global problems. National Research Council. National Academy Press, Washington D.C. 141 pp. |**8**| Somyos Kijkar, 1992. Handbook: Planting stock production of Azadirachta spp. at the ASEAN-Canada Forest Tree Seed Centre. ASEAN-Canada Forest Tree Seed Centre Project, Muak-Lek, Saraburi, Thailand. 20 pp. |**9**| Tampubolon, A.P. & Alrasyid, H., 1989. The neem tree and its developmental prospect in rainfed zones in Indonesia. Duta Rimba 15(109-110): 8-12. |**10**| Tewari, D.N., 1992. Monograph on neem (Azadirachta indica A. Juss.). R.P. Singh Gahlot for International Book Distributors, Dehra Dun. 279 pp.

Selection of species

Azadirachta excelsa (Jack) Jacobs

Gard. Bull. Sing. 18: 75 (1961).

Synonyms *Melia excelsa* Jack (1820), *Azadirachta integrifolia* Merr. (1909).

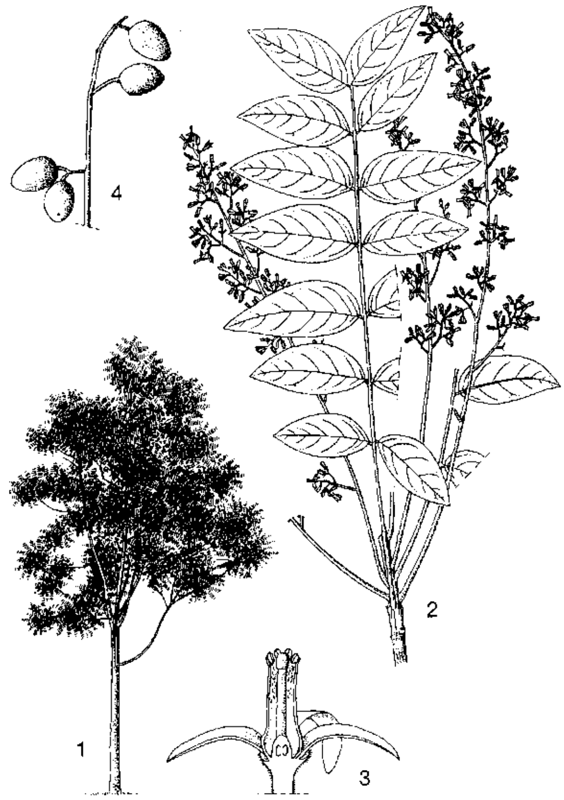
Vernacular names See genus treatment.

Distribution Peninsular Malaysia, Sumatra, Borneo, the Philippines, Sulawesi, the Aru Islands and New Guinea.

Uses See genus treatment. It is also planted along roadsides and farm boundaries or in rubber plantations.

Observations A large deciduous tree up to 50 m tall, bole up to 125 cm in diameter, buttresses absent; leaves up to 60(-90) cm long, with 7-11 pairs of leaflets, leaflets asymmetrical, lanceolate to elliptical, up to 12.5 cm × 3.5 cm, margin entire; flowers greenish-white; fruit oblong, 2.4-3.2 cm long. *A. excelsa* usually occurs in old clearings or old secondary forest, but is also found in primary dipterocarp forest, e.g. in Kalimantan, up to 350 m altitude. The density of the wood is 550-780 kg/m³ at 15% moisture content. See also the table on wood properties.

Selected sources 77, 78, 103, 162, 227, 228, 234, 258, 295, 394, 418, 428, 527, 705, 721.



Azadirachta excelsa (Jack) Jacobs – 1, habit of young tree; 2, flowering twig; 3, sectioned flower; 4, branchlet with fruits.

Azadirachta indica A.H.L. Juss.

Mém. Mus. Nat. Hist. Nat. Paris 19: 221, t. 13, fig. 5 (1832).

Synonyms *Melia azadirachta* L. (1753), *Melia indica* (A.H.L. Juss.) Brandis (1874), *Antelaea azadirachta* (L.) Adelb. (1948).

Vernacular names See genus treatment.

Distribution Native to the dry forest areas of the Indo-Pakistan subcontinent and possibly also to Burma (Myanmar). It is widely cultivated, also as a plantation tree, and sometimes occurs naturalized throughout India, Pakistan, Sri Lanka, Thailand and Indonesia. More recently it has also been planted in Peninsular Malaysia and Singapore, the Philippines, Australia, Saudi Arabia, tropical Africa, the Caribbean, Central and South America, and the southern United States.

Uses See genus treatment.

Observations A small to medium-sized evergreen to deciduous (drier regions) tree up to 25(-30) m tall, bole usually short, branchless for up to 7.5 m, up to 90 cm in diameter, sometimes fluted; leaves up to 38 cm long, with 4-7 pairs of leaflets, leaflets asymmetrical, lanceolate to ovate, 3.5-10 cm × 1.2-4.0 cm, margin serrate; flowers white; fruit oblong or ovoid-oblong, 1.2-1.8 cm long. *A. indica* grows naturally in mixed primary monsoon forest in semi-arid to wet regions, from sea-level up to 700 m altitude. The density of the wood is 720-930 kg/m³ at 12% moisture content. See also the table on wood properties.

Selected sources 36, 78, 87, 95, 104, 162, 258, 295, 348, 434, 451, 485, 500, 535, 539, 637, 648.

B. Sunarno (general part, properties, selection of species),
N. Tonanon (properties),
S. Noshiro (wood anatomy)

Beilschmiedia Nees

Wallich, Pl. Asiat. rar. 2: 61, 69 (1831).
LAURACEAE
$x = 12$ ($n = 12$ or $2n = 24$ for several non-Malesian species)

Trade groups Medang: lightweight to medium-weight hardwood, e.g. *Beilschmiedia dictyoneura* Kosterm., *B. lucidula* (Miq.) Kosterm., *B. madang* Blume.
Medang is used as the trade name for the timber of most *Lauraceae* genera, such as *Alseodaphne*, *Cinnamomum*, *Cryptocarya*, *Dehaasia*, *Litsea*, *Persea* and *Phoebe*.

Vernacular names Medang. Indonesia: huru. Philippines: bagaoring (Samar-Leyte Bisaya). Burma (Myanmar): kyese. Laos: chik dong.

Origin and geographic distribution *Beilschmiedia* consists of about 200 species and occurs throughout the tropics, and also in the Himalayas, subtropical China and Taiwan. Tropical Africa is the richest in species; tropical America has some 15 species. The genus is represented throughout the Malesian area by about 50 species, most of which have a small area of distribution.

Uses The timber is used for light construction, flooring, mouldings, interior finish, furniture, picture frames, interior fitting and carving. In general, medang timber is also suitable for veneer and plywood production.

Production and international trade The timber of *Beilschmiedia* is not traded separately, but together with that of other *Lauraceae* genera as medang, and probably constitutes only a minor proportion of the total amount handled.
In 1984, the total export of medang from Peninsular Malaysia to Singapore was 1500 m^3 with a value of US$ 62 000, and in 1992 the export from Sabah was 52 000 m^3 (about 10% as sawn timber) with a total value of US$ 4.3 million. In 1992 in Papua New Guinea, the minimum price for saw logs was US$ 43/m^3. Japan imports medang mainly from Sabah and Sarawak.

Properties *Beilschmiedia* wood is a lightweight to medium-weight hardwood. The heartwood is pale greyish-brown with dark brown streaks, not sharply demarcated from the pale red-brown or pale brown sapwood. The density is (430–)470–680(–815) kg/m^3 at 15% moisture content. The grain is usually straight, texture moderately fine. The wood has a slight odour when fresh.
No specific tests on the mechanical properties have been performed on the wood of South-East Asian *Beilschmiedia* species. However, the properties are probably comparable with those of most other *Lauraceae* wood.
The rates of shrinkage of medang are moderate to high. The wood is generally easy to air dry.
The wood is easy to saw although some silica is sometimes present. Planing is easy and nailing and peeling properties are good. Medang is usually rated as non-durable and susceptible to termite, *Lyctus* and fungal attack. The timber should be treated with anti-stain chemicals immediately after sawing. The heartwood is difficult to treat with preservatives, but the sapwood is permeable. Maximum BFCA preservative penetration is 6 mm after 23 days using the diffusion process.

Description Evergreen shrubs or small or medium-sized to fairly large trees up to 35(–40) m tall; bole up to 80(–110) cm in diameter, not buttressed or with small buttresses up to 1.5(–2) m high; bark surface smooth, lenticellate to fissured and dippled, grey, grey-brown to reddish-brown or dark brown, inner bark granular (not fibrous), red or reddish-brown to dark reddish-brown or dark brown, sometimes creamy, often with a strong aromatic smell; sapwood yellow or yellow-brown when freshly cut. Leaves arranged spirally, alternate, or subopposite to opposite, simple and entire, leathery to rigidly leathery, with glandular dots and aromatic when crushed, pinnately veined, often prominently reticulate below; stipules absent. Inflorescence an axillary, lateral or subterminal raceme or panicle, usually short and few-flowered. Flowers bisexual, regular, 3-merous, small, without an involucre; perianth segments 6, united in a short tube below, subequal, deciduous in fruit; fertile stamens 6 or 9, in 3 rows inserted on the perianth tube, those of the outer 2 rows introrse, those of the inner row extrorse and with 2 glands on each filament, anthers 2-celled and opening with a valve from the base to the top, an innermost row of cordate to ovoid, usually short-stalked staminodes present; ovary superior, sessile, 1-celled, with a single, pendulous, anatropous ovule, style short, conical, obtuse, with an inconspicuous stigma decurrent on one side. Fruit a 1-seeded berry, oblong to ovoid, on a naked, sometimes slightly thickened pedicel. Seed without albumen, with a thin testa; cotyledons large, flat, convex and pressed against each other, succulent; embryo minute. Seedling with hypogeal, cryptocotylar germination; all leaves arranged spirally.

Wood anatomy

– Macroscopic characters:

Heartwood pale greyish-brown with dark brown streaks, not sharply demarcated from the pale red-brown or pale brown sapwood. Grain usually straight. Texture moderately fine; wood with low lustre, no distinctive odour or taste. Growth rings faint to distinct; vessels and rays barely visible to the naked eye; parenchyma not distinct without a lens. Ripple marks absent.

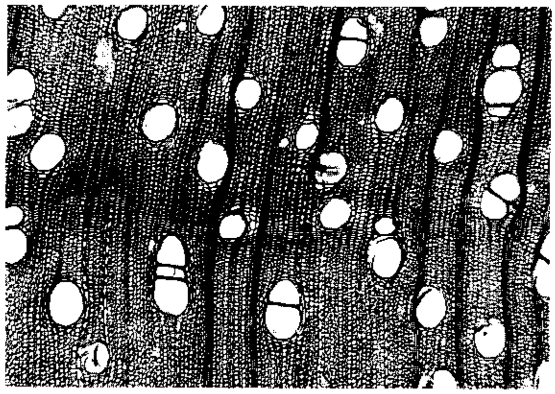
– Microscopic characters:

Growth rings indistinct to distinct, marked by marginal parenchyma bands and slight differences in fibre wall thickness. Vessels diffuse, 3–12/mm^2, solitary and in radial multiples of 2–6, very rarely in small clusters, round to oval or slightly angular, average tangential diameter 100–220 μm; perforations simple; intervessel pits non-vestured, alternate, round to polygonal, 7–10 μm; vessel-ray and vessel-parenchyma pits large and simple or with greatly reduced borders; helical thickenings, deposits and tyloses absent. Fibres c. 1200 μm long, non-septate, thin-walled to moderately thick-walled, with minutely bordered pits confined to the radial walls. Parenchyma abundant, paratracheal parenchyma vasicentric, apotracheal parenchyma in marginal (or irregular zonate) 1–7 cells wide bands, in 2–4-celled strands. Rays 6–8/mm, (1–)2–4(–5) cells wide, (0.1–)0.3–0.5 mm high, heterocellular, composed of procumbent body ray cells and one or two rows of square to upright marginal cells. Crystals absent or sporadic, prismatic, in ray or axial parenchyma cells. Silica bodies present in some of the species. Oil cells present in only some of the species, associated with ray and axial parenchyma cells, and isolated among fibres.

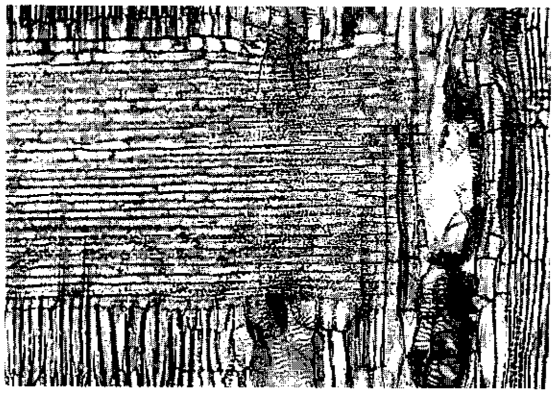
Species studied: *B. acutifolia*, *B. bullata* Allen, *B. dictyoneura*, *B. gemmiflora* (Blume) Kosterm., *B. glauca* S.K. Lee & Lau, *B. lucidula*, *B. roxburghiana* Nees, *B. sphaerocarpa* Winkler.

Growth and development During germination the fruit splits at one pole and the plumule is released from the envelopments by slight elongation of the cotyledonary petioles. No resting stage occurs. The taproot is long and slender with many slender, unbranched lateral roots. The first leaves are sessile, scale-like and are soon shed.

Although evergreen, most of the species flower



transverse section (×25)



radial section (×75)

tangential section (×75)

Beilschmiedia lucidula

and develop new reddish leaves periodically. Pollination is by insects; seed dispersal takes place by animals which eat the fleshy fruits.

Other botanical information *Beilschmiedia* is one of the *Lauraceae* genera in South-East Asia whose species are still comparatively unknown and ill-defined. It requires a thorough taxonomic revision. The present state of knowledge results in doubtful identifications, unreliable nomenclature and often absence of information at the species level.

The genus is probably most closely related to *Cryptocarya* and *Dehaasia* and is characterized by the absence of a persistent involucre, a deciduous perianth, the 2-celled anthers, the often reticulately veined leaves and the naked fruiting pedicel which may be slightly thickened.

Beilschmiedia is divided into 2 subgenera: subgenus *Beilschmiedia* with 9 fertile stamens and subgenus *Hexarrhena* Stapf with 6 fertile stamens.

In New Zealand, the timber of *B. tawa* (A. Cunn.) Benth. & Hook.f. ex Kirk, which occurs in montane *Podocarpus-Nothofagus-Agathis* forest, is fairly well-known and traded under the name 'tawa'. In Taiwan, *B. erythrophloia* Hayata is a fairly well-known timber used mainly for plywood production. In tropical Africa, the timber of *Beilschmiedia* spp. is called 'kanda'.

Ecology Timber-producing species of *Beilschmiedia* usually occur in primary lowland rain forest, sometimes ascending into the montane zone up to 1400(–1750) m altitude. They are elements of the subcanopy or canopy layer but never emergent and are generally found on fertile soils, sometimes in swampy locations, rarely on limestone.

Propagation and planting *Beilschmiedia* can be propagated by seed. About 45% of the seed of *B. madang* germinates in 1–3.5 months. Germination of seed of *B. roxburghiana* is reported to be good and more or less simultaneous.

Yield In natural forest in Irian Jaya, on average 0.1 trees/ha are found with an estimated timber volume of 0.14 m^3.

Genetic resources There are no records of germplasm collections nor of any specific activities to conserve the genetic resources of *Beilschmiedia*. In the Malesian region a large number of species are found and most have a small area of distribution. Therefore, the genetic diversity may be reduced through conversion of natural forest into other vegetation types.

Prospects Although the species of *Beilschmiedia* are insufficiently known, they will probably continue to make up part of the medang timber traded, most likely in very much the same proportions as at present.

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Selection of species

Beilschmiedia acutifolia Teschn.

Bot. Jahrb. Syst. 58: 403 (1923).

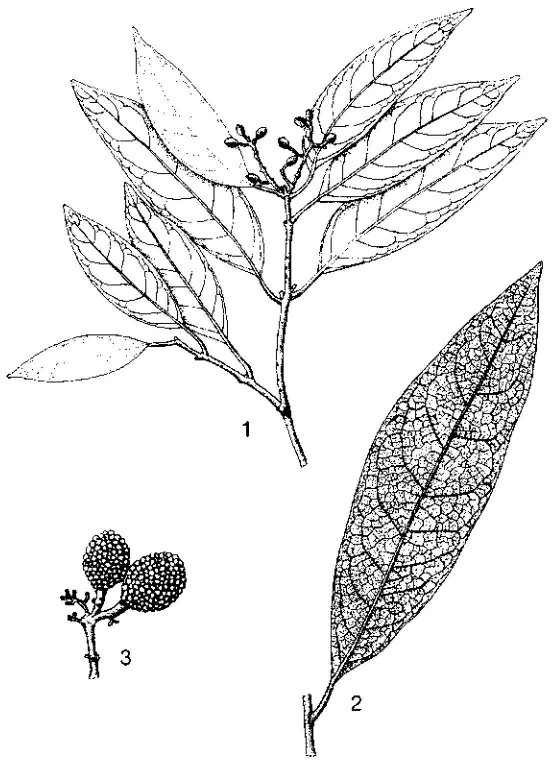
Synonyms *Beilschmiedia archboldiana* Allen (1942).

Distribution New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 26 m tall, bole branchless for up to 21 m, up to 60 cm in diameter, buttresses absent, bark surface smooth or flaking in small patches, brown or pale brown; leaves alternate to subopposite, 5–15 cm × 2–5 cm, glabrous above, pubescent below, midrib prominent on both surfaces, tertiary venation loosely reticulate above, prominent below, petiole 0.3–1.5 cm long; flowers minutely pubescent; fruit ellipsoid, 1.4–1.6 cm × 0.9–1.1 cm. *B. acutifolia* occurs in primary lowland and montane forest up to 1500 m altitude.

Selected sources 13, 316, 322, 635.



Beilschmiedia dictyoneura Kosterm. – 1, fruiting twig; 2, leaf; 3, branchlet with dried warty fruits.

Beilschmiedia dictyoneura Kosterm.

Reinwardtia 7: 24 (1965).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 55 cm in diameter, buttresses short or absent, bark surface smooth to finely fissured or dippled, grey-brown, inner bark reddish-brown; leaves opposite or subopposite, 7–20 cm × 1–5.5 cm, glabrous, midrib raised above, tertiary veins laxly reticulate, more distinct above than below, petiole 0.8–1.5 cm long; flowers pilose; fruit ellipsoid to oblong, up to 15 mm × 12 mm. *B. dictyoneura* is fairly common but occurs scattered in lowland and hill forest up to 1000 m altitude.

Selected sources 316, 317, 705.

Beilschmiedia dilmyana Kosterm.

New and Crit. Mal. Pl. IV: 23, fig. 12, 15 (1955).

Distribution Papua New Guinea and the Aru Islands.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 27 m tall, bole up to 40 cm in diameter; leaves alternate, 8–12 cm × 20–27 cm, glabrescent, midrib flattened above and prominent below, tertiary venation not visible or obscure below, petiole 1.5–2 cm long; flowers densely minutely brown sericeous; fruit unknown. *B. dilmyana* is found in rain forest at low altitude.

Selected sources 310, 316.

Beilschmiedia eusideroxylocarpa (Kosterm.) Kosterm.

Reinwardtia 8: 23 (1970).

Synonyms *Endiandra eusideroxylocarpa* Kosterm. (1960).

Distribution Borneo (Brunei and Sarawak).

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 55 cm in diameter, with buttresses up to 1 m high, bark surface scaly; leaves alternate, 4–7 cm × 1.5–4 cm, glabrous, midrib slightly prominent above, petiole c. 0.5 cm long; flowers glabrous; fruit ellipsoid, up to 13 cm × 5.5 cm. *B. eusideroxylocarpa* is insufficiently known and found on ridges on sandy loam soil up to 1250 m altitude.

Selected sources 314, 316, 322.

Beilschmiedia gigantocarpa Kosterm.

New and Crit. Mal. Pl. IV: 23, fig. 12, 15 (1955).

Vernacular names Indonesia: palumbakuni, tambara (Sulawesi).

Distribution Central Sulawesi (Malili District).

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole branchless for up to 10 m, up to 70 cm in diameter, with buttresses up to 2 m high, bark surface smooth, grey, inner bark red to dark red; leaves opposite, 5–15 cm × 15–30 cm, glabrous, midrib flattened above and prominent below, tertiary venation reticulate and slightly prominent on both surfaces, petiole 2–2.5 cm long; flowers glabrous; fruit subglobose, up to 8 cm × 7 cm. *B. gigantocarpa* is locally common at low altitude.

Selected sources 310, 316.

Beilschmiedia glabra Kosterm.

Reinwardtia 7: 22 (1965).

Distribution Peninsular Malaysia (rare), Sumatra (rare) and Borneo.

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 80 cm in diameter, without or with small buttresses, bark surface smooth to finely cracked, dark red-brown, inner bark creamy to orange-brown with a sour smell; leaves opposite, 10–15 cm × 3.5–6 cm, glabrous, midrib impressed above, tertiary venation prominent on both surfaces, petiole 2–3(–4) cm long; flowers with perianth lobes sparsely minutely pilose inside; fruit ellipsoid, up to 2.5 cm × 3.5 cm. *B. glabra* occurs in primary lowland forest, sometimes in marshy locations, also on limestone, up to 1200 m altitude.

Selected sources 317, 705.

Beilschmiedia insignis Gamble

Kew Bull.: 147 (1910).

Vernacular names Malaysia: medang (general).

Distribution Peninsular Malaysia.

Uses The wood is used as medang.

Observations A medium-sized tree up to 34 m tall, bole up to 60 cm in diameter, bark surface smooth, lenticellate, grey to dark grey, inner bark dark brown; leaves opposite to alternate, 11–35 cm × 6–12 cm, glabrous, midrib flattened above and keeled below, tertiary venation faint above and raised below, petiole 2–3.5 cm long; flowers glabrous; fruit subglobose, up to 4 cm in diameter, short-beaked. *B. insignis* occurs scattered in moist locations in lowland and montane forest. The density of the wood is about 575 kg/m^3 at 15% moisture content.

Selected sources 140, 181, 316, 529, 705, 734.

Beilschmiedia lucidula (Miq.) Kosterm.

Reinwardtia 8: 23 (1970).

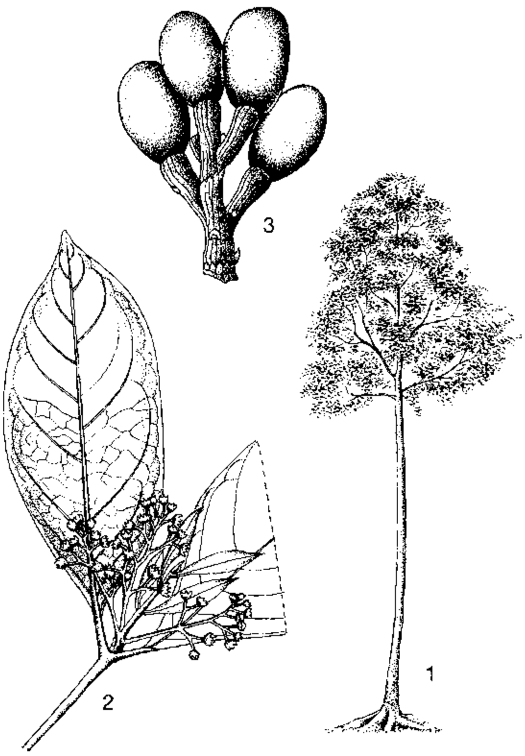
Synonyms *Cryptocarya lucidula* Miq. (1858), *Beilschmiedia praecox* Koord. & Valeton (1904), *Beilschmiedia nervosa* (Elmer) Merr. (1915), *Beilschmiedia assamica* auct. non Meissn.

Vernacular names Indonesia: brabas (Java). Philippines: bagaoring (Samar-Leyte Bisaya), ilak (Bagobo), lalanig (Subanun).

Distribution Peninsular Malaysia, Borneo, the Philippines and the extreme east of Java.

Uses The wood is used as medang.

Observations A medium-sized tree up to 21 m tall, bole up to 65 cm in diameter, bark surface smooth with scattered lenticels, greenish-grey; leaves opposite, 5.5–18 cm × 3.5–8.5 cm, glabrous, midrib raised above and below, tertiary venation distinct on both surfaces, petiole 0.5–1.8 cm long; flowers glabrous or hairy inside; fruit obovate to ellipsoid, 2–2.5 cm × 1–1.5 cm. *B. lucidula* was formerly thought to be identical to *B. assamica* Meissn. from India and mainland South-East Asia, but this proved to be incorrect. It occurs in primary lowland forest on periodically dry soil, volcanic sands and in swamps, up to 1200 m altitude. The density of the wood is 555–685 kg/m^3 at 15% moisture content.



Beilschmiedia lucidula (Miq.) Kosterm. – 1, tree habit; 2, flowering twig; 3, branchlet with fruits.

Selected sources 35, 77, 140, 303, 316, 322, 419, 421, 426, 474, 527, 705.

Beilschmiedia madang Blume

Mus. Bot. Lugd.-Bat. 1(21): 332 (1851).

Synonyms *Beilschmiedia malaccensis* (Meissn.) Hook.f. (1886), *Beilschmiedia curtisii* Gamble (1910), *Beilschmiedia scortechinii* Gamble (1910).

Vernacular names Indonesia: huru (Sundanese, Java), mauseu tahang (Simeuluë, Sumatra). Malaysia: medang mekolopon (Peninsular).

Distribution Peninsular Malaysia, Singapore, Simeuluë, Bangka and western Java.

Uses The wood is used as medang, e.g. for house building.

Observations A medium-sized tree up to 24 m tall, bole branchless for up to 18 m, up to 50 cm in diameter, with buttresses up to 1.5 m high, bark surface smooth, lenticellate, fawn, inner bark red; leaves alternate, 6.5–30 cm × 2–13 cm, glabrous to reddish-brown pubescent below, midrib raised above, tertiary venation faint above and distinct below, petiole 1–3 cm long; flowers hairy; fruit oblong, c. 2.5 cm × 1–1.5 cm. *B. madang* occurs scattered in lowland and lower montane forest up to 1250 m altitude. The density of the wood is 490–590 kg/m^3 at 15% moisture content.

Selected sources 35, 77, 78, 181, 234, 303, 465, 474, 529, 705.

Beilschmiedia micrantha Merr.

Univ. Calif. Publ. Bot. 15: 85 (1929).

Vernacular names Malaysia: medang wangi (Sabah).

Distribution Borneo (Sabah).

Uses The wood is used as medang, e.g. for light construction and flooring.

Observations A tree with a bole up to 45 cm in diameter; leaves 15–20 cm × 4.5–12 cm, midrib prominent below, petiole 1–1.5 cm long; flowers densely pubescent; fruit subglobose, 1.5–2 cm in diameter. *B. micrantha* is still insufficiently known, occurring in humid lowland forest. The density of the wood is about 480 kg/m^3 at 15% moisture content.

Selected sources 12, 77, 427, 549.

Beilschmiedia morobensis Kosterm.

Reinwardtia 8: 24 (1970).

Distribution New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 110 cm in diameter, bark surface rough, peeling off in small irregular flakes, red-brown, inner bark wine-red, marbled; leaves alternate, 6–9 cm × 2–4 cm, glabrous, midrib pustular, slightly prominent on both surfaces, tertiary venation obscurely prominent on both surfaces, petiole 0.5–0.8 cm long; flowers minutely tomentose; fruit unknown. *B. morobensis* is found from sea-level up to 1200 m altitude.

Selected sources 322.

Beilschmiedia novoguineensis Teschn.

Bot. Jahrb. Syst. 58: 401 (1923).

Synonyms *Endiandra sphaerica* Allen (1942).

Distribution Papua New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 20 m tall, bark surface greyish; leaves 7–20 cm × 1–5 cm, glabrous, midrib sunken above, prominent below, tertiary venation laxly reticulate above, petiole 0.7–1.2 cm long; flowers sparsely pilose; fruit globose, 1.0–1.1 cm in diameter, apiculate. *B. novoguineensis* is incompletely known, occurring in rain forest up to 850 m altitude.

Selected sources 13, 316, 635.

Beilschmiedia palembanica (Miq.) Kosterm.

Reinwardtia 4: 31 (1956).

Synonyms *Cryptocarya palembanica* Miq. (1862), *Beilschmiedia longipes* Hook.f. (1886), *Beilschmiedia sumatrensis* Ridley (1923).

Vernacular names Indonesia: medang kuning (Sumatra).

Distribution Peninsular Malaysia and Sumatra.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 55 cm in diameter, with buttresses up to 1 m high, bark surface smooth, lenticellate, grey, inner bark chocolate-brown; leaves subopposite to alternate, 9–24.5 cm × 3–8.5 cm, slightly hairy below, grey above when dry, midrib sunken and covered with powdery hairs above, tertiary venation prominently reticulate and distinct below, petiole 0.5–2 cm long; flowers hairy; fruit subglobose, c. 1.5 cm × 1 cm. *B. palembanica* occurs scattered in lowland and lower montane forest up to 1400 m altitude.

Selected sources 310, 316, 705.

Beilschmiedia podagrica Kosterm.

Reinwardtia 7: 294 (1968).

Distribution Papua New Guinea and Biak Island.

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 38 m tall, bole branchless for up to 25 m, up to 120 cm in diameter, with buttresses up to 1.5 m high, bark surface slightly rough with many shallow fissures, dark brown or grey-brown, inner bark straw-coloured; leaves arranged spirally, 11–15 cm × 3.5–9.5 cm, glabrous, midrib slightly prominent above, prominent below, tertiary venation not prominent above, laxly reticulate and prominent below, petiole 2–3 cm long; flowers unknown; fruit globose, c. 1.2 cm in diameter. *B. podagrica* is found in lowland and hill forest up to 1100 m altitude.

Selected sources 318.

Beilschmiedia pustulata Kosterm.

Reinwardtia 8: 28 (1970).

Synonyms *Endiandra dielsiana* Teschn. (1923), *Endiandra archboldiana* Allen (1942), *Endiandra glandulosa* Allen (1942).

Distribution New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to at least 30 m tall, bole branchless for up to 12 m, up to 50 cm in diameter, bark surface rough or shallowly fissured and scaly, grey to dark brown or blackish; leaves alternate to subopposite, 5–15 cm × (2.5–)4.5–8.5 cm, glabrescent, pustulate, midrib impressed above and prominent below, petiole 1–1.5 cm long; flowers pubescent inside; fruit ellipsoid, c. 2.5 cm × 1.5 cm. *B. pustulata* is locally common in primary forest, sometimes in *Nothofagus* forest, on hills and ridges, at 500–1750 m altitude.

Selected sources 13, 316, 321, 322, 635.

E. Boer (general part),
M.S.M. Sosef (general part, selection of species),
S.I. Wiselius (properties),
R.P. Escobin (wood anatomy)

Bischofia Blume

Bijdr. fl. Ned. Ind., part 17: 1168 (1827).
EUPHORBIACEAE
x = unknown; *B. javanica*: $2n = 98$

Trade groups Bishop wood: medium-heavy hardwood, a single species: *Bischofia javanica* Blume, Bijdr. fl. Ned. Ind., part 17: 1168 (1827).

Vernacular names Bishop wood: Java cedar (En). Bois de l'évêque (Fr). Indonesia: gadog (general), gintungan (Javanese), kerinjing (Sumatra). Malaysia: jitang (Peninsular), tuai (Sabah). Papua New Guinea: Java cedar. Philippines: tuai (Filipino). Laos: 'khom 'fat, 'foung 'fat. Thailand: toem, pradu-som (general). Vietnam: nhoi.

Origin and geographic distribution *Bischofia* comprises 2 species. One occurs in China only. The other (*B. javanica*) is much more widespread and is found from India and the Himalaya to China, Taiwan, southern Japan, Indo-China, Thailand and throughout the Malesian area (but rare in Peninsular Malaysia and large parts of Borneo) towards north-eastern Australia and the Pacific east to Samoa and Tonga. It is locally planted as a timber plantation species and as an ornamental in its natural area of distribution (e.g. near Medan, Sumatra), and has been introduced as a fast growing ornamental tree in East Africa and South Africa, and in the United States (California, Florida) where it has become a weed.

Uses Bishop wood is used for general construction (beams, posts), bridges, decking, sleepers, mining props, flooring, interior finish, joinery, furniture, lining, agricultural implements, charcoal, carving, pencils and billiard cue butts. It is a potential source of long fibres for pulp and paper production, and is also suitable for the production of veneer and plywood, and charcoal.

In India, it is considered to be an excellent shade tree in coffee and cardamom plantations. In Polynesia, a red dye is extracted from the bark. The bark also contains tannin, used for toughening nets and ropes.

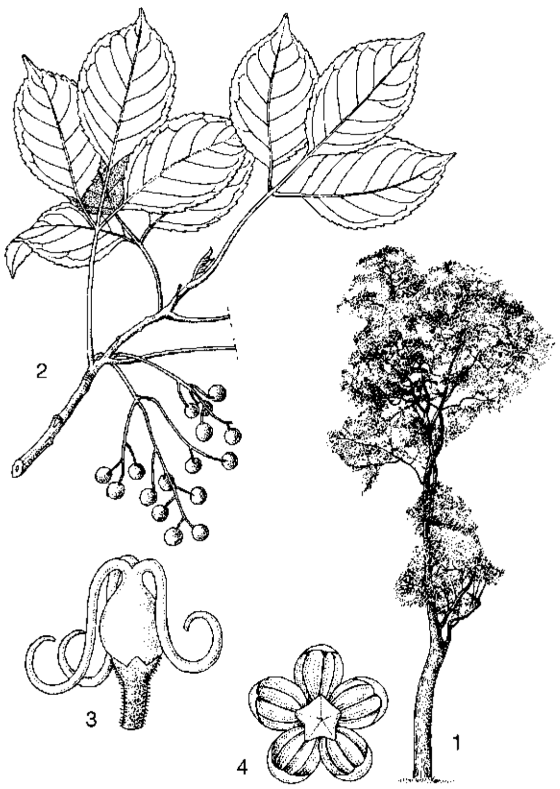
Production and international trade No statistics are available on international trade of Bishop wood, but it is regarded as a commercial hardwood in Papua New Guinea. The wood is probably mostly consumed locally.

Properties Bishop wood is medium-weight and moderately hard to hard. The heartwood is purplish-brown to reddish-brown and is sharply differentiated from the narrow, pale brown to pale reddish-brown sapwood. The density is 520–1010 kg/m^3 at 15% moisture content. The grain is generally interlocked, texture moderately fine to rather coarse and even. The wood surface is rather dull to slightly glossy. Fresh wood smells of vinegar.

At 12% moisture content, the modulus of rupture is 102–111 N/mm^2, modulus of elasticity 10 500–11 455 N/mm^2, compression parallel to grain 45.5–59.5 N/mm^2, shear 17–21 N/mm^2, cleavage 83 N/mm radial and 118 N/mm tangential, Janka side hardness 7445–8180 N and Janka end hardness 9645–11 325 N. See also the table on wood properties.

The rates of shrinkage of Bishop wood are moderate to high: from green to 12% moisture content 1.0–2.6% radial and 3.2–6.2% tangential, from green to oven dry 3.9% radial and 7.5% tangential. It is difficult to season Bishop wood, because of its tendency to check, split and warp, especially in back-sawn boards. Defects may be diminished by quarter sawing. Air drying 2 cm thick boards from green to 30% moisture content takes 2 months. Kiln drying requires a mild schedule. A dry bulb temperature of 38–60°C and a corresponding relative humidity of 86–38%, or 41–57°C and 60–15%, respectively, are recommended.

Bishop wood is rather difficult to saw when dry, but it seems to be fairly easy to saw green. It can be bored and mortised with very good results; planing, shaping, turning and sanding give good to very good results. Good veneer can be produced at a peeling angle of 92° without pretreatment, but the veneer is wavy after drying. Gluing the ve-



Bischofia javanica Blume – 1, tree habit; 2, fruiting twig; 3, female flower with calyx removed; 4, male flower.

neer with urea-formaldehyde produces a plywood complying with the Japanese standard. Sulphate pulping yields a pulp with a high overall strength; hence a strong paper can be manufactured from Bishop wood.

Bishop wood is classified as moderately durable to durable. It is susceptible to *Lyctus* and dry-wood termite attack, whereas its susceptibility to wood-rotting fungi varies from not resistant to resistant. Longhorn and ambrosia beetles have also been recorded in Bishop wood. The heartwood is difficult to treat with copper-chrome-arsenic preservative by the vacuum-pressure process, but the sapwood can be easily penetrated by preservatives. Hot soaking on an experimental scale for 1, 3 and 5 hours using BFCA resulted in penetrations of 3.7, 4.5 and 5.4 mm with retentions of 2.8, 2.2 and 2.3 kg/m^3, respectively.

Bishop wood contains 49–51% cellulose, 23–42% lignin, 9.7–14.4% pentosan, 0.4–1.1% ash and 0.4–1.7% silica. The solubility is 1.4–8.0% in alcohol-benzene, 4.1% in cold water, 5.0–5.8% in hot water and 11.1–29.4% in a 1% NaOH solution. The wood is not very suitable as a fuelwood.

The bark contains about 16% tannin.

Description Dioecious, usually deciduous, medium-sized to fairly large, occasionally large trees up to 35(–50) m tall; bole straight or poorly shaped, branchless part usually short but sometimes up to 20 m long, up to 80(–170) cm in diameter, sometimes with steep buttresses up to 3 m high; bark fissured and scaly with small thick shaggy scales, reddish-brown to purplish-brown, inner bark fibrous, spongy, pink, exuding a red sap; crown dense and rounded. Leaves arranged spirally, pinnately 3-foliolate, glabrous; petiole 8–20 cm long; stipules oblong-triangular, papery, 7–22 mm long, early caducous; leaflets elliptical to ovate, 6–16 cm × 3–10 cm, base rounded to broadly cuneate, apex acuminate, margin finely crenate-serrate, pinnately veined, shiny above, terminal leaflet long-stalked. Flowers unisexual, actinomorphic, 5-merous, small, greenish, apetalous; disk absent. Male flowers in an axillary, many-flowered, 9–20 cm long panicle; sepals united at base, hooded; stamens 5, free, opposite to the calyx lobes; pistillode broadly peltate and short-stalked. Female flowers in a lax, 15–27 cm long panicle; calyx lobes 5, caducous; staminodes very small; ovary superior, globose, 3(–4)-celled, with 2 apical pendulous ovules per cell, style short, with 3 long and spreading to recurved stigmas. Fruit a globose drupe, indehiscent, 1.2–1.5 cm across, bluish-black, with a horny to leathery pericarp and fleshy mesocarp; cells 1–2-seeded. Seed oblong to obovoid, about 5 mm long, brown. Seedling with epigeal germination; cotyledons leafy, petiolate; first few leaves simple, next ones unifoliolate, subsequent ones (from about the 10th leaf) 3-foliolate.

Wood anatomy

– Macroscopic characters:

Heartwood purplish-brown or dark reddish-brown or brown, distinctly demarcated from the pale cream-coloured to reddish-brown or pink sapwood. Grain usually interlocked. Texture medium; wood slightly lustrous. Growth rings indistinct; vessels barely visible to the naked eye, easily seen with hand lens; parenchyma not distinct; rays narrower than vessels; ripple marks absent.

– Microscopic characters:

Growth rings absent. Vessels diffuse, 5–20/mm^2, solitary and in radial multiples of 2–4(–5), radial multiples of 4 common in some samples, solitary vessels oval in outline, average tangential diameter 140–160 μm, maximum tangential diameter

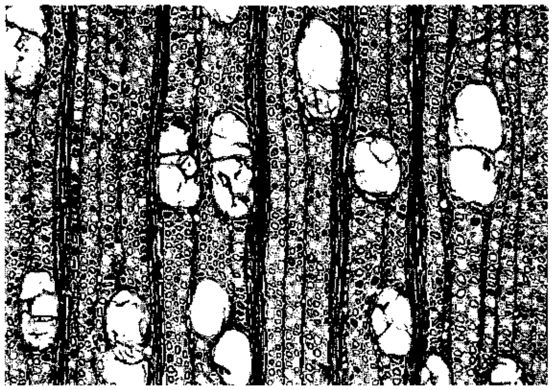
200 μm; perforations exclusively simple; intervessel pits alternate, non-vestured, polygonal, 10–14 μm; vessel-ray pits coarse with reduced borders or simple, elongated and scalariform to more or less circular or irregular in outline; helical thickenings absent; thin-walled tyloses common. Fibres 1200–3200 μm long (2100–2500 μm on average), septate, mostly medium thick-walled, with a few conspicuous simple pits in the radial walls. Axial parenchyma absent to rare, with an occasional cell touching a vessel. Rays 3–7/mm, tending to be of 2 sizes, 1-seriate and 4–5(–6)-seriate, total multiseriate ray height, including uniseriate margins, up to 2–3 mm, range of the height of the multiseriate portion of the ray 200–1500 μm (550–700 μm on average), multiseriate rays heterocellular with 1–10 rows of upright cells, sheath cells sometimes present, uniseriate rays common and composed of upright cells (rays generally conform to Kribs type heterogeneous I and II). Solitary prismatic crystals common in upright and square ray cells, cells with crystals non-chambered or with 2–4 chambers. Oil cells, canals and storied structure absent.

Growth and development The seedlings show a fast root growth. The taproot is tuberous for a short length and then tapers quickly. Thin but long secondary roots are present below the collar region.

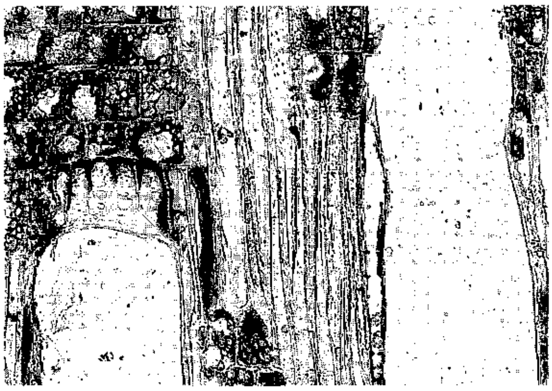
Growth is comparatively slow during the first 3 years, becoming fairly rapid in subsequent years. Under normal conditions, an average annual diameter increment of 1.0 cm and an average annual height increment of 1 m can be obtained. Exceptions have been reported, e.g. a diameter at breast height of 41 cm for 18-year-old trees and a height of 7.5 m for 3-year-old trees and of 10 m for 6-year-old trees.

Bishop wood flowers every year from an age of about 8 years onward. In West Java, flowering usually takes place in August–November(–December) and mature fruits can be found in (January–)February–June with a peak in March. In Central Java, the fruiting period is from May–November, in East Java from November–December.

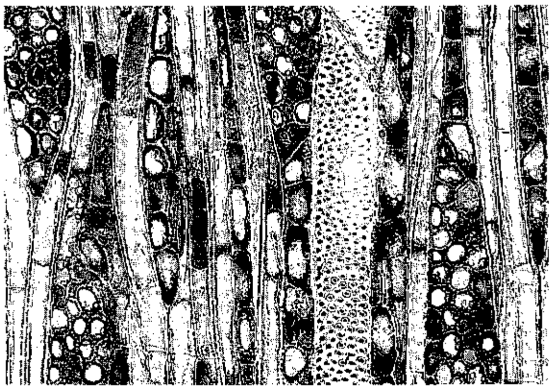
Other botanical information *Bischofia* is an aberrant genus within the *Euphorbiaceae*, mainly because of its pinnately 3-foliolate leaves and fleshy, indehiscent fruits, and has alternatively been accommodated into a plant family of its own (*Bischofiaceae*) or in the *Staphyleaceae*. However, embryological and leaf anatomical evidence support its position within the *Euphorbiaceae*, where it is regarded as the only genus of the tribe



transverse section (×35)



radial section (×75)



tangential section (×75)

Bischofia javanica

Bischofieae within the subfamily *Phyllanthoideae*.

Ecology Bishop wood prefers areas with a more or less distinct dry season (climate types B and C). Its altitudinal range is from sea-level to 1800 m. Bishop wood is fairly common but usually found scattered in primary and old secondary dry and deciduous forest or monsoon forest but also in evergreen forest, swamp forest and teak forest, sometimes in more open places like savanna tracts. It is most frequent on river banks, shady ravines and prefers deep, loose soils such as sandy, rocky or loamy soils with sufficient water content; occasionally it is found on limestone. In the monsoon forest of Timor, Bishop wood has been found in association with *Alstonia scholaris* (L.) R.Br., *Cordia subpubescens* Decne., *Exocarpos latifolia* R.Br., *Ficus saxophila* Blume, *Tetrameles nudiflora* R.Br. and *Toona sureni* (Blume) Merr.
Bishop wood is reported to be the only tall tree of secondary forest in the Philippines.

Propagation and planting Bishop wood can be propagated by seed, wildlings and stem cuttings. One kg contains 61 500–90 000 dry seeds. Seed may be collected in large quantities and can be stored for up to 6 months. Bishop wood is well suited for large-scale plantations. Seed may be sown under shade or in full sunlight, provided watering is adequate. Germination starts 1–3 weeks after sowing and after 5–6 weeks about 70% of the seed has germinated. Young plants need plenty of water; therefore, direct sowing in the field is not appropriate. In India, 7-month-old seedlings attained a height of 50–80 cm and containerized and bare-rooted seedlings planted under shade in the field showed 90% and 50–70% survival, respectively.
Stumps should be robust, at least 2.5 cm in diameter, to give a survival of close to 100%. Recommended shoot and root length are 20 cm and 30 cm, respectively. The survival rate drops sharply when thinner stumps are used.
In Java, Bishop wood has been planted in pure stands at 2 m × 3 m, and in mixed plantations in alternating rows with *Calophyllum inophyllum* L. and *Bombax ceiba* L. at 1 m × 3 m, and with *Acacia mearnsii* De Wild. at 2.5 m × 5 m. Survival rates of wildlings and stumps with a shoot length of 20 cm and a root length of 30 cm are close to 100%.

Silviculture and management Self-pruning of thick branches in Bishop wood is good once the canopy of the stand closes, which is at least 5 years or more after planting at a spacing of 2 m × 3 m. Planting at a closer spacing is recommended to reduce this period. Pruning wounds heal very well; the tree may survive girdling involving the removal of a strip of bark 30 cm wide. The tree may develop forks as a result of attacks by top and twig-boring insects.
Roots spread out superficially and the tree sprouts vigorously after cutting, making it difficult to eradicate.

Diseases and pests In Java, young trees are heavily attacked by top and twig-borers, causing failure of plantations in less suitable locations. On favourable sites, the trees can grow rapidly and survive attack. Caterpillars of *Metanastria hyrtaca* and *Selepa celtis* are found feeding on the foliage of Bishop wood. In Indonesia, fungi reported to attack the trees are *Corticium salmonicolor* and *Glomerella cingulata*, of which the conidial state is *Colletotrichum gloeosporioides*. In southern China, Bishop wood has suffered severely from witches' broom.

Yield In Java, an 8-year-old pure plantation on a moderately fertile soil and with a planting space of 2 m × 3 m yielded 12 m^3/ha of clear-bole wood.

Genetic resources *B. javanica* has a large area of distribution and is planted in trial plantations, so it does not seem to be endangered. No conservation of genetic material in germplasm or seed banks, nor any activities related to breeding have been reported.

Prospects Because it frequently contains defects and has interlocked grain, the timber of Bishop wood is less suitable for sawnwood applications. However, good-quality plywood and paper can be manufactured from it and Bishop wood shows several positive features for the establishment of plantations, in pure or mixed stands. Breeding borer-resistant trees would make it more worthwhile to plant Bishop wood on less favourable soils. More research is needed into silvicultural aspects.

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Other selected sources 2, 3, 8, 36, 51, 61, 77, 78, 88, 125, 126, 135, 140, 145, 167, 168, 169, 170, 234, 260, 289, 297, 330, 357, 381, 411, 448, 486, 522, 526, 528, 534, 555, 574, 595, 614, 617, 648, 656, 676, 679, 689, 721, 747.

B. Sunarno (general part),
A. Martawijaya (properties),
E. Wheeler (wood anatomy)

Burckella Pierre

Not. bot. Sapot.: 3 (1890).
SAPOTACEAE
x = unknown

Trade groups Burckella: moderately heavy hardwood, e.g. *Burckella macropoda* (Krause) H.J. Lam, *B. obovata* (J.G. Forster) Pierre.

Vernacular names Burckella. Indonesia: kaum (Irian Jaya).

Origin and geographic distribution *Burckella* consists of about 14 species and is distributed from the Moluccas and New Guinea to Fiji, Samoa and Tonga. About 6 species occur in Malesia. *B. obovata* has the largest area of distribution, from Halmahera (the Moluccas) to Vanuatu, and is cultivated for its fruits in this area and also in Java.

Uses The wood is suitable for light construction, furniture, doors, interior fittings, flooring, moulding, joinery and veneer; locally it is also used for poles of houses, and in the Solomon Islands also for canoes and carving.

The fruits of *B. obovata* are edible, and the tree is often cultivated in home gardens. Fruits and leaves are used in New Guinea for making dyes. The bark exudes a latex sometimes utilized in making chewing gum and in electric cables.

Production and international trade No statistics are available on production and trade, but Japan imports small amounts of *Burckella* timber, mainly from Papua New Guinea (about 1% of the total timber import from Papua New Guinea). The timber is ranked in Papua New Guinea in MEP (Minimum Export Price) group 2, and in 1992 fetched a minimum price for saw logs of US\$ 60/m^3. In the Solomon Islands, it is ranked among the commercially important timbers.

Properties *Burckella* is a moderately heavy and hard wood, resembling nyatoh from other *Sapotaceae* genera such as *Palaquium*. The heartwood is pinkish-brown to red-brown, and not distinctly demarcated from the paler sapwood which is 4–5 cm wide. The density is 590–790 kg/m^3 at 15% moisture content. The grain is usually interlocked, sometimes straight, texture moderately fine to coarse.

At 14% moisture content the modulus of rupture of *B. macropoda* wood from Papua New Guinea is 120 N/mm^2 and the modulus of elasticity 14 100 N/mm^2.

Shrinkage during drying is moderate to fairly high: from green to 15% moisture content 1.5–2.1% radial and 4.1–4.9% tangential, from green to 12% moisture content about 2.4% radial and 5.7% tangential, and from green to oven dry 3.9–5.0% radial and 8.3–9.3% tangential. Deformation on cross section (collapse) may be moderately severe during kiln drying. Wet cores may remain after drying and back-sawn planks may develop long surface checks. Preliminary air drying is recommended for thick boards.

The wood contains silica (up to 1.9% in *B. obovata*); this may cause problems in sawing. Tests show that the wood performs very good in planing, shaping, boring, mortising and sanding, and fair in turning. The peeling properties are usually poor, even when pre-heated. Dust of dry wood is irritating to nose, throat and eyes.

The wood is only moderately durable. Logs may be attacked by pinhole borers and termites. The sapwood is not susceptible to *Lyctus* attack. The heartwood is difficult to treat with preservatives, but the sapwood is much easier; a test on wood of *B. macropoda* using a pressure treatment showed an absorption of the heartwood of 41 kg/m^3 and of the sapwood of 357 kg/m^3.

The yield of pulp is usually low; unbleached pulp is rather dark. However, the yield of pulp of *B. macropoda* wood for fibreboard may be as high as 85% at a steaming temperature of 185°C.

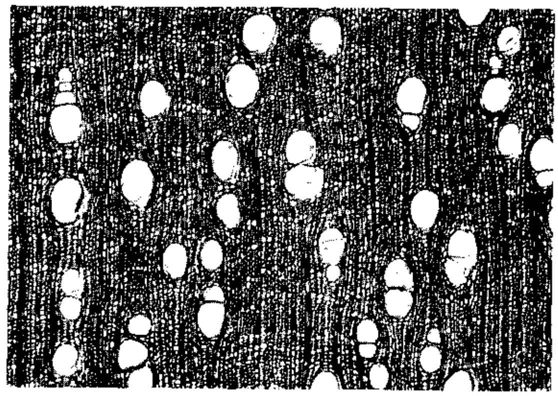
The wood of *B. macropoda* contains 35% lignin, 67% holocellulose and 50% α-cellulose (calculated on an ash- and lignin-free basis) and 1.9% ash. The solubility is 1.2% in alcohol-benzene, 2.4% in cold water, 3.5% in hot water and 14.7% in a 1% NaOH solution. *Burckella* wood contains saponin.

Description Medium-sized to fairly large, laticiferous trees up to 50 m tall; bole columnar or tapering, branchless for up to 25 m and up to 100 cm in diameter, with buttresses up to 2 m high; bark 1–2 cm thick, bark surface greyish-brown with irregular fissures stripping off in small pieces, inner bark fibrous, brown to pale red-brown. Leaves arranged spirally, often crowded at tip of branches, simple and entire, usually obovate, loop-veined with tertiary venation parallel to secondary veins, reticulate or oblique; stipules present or absent. Flowers in fascicles, densely clustered at tips of branchlets in the axils of scale leaves to form a pseudo-terminal inflorescence, bisexual; sepals 4, partially united, strongly imbricate; corolla with tube barbate at throat and 8(–9) imbricate, erect or slightly spreading lobes; stamens 16–18(–30), inserted in 1–2 rows at the top of the corolla tube, with free and geniculate filaments or anthers sessile, anthers extrorse; ovary (3–)4(–5)-locular, hairy or glabrous, often enveloped by an annular or patelliform nectary, style long, exserted. Fruit a large, 1-seeded berry, crowned by the persistent style. Seed usually broadly ellipsoid, sometimes dorsi-ventrally compressed, with very large hilum covering at least half of the seed surface; cotyledons plano-convex, endosperm absent.

Wood anatomy

– Macroscopic characters:

Heartwood pinkish-brown to reddish-brown, occasionally with irregular dark-coloured streaks, not distinctly demarcated from the paler sapwood (yellowish-white when fresh, turning to pale pink-



transverse section (×25)

radial section (×75)

tangential section (×75)

Burckella macropoda

ish on exposure). Grain generally interlocked. Texture usually coarse. Growth rings indistinct.

– Microscopic characters:

Vessels diffuse, occasionally with a fairly conspicuous tendency of radial arrangement depending on the species, 12–22/mm^2, solitary (usually scanty) and in radial multiples of 2–7(–15), 100–200 (–230) μm in tangential diameter; perforations simple; intervessel pits alternate, 6–8 μm in diameter; vessel-ray and vessel-parenchyma pits often elongated and gash-like and/or palisade-like; tyloses present and distinct. Fibres 890–1820 μm long, thick-walled (c. 5 μm thick), with numerous slit-like, simple to minutely bordered pits. Parenchyma apotracheal, abundant and forming a reticulate pattern, usually in 1-celled bands. Rays 12–15/mm, 1–2-seriate, (160–)200–1340(–1800) μm high, heterocellular with several rows of square and/or upright cells (Kribs type heterogeneous I–II). Silica bodies numerous in ray cells and scarce in axial parenchyma cells.

Species studied: *B. erythrophylla*, *B. macropoda*, *B. obovata*, *B. polymera*.

Growth and development *Burckella* is a fast-growing light demanding species with a spreading crown.

Other botanical information *Burckella* is closely related to *Madhuca*. It differs from the latter genus by its pseudo-terminal inflorescence, its partially united sepals, the usually 4-locular ovary, and its very broad seed scar; moreover, it usually has less numerous stamens and a larger fruit.

Ecology *Burckella* usually occurs in primary forest in the lowland, in the Moluccas on red-yellow podzolic soils up to 250 m altitude, but in New Guinea up to 1000 m. It is locally common, especially in flood plains in northern Papua New Guinea and the Solomon Islands (*B. obovata*). It thrives in areas with a climatic type B and has been found in association with *Homalium foetidum* (Roxb.) Benth., *Pometia pinnata* J.R. Forster & J.G. Forster, *Intsia bijuga* (Colebr.) O. Kuntze, *Canarium* spp. and *Diospyros* spp.

Propagation and planting In Papua New Guinea, germination of *Burckella* seed is satisfactory. Wildlings are also used for planting stock production and their development in the nursery is favourable.

Silviculture and management Regeneration of *Burckella* in natural forest is profuse. Although it is a light-demanding species, it tolerates shade very well.

Harvesting In the Solomon Islands the fruits of *B. obovata* are harvested shortly before they are ripe to prevent damage.

Yield A log of *B. macropoda* may yield up to 6.1 m^3 of timber in New Britain (Papua New Guinea).

Handling after harvest Green wood has a high moisture content (about 97% in *B. macropoda*), and the logs usually do not float in water. The fruits of *B. obovata* are usually eaten raw, but sometimes they are baked (often 'earth baked') which enables short-term preservation. Long-term preservation can be achieved by 'pit fermentation', a process commonly used for breadfruit (*Artocarpus* spp.).

Genetic resources Several *Burckella* species occur very locally (e.g. *B. erythrophylla* and *B. magusum* P. v. Royen in New Guinea) and could be easily endangered as a result of indiscriminate logging.

Several cultivars of *B. obovata* have been recognized in the Solomon Islands based on the shape and taste of the fruits.

Prospects Very little is known about the ecology and regeneration of *Burckella*, and there is only limited experience with planting *Burckella* in Papua New Guinea, apart from cultivation of *B. obovata* as a fruit tree. Its fast growth and light-demanding character make it a promising plantation species. More research on silvicultural aspects is needed.

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Selection of species

Burckella erythrophylla H.J. Lam

Nova Guinea 14: 554, t. 100 (1932).

Distribution Papua New Guinea.

Uses The timber is reputed to be used. The leaves can be used for making a red dye.

Observations A medium-sized to large tree, up to 50 m tall, with bole up to 80 cm in diameter and spur roots up to 2 m high and spreading out about 2 m from the bole; leaves obovate, 3–10 cm × 2–4 cm, glabrous, reddish when dry, petiole up to 2 cm long; pedicels up to 1 cm long; fruit ellipsoid, up to 7 cm × 4.5 cm. *B. erythrophylla* is not common and grows in primary forest.

Selected sources 343, 345, 659.

Burckella macropoda (Krause) H.J. Lam

Nova Guinea 14: 554, t. 99 (1932).

Synonyms *Illipe macropoda* Krause (1923), *Croixia macropoda* (Krause) Baehni (1965).

Vernacular names Papua New Guinea: rang rang (New Britain).

Distribution New Guinea, Fiji.

Uses The timber is used for light construction, furniture and plywood.

Observations A medium-sized to fairly large tree, up to 40 m tall, with bole branchless for up to 24 m and up to 65 cm in diameter, buttresses up to 2 m high; leaves narrowly obovate or obovate, 7–25 cm × 3–9 cm, glabrous, petiole up to 6.5 cm long; pedicels up to 3.5 cm long; fruit pear-shaped, up to 11 cm × 5 cm. Two varieties are distinguished: var. *macropoda* occurs in New Guinea up to 1000 m altitude, var. *macrantha* (H.J. Lam) H.J. Lam & P. v. Royen (synonym: *Burckella macrantha* H.J. Lam) occurs in Fiji. The density of the wood is 590–790 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 37, 343, 345, 491, 659, 731, 732.

Burckella obovata (J.G. Forster) Pierre

Not. bot. Sapot.: 4 (1890).

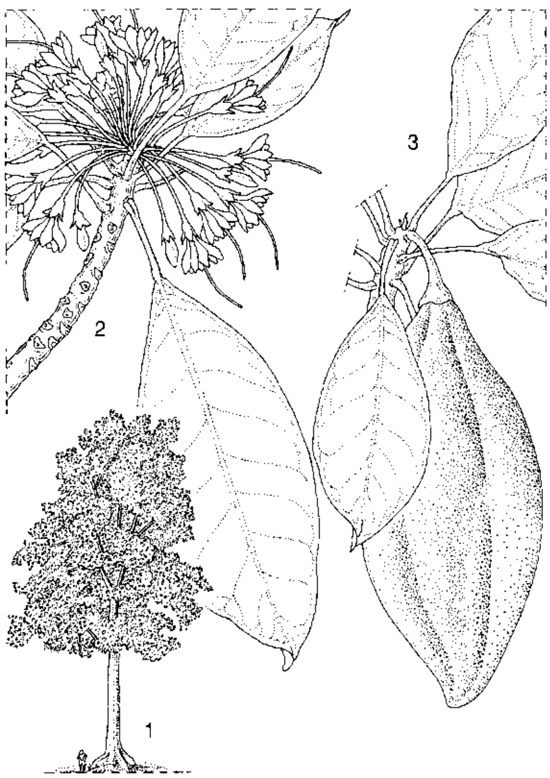
Synonyms *Bassia obovata* J.G. Forster (1786), *Burckella cocco* (R. Scheffer) Pierre (1890), *Croixia obovata* (J.G. Forster) Baehni (1965).

Vernacular names Red silkwood (En). Indonesia: balam (Moluccas), kaum (Irian Jaya). Papua New Guinea: burckella (general), evatnari, natu (New Ireland).

Distribution The Moluccas, New Guinea, Vanuatu, the Bismarck Archipelago and the Solomon Islands; locally cultivated in home gardens for the fruits in its area of distribution and also in Java.

Uses The timber is used for light construction, furniture, interior fittings, flooring, moulding and veneer, and locally also for poles of houses and canoes. The pleasantly smelling fruits with whitish flesh are edible.

Observations A medium-sized to fairly large tree up to 36 m tall, with columnar or tapering bole up to 100 cm in diameter, buttresses plank-like, up to 2 m high; leaves broadly obovate to obovate or elliptical, 10–30(–40) cm × 5–13 cm, glabrous, petiole up to 4(–7.5) cm long; pedicels up to 2.5 cm long; fruit ellipsoid to obovoid, up to 15 cm × 8 cm, furrowed. *B. obovata* occurs in lowland



Burckella obovata (J.G. Forster) Pierre – 1, tree habit; 2, flowering twig; 3, twig with fruit.

forest, often in coastal rain forest. The wood is pinkish-brown to reddish-brown and has a density of about 730 kg/m³ at 12% moisture content.

Selected sources 12, 36, 37, 145, 164, 229, 234, 289, 343, 345, 491, 673, 699, 706.

Burckella polymera P. v. Royen

Blumea 6(3): 590, fig. 3 (1952).

Vernacular names Indonesia: fala ko-ra, pwa (Irian Jaya).

Distribution New Guinea.

Uses The timber is used locally.

Observations A medium-sized to large tree, up to 50 m tall; leaves obovate, 9–22 cm × 4–9 cm, puberulous below, petiole up to 4 cm long; pedicels up to 3 cm long; mature fruit unknown. *B. polymera* grows in lowland rain forest. It is somewhat doubtful whether this species really belongs to *Burckella* as it has been described as having a 7–8-celled ovary. The density of the wood is about 670 kg/m³ at 12% moisture content.

Selected sources 145, 289, 345, 659.

Burckella poolei H.J. Lam

Nova Guinea 14: 555, t. 102 (1932).

Vernacular names Indonesia: javare etepako (Irian Jaya). Papua New Guinea: baiabu (Vailala).

Distribution The Moluccas and New Guinea.

Uses The timber is reputed to be used.

Observations A medium-sized tree up to 33 m tall, with bole up to 100 cm in diameter, spur roots present; leaves narrowly obovate, 12–30 cm × 3.5–7 cm, glabrous, petiole up to 3.5 cm long; pedicels up to 4 cm long; fruit unknown. *B. poolei* occurs in the Moluccas up to 250 m altitude.

Selected sources 343, 345, 706.

Burckella sorei P. v. Royen

Gard. Bull. Sing. 22: 33 (1967).

Distribution Papua New Guinea (Bougainville) and the Solomon Islands (Guadalcanal).

Uses The timber is used for light construction, interior finishing, mouldings and veneer.

Observations A medium-sized to fairly large tree up to 36 m tall, with bole up to 65 cm in diameter and buttresses up to 3 m high; leaves elliptical, c. 12.5 cm × 6 cm, glabrous, petiole up to 3 cm long; pedicels up to 4 cm long; fruit ovoid to ellipsoid, up to 15 cm long. *B. sorei* is sometimes confused with *B. obovata*, which differs in its usually larger, more obovate leaves with less fine venation and larger flowers. It occurs in lowland rain forest, usually on well-drained sites. The wood is fairly hard and heavy.

Selected sources 164.

R.H.M.J. Lemmens (general part, properties, selection of species),
S. Sudo (wood anatomy)

Canarium L.

Amoen. Acad. 4: 143 (1759).

BURSERACEAE

x = unknown; *C. ovatum*: $2n = 46$, $2n = 48$ for 2 species from Indo-China and China (*C. album* Raeuschel ex DC. and *C. pimela* König)

Trade groups Kedondong: lightweight to medium-weight hardwood, e.g. *Canarium hirsutum* Willd., *C. indicum* L., *C. littorale* Blume, *C. luzonicum* (Blume) A. Gray.

Kedondong is the standard trade name for all timber of the family *Burseraceae*, hence in addition to *Canarium* timber also including the timber of *Dacryodes, Garuga, Protium, Santiria, Scutinanthe* and *Triomma*.

Vernacular names Kedondong. Brunei: upi. Indonesia: kenari, kerantai. Malaysia: kerantai (Sabah), upi, seladah (Sarawak). Papua New Guinea: canarium, galip. Philippines: pili, pilingliitan, pagsahingin (Filipino). Thailand: makoem. Vietnam: tr[as]m.

Origin and geographic distribution *Canarium* consists of about 80 species and is distributed in the Old World tropics, from tropical Africa to tropical Asia, northern Australia and the Pacific. The main centre of diversity lies in the Malesian area where most species occur in the moister parts, hence in Peninsular Malaysia, Sumatra and Borneo in the west and New Guinea in the east.

Uses The timber, being part of the kedondong trade group, is used for house building, light or temporary constructions, doors, window frames, flooring, mouldings, interior finish, boxes, crates, furniture, joinery, prahus and canoes, veneer and plywood. It is locally preferred for tool handles and also used as firewood. The wood cannot be used for outdoor construction because it is non-durable and difficult to treat with preservatives. Paddles have been manufactured from the buttresses.

The fruits of some species are boiled and eaten; the pulp is edible. The fruit pulp also contains an oil, which is occasionally used for cooking and lighting. Several species have edible seeds. Occasionally, an edible oil is extracted from the kernels, which may be used as a substitute for coconut oil. In the Solomon Islands, the oil is used in skin and hair care products. The kernel, known as pilinut (or ngali in Melanesia), is used commercially for bakery products and as a flavouring for ice-cream. It can also be eaten roasted or boiled and forms an important element of rural cooking in Melanesia. The hard and thick shell enclosing the seeds makes an excellent fuel for cooking. When polished and varnished, the stone is an attractive ornament. The bark of a few species is known to yield tannin. Resin, known as 'Manila elemi' in the Philippines, is used locally as a varnish, for caulking boats, for torches, as a kind of glue for fixing metal in wood (e.g. for knives) and in local medicine; it is also exported for use in medicinal ointments, and occasionally in varnishes. In China, it is used to manufacture transparent paper used for making window panes. A decoction of the roots is also used for medicinal purposes. As well as being cultivated for its fruits and seeds, *Canarium* trees are also planted in windbreaks and their symmetrical branching makes them attractive avenue and shade trees.

Production and international trade Instead of being traded separately, *Canarium* timber is usually mixed with the timber of other *Burseraceae* genera and sold as kedondong. In 1983, 16 350 m^3 of kedondong sawlogs were exported from Peninsular Malaysia (69% to Singapore, 19% to South Korea and 12% to Hong Kong) with a total value of US$ 675 000, and in 1984 9500 m^3 (99% to Singapore and 1% to Japan) with a value of US$ 395 000 (US$ 42/m^3). The export of round logs from Sabah was only 1170 m^3 with a value of US$ 75 000 (US$ 64/m^3) in 1987, but in 1992 the export of kedondong timber from Sabah was much more: 15 000 m^3 (17% as sawn timber, 83% as logs) with a total value of US$ 1.3 million (US$ 170/m^3 for sawn timber and US$ 69/m^3 for logs). *Canarium* timber is often imported into Japan in consignments of 'mixed light hardwood'. Japan imports *Canarium* timber from Sabah, Sarawak, Papua New Guinea and the Solomon Islands.

The Philippines is the only country producing and processing pilinuts in commercial quantities. In 1983–1987, the annual volume was 2925 t of dried stones from an estimated area of 2700 ha. The most important pilinut-producing region is Bicol. The rural production of pilinuts in Melanesia is probably high.

Properties *Canarium* wood is lightweight to medium-weight and moderately soft to moderately hard. The heartwood is nearly white or buff-coloured to pale pinkish-brown or reddish-brown, sometimes with yellowish streaks. The sapwood is paler and often not clearly demarcated from the heartwood. The density is (360–)390–780(–815) kg/m^3 at 15% moisture content. The grain is rather straight to shallowly interlocked, texture fine to moderately coarse and even. Planed surfaces are lustrous and the wood has no distinctive odour or taste.

At 12% moisture content, the modulus of rupture is 77.5–109 N/mm^2, modulus of elasticity 7370–14 630 N/mm^2, compression parallel to grain 38–60.5 N/mm^2, compression perpendicular to grain 8–9.5 N/mm^2, shear 13–14 N/mm^2, cleavage c. 60 N/mm radial, Janka side hardness 3275–5205 N and Janka end hardness 5160–5670 N.

The rates of shrinkage are moderately low to fairly high: for *C. littorale* wood from green to 15% moisture content 2.4% radial and 4.1% tangential, for *C. asperum* wood from green to oven dry 5.1% radial and 6.6% tangential. The timber dries rather slowly but without serious defects, although slight bowing, springing and splitting may occur. Boards 15 mm thick take about 3.5 months to air dry from green condition to 15% moisture content, and boards 40 mm thick take about 4 months. Kiln-drying schedule J is recommended in Malaysia; boards 25 mm thick take about 6 days to kiln dry from 50% to 10% moisture content. During drying, the wood is susceptible to mould and blue staining.

The wood is easy to moderately difficult to saw and plane, depending on the density and silica content. Lighter-weight and non-siliceous wood saws easily and the planed surfaces are smooth on the radial and tangential surfaces. Heavier and siliceous wood (silica contents up to 1.7% have been reported) is much harder to saw and the blunting effect on saw teeth is severe; planed surfaces are smooth and non-lustrous. Usually the wood bores, turns, nails and glues well, and it is easy to rotary peel and produces a good tight veneer. Brittle heart may cause some problems during peeling. Kedondong is likely to be suitable for fibreboard and particle board.

The wood is non-durable in exposed conditions or in contact with the ground. Graveyard tests in Malaysia showed an average life in contact with the ground of 1.2 years for *C. littorale* wood. The wood is readily attacked by fungi and termites, and blue staining can be a serious problem. The sapwood is very susceptible to powder-post beetle attack. The heartwood is highly resistant to preservative treatment, because of the occurrence of tyloses (an absorption of 32 kg/m^3 has been achieved using an open tank method), but the sapwood is permeable.

Wood of *C. littorale* contains 69% holocellulose, 42% α-cellulose, 25.5% lignin, 14% pentosan and 0.4% ash. The solubility is 1.2% in alcohol-benzene, 2.7% in hot water and 15.6% in a 1% NaOH solution.

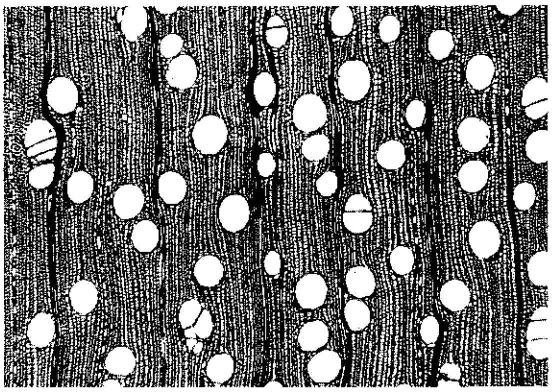
Description Dioecious, evergreen, medium-sized to fairly large, sometimes large trees up to 35(–60) m tall, rarely shrubs; bole branchless for up to 25(–45) m, up to 120(–200) cm in diameter, buttresses present; bark surface smooth to scaly or dippled, often greyish, inner bark sometimes laminated, pinkish or reddish-brown, with strong resinous smell and clear sticky or oily exudate; pith of twigs usually containing vascular strands. Leaves arranged spirally, imparipinnate, with (1–)3–17(–27) opposite and often toothed leaflets; base of petiole and of petiolules often swollen; stipules usually present, entire to fimbriate. Inflorescence terminal or sometimes axillary, paniculate or sometimes reduced to a raceme or a spike. Flowers actinomorphic, 3-merous, functionally unisexual but vestiges of the opposite sex present; calyx cupular with deltoid lobes, nearly always densely hairy inside; petals free, usually imbricate, creamy white, with inflexed tips; stamens 6, or rarely 3, free to entirely connate; disk intrastaminal, 6-lobed, often pilose; ovary superior, 3-celled, each cell with 2 axillary ovules, stigma sessile or short-stalked. Fruit an oblong drupe, seated on a persistent enlarged calyx, hairy or glabrous, ripening blue-black, glaucous at first, very wrinkled when dry; endocarp stony (pyrene), with 1 or 2 cells slightly to nearly entirely reduced. Seed with palmatifid to 3-foliolate and variously folded cotyledons. Seedling with epigeal germination; first 2 leaves simple and opposite, entire or toothed, subsequent leaves alternate and eventually arranged spirally and imparipinnate.

Wood anatomy

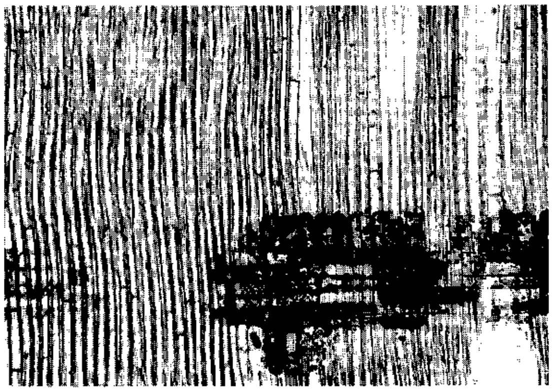
– Macroscopic characters:

Heartwood buff-coloured, pale pinkish-brown or reddish-brown, often not clearly distinct from the nearly white or greyish-white sapwood. Grain rather straight to shallowly interlocked. Texture fine to moderately coarse. Growth rings generally indistinct or absent, sometimes delimited by dark fibrous bands; vessels visible to the naked eye, tyloses infrequent; parenchyma not visible with a hand lens; rays not visible to the naked eye; ripple marks absent.

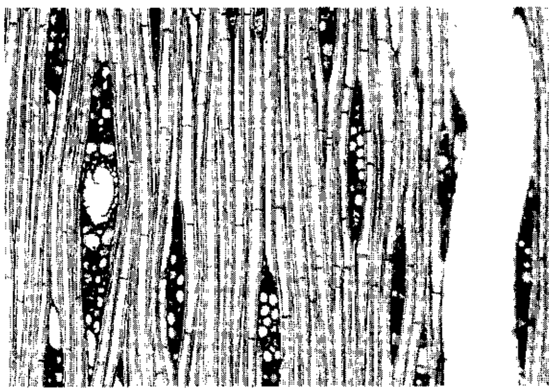
– Microscopic characters:



transverse section (×25)



radial section (×75)



tangential section (×75)

Canarium luzonicum

Growth rings indistinct or absent, sometimes delimited by dark fibrous bands. Vessels diffuse, 8–13/mm^2, in short radial multiples, mostly 120–200 μm in diameter (up to 280 μm in *C. indicum*); perforation plates simple; intervessel pits alternate, non-vestured, circular or oval, 8–10 μm (occasionally up to 12 μm in *C. asperum*); vessel-ray pits simple with much reduced borders, enlarged, horizontally to vertically elongated or round; tyloses occasional to absent. Fibres 0.8–1.4 mm long, septate, thin-walled to thick-walled, with simple to minutely bordered pits mainly confined to the radial walls. Axial parenchyma absent or extremely rare to scanty and vasicentric, in strands with 8 or more cells. Rays usually 3–7/mm, mostly 300–600 μm high, typically heterocellular with one row of upright and/or square marginal cells (sometimes with two rows), mostly 2–3(–4) cells wide; storied structure absent. Prismatic crystals in upright cells and occasionally procumbent cells in *C. acutifolium*, *C. asperum*, *C. luzonicum* and *C. ovatum*, in chambered upright cells and chambered axial parenchyma cells and occasionally in fibres in *C. indicum* and absent from *C. hirsutum*; one crystal per cell or chamber. Silica bodies absent or present in procumbent and upright ray cells and fibres in *C. asperum* and *C. hirsutum*. Radial canals absent in *C. acutifolium*, *C. asperum* and *C. hirsutum*, but present in *C. indicum*, *C. luzonicum* and *C. ovatum*; rays containing canals enlarged locally around the canal, producing distinct fusiform rays.
Species studied: *C. acutifolium*, *C. asperum*, *C. hirsutum*, *C. indicum*, *C. luzonicum*, *C. ovatum*.

Growth and development An average annual diameter increment of a small *C. asperum* tree in secondary forest of 1.9 cm has been recorded. In plantation trials of *C. indicum* in the Solomon Islands the growth rates averaged 2.8 m/year in height and 3 cm/year in diameter. Juvenile trees of *C. ovatum* produce lateral shoots late. They may grow to a height of 2 m or more in about 3–4 years before branching.
The trees flower mainly in the dry season and fruit during the wet season, although many species do not have definite flowering or fruiting seasons. Flowering and fruiting of *C. vulgare* occurs throughout the year in West Java, as does the flowering of *C. decumanum*; fruits are ripe in February–March and October. Pollination is probably effected by insects. The fruits are dispersed by fruit-eating pigeons and monkeys, and are occasionally eaten and dispersed by bats.

Other botanical information *Canarium* is closely related to the genera *Dacryodes*, *Haplolobus* and *Santiria*. It is characterized by the often stipulate leaves, the vascular strands being usually present in the twigs, and especially by the peculiar fruits with a thick-walled, bony, and 1–3-seeded stone, the pyrene. Material without fruits may be confused with the other 3 related genera.
The genus *Canarium* is subdivided into 3 subgenera: subgenus *Canarium*, subgenus *Canariellum* (Engl.) Leenh., and subgenus *Africanarium* (Leenh.) Leenh. The first is the most widespread, occurring from Africa to the Pacific. The second is restricted to eastern Queensland, New Caledonia and adjacent islands. The third is monotypic and confined to western Africa.

Ecology Species of *Canarium* are mainly canopy trees of primary lowland evergreen rain forest, although some species are found up to 1800 m altitude. They also occur in monsoon or more open forest, or in secondary forest, where some species may be locally abundant. The individuals usually occur scattered but *C. vulgare* may grow gregariously in rather dry rain forest.

Propagation and planting *Canarium* can be propagated by seed and seedlings may be prepared as stumps before planting. Vegetative methods of propagation are practised for the fruit species, e.g. budding and grafting techniques are used for *C. ovatum*. One kg contains 200–1350 seeds of *C. ovatum* and there are about 145 dry stones (each stone containing 1–2 seeds) of *C. vulgare* per kg. The fruits can be collected from the ground and the pulp needs to be removed to make germination possible. Germination can be hastened by nicking the end of the stone, slightly cracking it and soaking in cold or hot water. Air-dry seed can be stored without temperature control for several months up to 1.5 years, as recorded for *C. vulgare*, without losing its viability. *C. littorale* stones showed 25–100% germination in 30–171 days in different germination trials, *C. megalanthum* stones 95% germination in 17–21 days, and *C. pseudosumatranum* stones 90% germination in 34–88 days. *C. vulgare* stones have 85% viability. Seeds are sown under shade. A plantation trial in Indonesia with stumps was not very successful because of serious attacks by termites. Only stumps of 40 cm long and with a diameter of 1–2.5 cm of *C. littorale* had a survival rate of 75% after being planted out. The African species *C. schweinfurthii* Engl. was planted in Java as a trial and developed well. For fruit production, approximately 120 *C. indicum* trees are planted per ha (spacing about 9 m) in the Solomon

Islands, and *C. ovatum* is planted in the Philippines at a spacing of 12–15 m (45–70 trees/ha).

Silviculture and management As *Canarium* trees generally grow scattered and the fruits are often collected for their stones, natural regeneration is scarce.

Diseases and pests Anthracnose of young seedlings has been observed in *C. ovatum*, but this is easily controlled by fungicides.

Harvesting The usually tall buttresses may hinder harvesting of the logs. Trees of *C. luzonicum* may be tapped for resin on alternate days. The flow of resin diminishes towards the end of the dry season.

Yield In a plot of 50 ha of lowland forest in Peninsular Malaysia 4 *Canarium* species were present and in total 29 trees were over 40 cm in diameter. This means that much less than 1 tree over 40 cm in diameter per ha was present. In three different forest complexes around Samarinda, East Kalimantan, the yield of kedondong was 4.6 m^3/ha, 2.6 m^3/ha and 2.1 m^3/ha, respectively. Mature *C. indicum* trees yield at least 100 kg/year of fruits when open grown and under plantation conditions they can be expected to yield 7700 kg/ha of fruits annually (the kernels account for about 15% of the total weight). The productivity of *C. ovatum* trees varies considerably. The average yield of resin from a single mature tree of *C. luzonicum* is about 45 kg.

Handling after harvest Timber should be treated with anti-stain chemicals immediately after sawing. Kedondong logs float and may be transported by river.
After collecting the fruits, the pulp and the stone wall are removed and the seed is dried in the sun.

Genetic resources *Canarium* trees are common constituents of lowland and hill rain forest. The genetic resources will not be depleted easily as the timber has not been commercially important to date.

Breeding As *Canarium* trees are dioecious, they are cross-pollinated. This results in great variation among seedlings.

Prospects The prospects for *Canarium* seem to be more towards the production of fruits than of timber. The oil extracted from kernels of *C. indicum* is already being promoted as a product from the natural rain forest in the Solomon Islands. In Papua New Guinea, there is also interest in developing this industry. Pilinuts (from *C. ovatum* in the Philippines) have the potential to become a major export product. Plantations from which both timber and pilinuts can be harvested in a sustainable way might have good prospects. More research is needed on silviculture and propagation.

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Selection of species

Canarium acutifolium (A.DC.) Merr.

Interpr. Herb. amboin.: 302 (1917).

Vernacular names Indonesia: sakenau (Waigeo, Irian Jaya), bowwie, mengkis (Vogelkop, Irian Jaya).

Distribution Central Sulawesi, the Kai Islands, New Guinea and New Britain.

Uses The wood is used as kedondong. The resin has been used for lighting and for caulking boats.

Observations A medium-sized to large tree up to 45 m tall, bole branchless for up to 18 m, up to 90 cm in diameter, with buttresses up to 3 m high, bark surface scaly, grey-brown or pale brown, inner bark salmon-coloured; stipules subpersistent, filiform; leaves with (3–)5–11(–15) leaflets, leaflets glabrous, apex abruptly and rather long bluntly acuminate, margin entire, with 11–20(–25) pairs of secondary veins; inflorescence axillary, laxly pyramidal-paniculate; flowers c. 4 mm long, with 3 or 6 stamens; fruit ovoid, circular in cross section, 12–18 mm × 8–13 mm, glabrous. Three varieties are distinguished. Var. *acutifolium* (synonyms: *Canarium longiflorum* Zipp. ex Miq., *Canarium lineistipula* K. Schumann & Lauterb., *Canarium leeuwenii* H.J. Lam) is found in the Kai Islands, New Guinea and New Britain. Var. *aemulans* (Lauterb.) Leenh. (synonym: *Canarium aemulans* Lauterb.) differs in having 6 stamens and occurs in north-eastern New Guinea and New Britain, up to 1000 m altitude. Var. *celebicum* Leenh. also has 6 stamens, but in addition has leaflets with 20–25 pairs of secondary veins, and is found in Central Sulawesi only. *C. acutifolium* is common in primary and secondary forest, especially in more open locations, often on wet clayey soils, up to 200(–1000) m altitude. The density of the wood is 580–710 kg/m^3 at 15% moisture content.

Selected sources 162, 330, 342, 366, 474.

Canarium apertum H.J. Lam

Ann. Jard. Bot. Buitenzorg 42: 214, t. 5, fig. 6 (1932).

Synonyms *Santiria serrulata* Engl. (1883).

Vernacular names Indonesia: kedondong kijai, kedondong rusa (Sumatra), kedamu bikin (south-eastern Kalimantan). Malaysia: kedondong kemasul (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as kedondong.

Observations A medium-sized to large tree up to 43 m tall, bole up to 100 cm in diameter, with spreading buttresses up to 3 m high, bark surface scaly and lenticellate, grey-brown or grey-white, inner bark laminated, yellowish-brown; stipules absent; leaves with 3–15 leaflets, the rachis slightly swollen and flattened at base, leaflets with acute to rounded or emarginate apex, margin minutely serrate, almost glabrous to pubescent especially on the veins above and below, with 8–16(–18) pairs of secondary veins which are raised below and above give a bullate appearance to the blade; inflorescence terminal, broadly paniculate; flowers c. 10 mm long, petals clawed, stamens 6; fruit ovoid, acuminate, circular in cross section, 40–50 mm × 20–28 mm, fulvously tomentose especially near base and apex. *C. apertum* occurs scattered but locally common in lowland forest on flat or undulating land and hill sides, up to 500 m altitude. The density of the wood is 530–710 kg/m^3 at 15% moisture content.

Selected sources 9, 77, 162, 342, 705.

Canarium asperum Benth.

Hook.f., Journ. Bot., Lond. 2: 215 (1843).

Synonyms *Canarium villosum* Benth. & Hook.f. ex Fernandez-Villar (1880), *Canarium zollingeri* Engl. (1883), *Canarium unifoliolatum* Merr. (1921).

Vernacular names Indonesia: damar jahat (Sulawesi), damar itam (Ambon), kessi (Sumbawa). Philippines: pagsahingin (Filipino), sulusalungan (Bisaya), anteng (Iloko).

Distribution The Philippines, Borneo, Sulawesi, the Lesser Sunda Islands (including Bawean and Kangean Islands), the Moluccas, New Guinea and the Solomon Islands.

Uses The wood is used as kedondong, e.g. for temporary constructions, boxes, crates and veneer. The resin has been used for fuel and lighting, for caulking boats, and for painting hats. It is known locally in the Philippines as 'sahing'. This species also yields tannin.

Observations A medium-sized to fairly large tree up to 35 m tall, bole straight, cylindrical, branchless for up to 16 m, up to 100 cm in diameter, with prominent buttresses, bark surface pale grey; stipules subpersistent to caducous, narrow; leaves with 1–13 leaflets, leaflets with tapering to acute or bluntly acuminate apex, margin entire but serrulate to dentate in young plants, glabrous to pilose on the midrib above and the veins below, with (7–)12–15(–20) pairs of secondary veins; inflorescence spicate to narrowly paniculate; flowers 3–7 mm long, stamens 6; fruit ovoid to subglobose, circular to slightly trigonous in cross section, 9–14 mm × 4–11 mm, glabrous. This highly variable species is divided into 2 subspecies: subsp. *asperum* and subsp. *papuanum* (H.J. Lam) Leenh. (synonym: *Canarium papuanum* H.J. Lam). The former is further divided into 2 varieties: var. *asperum* and var. *clementis* (Merr.) Leenh. (synonyms: *Canarium clementis* Merr., *Canarium leytense* Elmer, *Canarium wenzelii* Merr.). The various taxa are mainly distinguished by the type of inflorescence. *C. asperum* is common and occurs in a wide variety of habitats, from dry to wet forest, sometimes in open forest or even savanna, up to 500(–1800) m altitude. The density of the wood is 495–635 kg/m^3 at 15% moisture content.

Selected sources 68, 77, 99, 125, 162, 342, 366, 369, 527, 528.

Canarium australianum F. v. Mueller

Fragm. 3: 15 (1862).

Distribution South-eastern New Guinea and northern Australia.

Uses The wood is used as kedondong, e.g. for furniture and joinery, and is locally preferred for tool handles. The resin has been used by aborigines to secure spear heads.

Observations A medium-sized tree up to 30 m tall, bole up to 45 cm in diameter; stipules caducous, narrow; leaves with 7–9(–15) leaflets, leaflets rounded to acute or shortly blunt-acuminate at apex, margin entire to slightly dentate, glabrous to minutely tomentose below, with 15–24 pairs of secondary veins; inflorescence axillary, narrowly paniculate; flowers 4–6.5 mm long, stamens 6; fruit ovoid, circular to bluntly triangular in cross-section, c. 20 mm × 12.5 mm, glabrous. The species is divided into 3 varieties, 2 of which occur in New Guinea: var. *australianum* and var. *glabrum* Leenh. *C. australianum* is found in rain and monsoon forest, in Australia in drier vegetations and even on coastal sands too, apparently restricted to areas with a periodically dry season, at low altitude. See also the table on wood properties.

Selected sources 59, 162, 342, 366.

Canarium balsamiferum Willd.

Sp. pl. 4(2): 760 (1806).

Synonyms *Canarium englerianum* Hochr. (1904), *Canarium longissimum* Hochr. (1904), *Canarium rooseboomii* Hochr. (1904).

Vernacular names Indonesia: damar nitih (Minahassa, Sulawesi), lemboa (southern Sulawesi), kamakoan (Ambon).

Distribution Sumbawa, Sulawesi and the Moluccas.

Uses The wood is reputed to be used as kedondong. The aromatic oil extracted from the resin is valued for its sweet scent.

Observations A medium-sized tree up to 30 m tall, bole branchless for up to 18 m, up to 70 cm in diameter, buttresses present; stipules absent; leaves with (7–)11–17 leaflets, leaflets with rather abruptly and shortly blunt-acuminate apex, margin entire, glabrous, with 8–15 pairs of secondary veins; inflorescence axillary, male one paniculate, female one mostly racemose; male flowers 10 mm long, female ones 5–6 mm long, stamens 6; fruit ovoid and acute, circular to slightly trigonous in cross-section, 20–40 mm × 13–20 mm, glabrous or slightly pubescent at the top. *C. balsamiferum* is found in primary forest, up to 700 m altitude. The density of the sapwood is 320–670 kg/m^3 at 15% moisture content.

Selected sources 162, 234, 342, 366, 474.

Canarium decumanum Gaertner

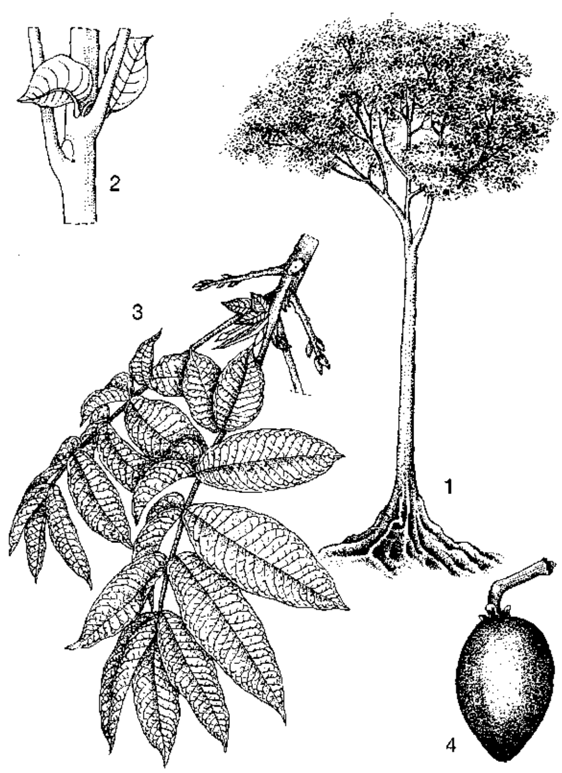
Fruct. sem. pl. 2: 99, t. 102 (1791).

Vernacular names Indonesia: kenari sabrang (Java), kenari besar (Moluccas), jilapat (Kalimantan). Malaysia: pomatodon (Sabah).

Distribution Northern and eastern Borneo, southern Sulawesi, the Moluccas and New Guinea; sometimes cultivated in Java.

Uses The wood is used as kedondong. The seeds are edible. The resin has been used for torches, for caulking boats and for fixing knives, but has been regarded as being of minor quality.

Observations A very large tree up to 60 m tall,



Canarium decumanum Gaertner – 1, tree habit; 2, stipules; 3, twig with leaves; 4, fruit.

bole up to 200 cm in diameter, with large buttresses up to 8 m high, bark surface smooth to dippled and scaly, pale brown to whitish, inner bark orange-red, with a strong mango smell, exuding a brownish sticky resin; stipules present, resembling small leaflets, caducous; leaves with (7–)9–11(–13) leaflets, rachis with sharp edges, leaflets with a gradually and acutely long-acuminate apex, margin entire, glabrescent, with 17–26 pairs of secondary veins which are prominent on both surfaces; inflorescence axillary, narrowly paniculate; male flowers 7–9 mm long, female ones 8–14 mm long, stamens 6; fruit ellipsoid, subtrigonous in cross-section, 70–85 mm × 45–60 mm, roughly hairy but glabrescent. *C. decumanum* is found scattered in primary forest, up to 450 m altitude. The density of the wood is 400–725 kg/m^3 at 15% moisture content.

Selected sources 68, 99, 162, 218, 342, 366.

Canarium denticulatum Blume

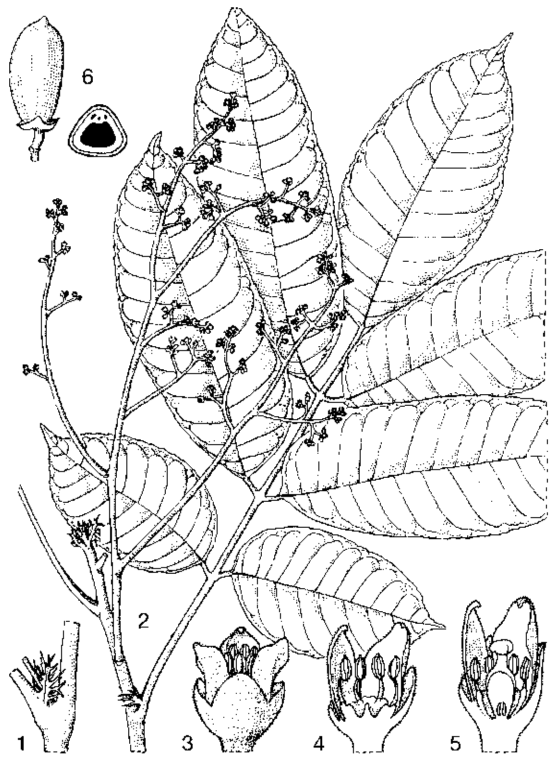
Bijdr. fl. Ned. Ind.: 1162 (1826).

Vernacular names Indonesia: madang rabung (Sumatra), kedamu (south-eastern Kalimantan), kenari utan (West Java). Malaysia: kedondong (general). Philippines: kalisau (Manobo), lancha-lancha (Sulu), ogat (Bagobo). Thailand: laenban (Trang).

Distribution Southern Andaman Islands, southern Burma (Myanmar), peninsular Thailand, Peninsular Malaysia, Sumatra, Java, Borneo and the Philippines.

Uses The wood is used as kedondong.

Observations A medium-sized, sometimes large tree up to 30(–50) m tall, bole branchless for up to 25 m, up to 80 cm in diameter, sometimes with low buttresses, bark surface smooth, greyish, inner bark exuding a pink to black resin; stipules persistent, inserted on the petiole, pectinate to branched like a tree; leaves with 5–13 leaflets, leaflets with acuminate apex, margin entire to sparsely dentate towards the apex, glabrous to sparsely tomentose, with (9–)11–17(–21) pairs of secondary veins which are prominent below; inflorescence axillary, paniculate; male flowers 4.5 mm long, female ones 7 mm long, stamens 6; fruit ellipsoid, slightly triangular in cross-section. Two subspecies can be distinguished: subsp. *denticulatum* (synonyms: *Canarium fissistipulum* Miq., *Canarium fuscum* Engl., *Canarium laciniatum* Elmer) is found throughout the range of the species; subsp. *kostermansii* Leenh. is an uncommon small tree differing by its leaflets being densely pubescent below and with a more prominently dentate margin, and is found in Kalimantan and Sabah. *C. denticulatum* is common in primary lowland and hill forest, up to 700 m altitude. The density of the wood is 500–750 kg/m^3 at 15% moisture content.



Canarium denticulatum Blume – 1, stipules; 2, flowering twig; 3, male flower; 4, sectioned male flower; 5, sectioned female flower; 6, fruit with cross section.

Selected sources 9, 77, 78, 99, 162, 342, 366, 474, 544, 574.

Canarium dichotomum (Blume) Miq.

Fl. Ind. Bat. 1, 2: 648 (1859).

Synonyms *Canarium dichotomum* var. *lucidula* Engl. (1883), *Canarium endertii* H.J. Lam (1932).

Vernacular names Indonesia: tuala-tuala (eastern central Sumatra), damar lang (Palembang, Sumatra), bangkukuk (south-eastern Kalimantan). Malaysia: kedondong, ketio bukit (Sarawak), balajan (Sabah).

Distribution Sumatra and Borneo.

Uses The wood is reputed to be used as kedondong.

Observations A medium-sized tree up to 32 m

tall, bole straight, up to 60 cm in diameter, with short buttresses up to 1.5 m high, bark surface minutely longitudinally fissured, greenish with yellowish spots, inner bark exuding a little reddish or black resin; stipules caducous or persistent, subulate to linear; leaves with 7–11(–17) leaflets, leaflets acuminate at apex with a blunt to acute acumen, margin entire, glabrous or sometimes densely appressed hairy below, with 9–18 pairs of secondary veins; inflorescence terminal, sometimes with additional axillary ones, paniculate; flowers 6–9(–12) mm long, stamens 6; fruit narrowly oblong and acute at both ends, trigonous in cross-section, 27–40 mm × 10–20 mm, glabrous. *C. dichotomum* is found in primary or sometimes secondary forest in well-drained locations, up to 1000 m altitude. The density of the sapwood is 370–630 kg/m^3 at 15% moisture content.

Selected sources 77, 99, 162, 342, 366, 474.

Canarium euryphyllum Perkins

Fragm. fl. Philipp. 1: 99 (1904).

Vernacular names Philippines: malatagun (general), mayakyat, tabuali (Tagalog).

Distribution The Philippines.

Uses The wood is used as kedondong.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 40 cm in diameter; stipules absent; leaves with (5–)9–15 leaflets, leaflets abruptly acuminate at apex with slender and blunt acumen, margin entire, practically glabrous, with (5–)8–10(–15) pairs of secondary veins; inflorescence axillary, paniculate to racemose; flowers c. 10 mm long, stamens 6; fruit broadly elliptical, broadly triangular in cross-section, 27–30 mm × 12–15 mm, glabrescent except for the apex. Two varieties have been distinguished. Var. *euryphyllum* (synonyms: *Canarium perkinsae* Merr., *Canarium stenophyllum* Merr., *Canarium microphyllum* Merr.) occurs throughout the Philippines. Var. *ramosii* (Merr.) Leenh. (synonyms: *Canarium ramosii* Merr., *Canarium paucinervium* Merr.) differs mainly in having 5–9 leaflets per leaf and in the c. 14 mm long flowers, and is found in Samar, Leyte and Mindanao. *C. euryphyllum* is rather common in forest, up to 500(–1700) m altitude.

Selected sources 162, 366, 544.

Canarium grandifolium (Ridley) H.J. Lam

Ann. Jard. Bot. Buitenzorg 42: 215 (1932).

Synonyms *Trigonochlamys grandifolia* Ridley (1910).

Vernacular names Malaysia: kedondong (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo (Brunei, Sabah).

Uses The wood is used as kedondong.

Observations A medium-sized to large tree up to 43 m tall, bole up to 70 cm in diameter, with buttresses up to 3.5 m high, bark surface dippled and scaly, grey or grey-white, inner bark laminated, yellow-brown, exuding clear to yellow-white resin; stipules absent; leaves with 5–7 leaflets, rachis swollen and flattened towards the base, pubescent, leaflets rounded at apex with a short acuminate tip, margin recurved, minutely serrate to entire, densely tomentose below and on the midrib above, with 9–14 pairs of secondary veins which are sunken above and prominent below; inflorescence terminal, rarely with additional axillary ones, male one paniculate, female one racemose to spicate; male flowers 13 mm long, female ones 15 mm long, stamens 3; fruit ellipsoid, 50 mm × 40 mm, slightly hairy at the apex. *C. grandifolium* is not uncommon in primary forest at low altitude.

Selected sources 9, 162, 342, 366, 705.

Canarium hirsutum Willd.

Sp. pl. 4(2): 760 (1806).

Synonyms *Canarium hispidum* Blume (1823), *Canarium multipinnatum* Llanos (1851), *Canarium subcordatum* Ridley (1920).

Vernacular names Indonesia: ki bonteng (West Java), kanari jaki (northern Sulawesi), mede-mede (Moluccas). Malaysia: kedondong (general), damar degun (Peninsular), kambayau burong (Sabah). Philippines: dulit (general), bakayan (Panay Bisaya), hagushus (Bikol).

Distribution Peninsular Malaysia, Sumatra, Java, Borneo, the Philippines, Sulawesi, the Moluccas, New Guinea, the Caroline Islands (Palau) and the Solomon Islands.

Uses *C. hirsutum* is an important source of kedondong. The resin is probably used for torches and as a glue. A decoction of the roots has locally been used medicinally against stomach pains.

Observations A medium-sized, sometimes large tree up to 32(–48) m tall, bole straight, branchless for up to 24(–36.5) m, up to 60(–200) cm in diameter, buttresses usually absent or very small, bark surface greyish-brown to dark brown; stipules absent or present, inserted at the base of the petiole, narrow; leaves with 9–27 leaflets, rachis thick with sharp edges, leaflets gradually to rather abruptly short-acuminate at apex, margin entire, variably pubescent to glabrous, with 12–30 pairs of secondary veins; inflorescence axillary, male one paniculate, female one subracemose; flowers 10–13 mm long, stamens 6; fruit ovoid, circular in cross-section, 20–63 mm × 17–45 mm, usually with irritating reddish-brown hairs. The species is highly polymorphic and 2 subspecies each with 2 varieties have been distinguished. Subsp. *hirsutum* with the varieties *hirsutum* and *beccarii* Leenh. occurs throughout the range of the species except for New Guinea. Subsp. *multicostulatum* Leenh. with the varieties *multicostulatum* and *leewenii* Leenh. is found in the Moluccas, New Guinea and the Solomon Islands. *C. hirsutum* is locally rather common in primary and secondary forest in wet to well-drained locations, usually at low elevations, rarely up to 1800 m altitude. The density of the wood is 360–780 kg/m^3 at 15% moisture content.

Selected sources 9, 77, 78, 99, 125, 162, 342, 366, 705.

Canarium indicum L.

Amoen. Acad. 4: 143 (1759).

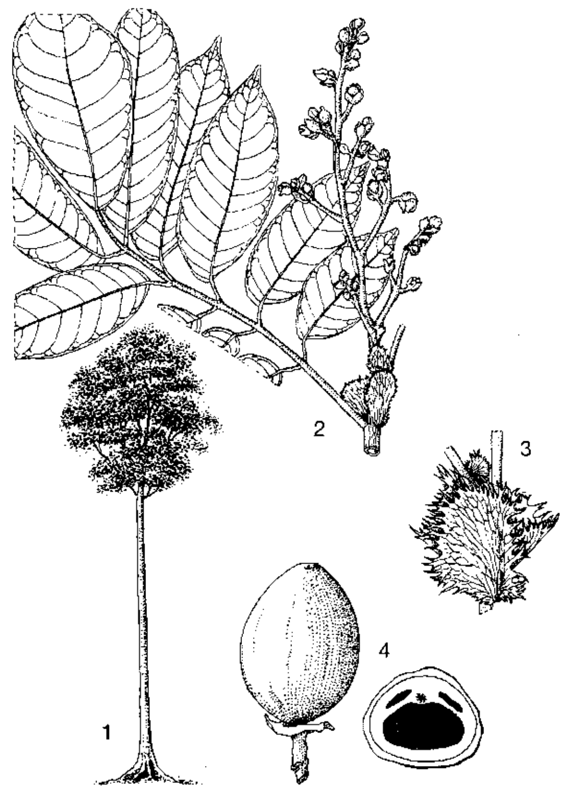
Synonyms *Canarium mehenbethene* Gaertner (1791), *Canarium zephyrinum* Duchesne (1836), *Canarium moluccanum* Blume (1850), *Canarium amboinense* Hochr. (1904).

Vernacular names Indonesia: kenari ambon (Sundanese), kanari ternate (northern Sulawesi), kanari bagea (Moluccas). Papua New Guinea: red canarium (general), galip (Pidgin), lawele (New Britain).

Distribution Sulawesi, the Moluccas, New Guinea, the New Hebrides, the Solomon Islands and the Santa Cruz Islands; often cultivated in Melanesia and sometimes elsewhere.

Uses The wood is used as kedondong, especially for light construction, mouldings, interior finish, and as a firewood. The edible seeds are more important: they are highly esteemed, especially in Melanesia. An oil extracted from the seeds serves as a substitute for coconut oil.

Observations A medium-sized to fairly large tree up to 40 m tall, bole usually short, branchless for up to 10(–26) m, up to 100 cm in diameter, with buttresses up to 1 m high, bark surface smooth to scaly and dippled, grey or brownish-grey to yellow-brown, inner bark laminated, reddish-brown to pinkish-brown, exuding a milky resin; stipules persistent, rarely inserted on the petiole, ovate to oblong, large and prominently dentate; leaves with 7–15 leaflets, leaflets with apex gradually to distinctly acuminate, margin



Canarium indicum L. – 1, tree habit; 2, flowering twig; 3, stipules; 4, fruit with cross section.

entire, glabrous, with (8–)10–15(–20) pairs of secondary veins which are slightly sunken above and prominent below; inflorescence terminal, broadly paniculate; male flowers c. 10 mm long, female ones up to 15 mm long, stamens 6; fruit ovoid, circular to slightly triangular in cross-section, 35–60 mm × 15–30 mm, glabrous. Two varieties have been distinguished. Var. *platycerioideum* Leenh. differs from var. *indicum* in having larger leaflets and larger fruits and is rare in Irian Jaya. *C. indicum* occurs naturally in primary and secondary rain forest, up to 500(–1850) m altitude. The density of the wood is 500–650 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 60, 145, 154, 162, 330, 342, 366, 673.

Canarium kaniense Lauterb.

Bot. Jahrb. Syst. 56: 322 (1920).

Synonyms *Canarium gawadaense* Baker f. (1923).

Distribution Papua New Guinea.

Uses The wood is reputed to be used as kedondong. The oily seeds are edible.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 75 cm in diameter, sometimes buttressed; stipules subpersistent, sometimes inserted on the petiole, elliptical to obovate with a dentate to slightly fimbriate margin; leaves with 7–11(–13) leaflets, leaflets with apex gradually to distinctly shortly to rather long-acuminate, margin entire, glabrous, with 9–15 pairs of secondary veins; inflorescence terminal and axillary, narrowly paniculate; flowers in glomerules, 7 mm long, stamens 6; fruit ovoid, triangular in cross-section, 50–60 mm × 30–40 mm, glabrous. Two varieties have been distinguished. Var. *globigerum* Leenh. differs from var. *kaniense* by its globose fruits with 3-winged pyrenes. *C. kaniense* is found in forests at (25–)1000–2000 m altitude.

Selected sources 162, 342, 366.

Canarium littorale Blume

Bijdr. fl. Ned. Ind.: 1164 (1826).

Synonyms *Canarium tomentosum* Blume (1850), *Canarium purpurascens* Benn. (1875), *Canarium rufum* Benn. (1875).

Vernacular names Brunei: damar kahingai, jelemu nanking, kawangan. Indonesia: mardundung (Palembang, Sumatra), ki kanari (Sundanese, Java), deluwak (Javanese, Java). Malaysia: kedondong bulan, kedondong gergaji, kedondong puteh (Peninsular).

Distribution Indo-China, Peninsular Malaysia, Sumatra, Java and Borneo.

Uses *C. littorale* is an important source of kedondong wood; the wood is used for e.g. house building. The resin is used for caulking boats, and is regarded in Chinese medicine as useful against itching.

Observations A medium-sized to large tree up to 45 m tall, bole branchless for up to 21 m, up to 100 cm in diameter, sometimes with short buttresses, bark surface smooth to dippled and scaly, grey-green to yellowish-brown, inner bark laminated, orange-red to brownish; stipules caducous or semi-persistent, kidney-shaped with wavy to deeply lobed margins; leaves with (1–)5–13 leaflets, rachis glabrous or hairy, leaflets shortly acuminate at apex, margin entire to serrulate or dentate, glabrous to densely tomentose below and on the midrib above, with 9–22 pairs of secondary veins which are more or less sunken above; inflorescence terminal, sometimes with additional axillary one, male one paniculate, female one subracemose; flowers 8–13 mm long, stamens 6; fruit ellipsoid to obovoid, circular to triangular in cross-section, 45–70 mm × 15–30 mm, glabrous to sparsely pilose. *C. littorale* is highly variable with 5 recognized forms. These are f. *littorale*, f. *purpurascens* (Benn.) Leenh., f. *pruinosum* (Engl.) Leenh., f. *tomentosum* (Blume) Leenh., and f. *rufum* (Benn.) Leenh. *C. littorale* is common in well-drained to swampy locations in humid climates to climates with slightly seasonal conditions, usually in lowland forest but sometimes in montane forest, up to 1100(–2000) m altitude. The density of the wood is 410–680 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 9, 77, 78, 99, 162, 294, 342, 366, 463, 465, 522, 705.

Canarium luzonicum (Blume) A. Gray

U.S. Expl. Exped., Phan.: 374 (1854).

Synonyms *Canarium carapifolium* Perkins (1904), *Canarium polyanthum* Perkins (1904), *Canarium oliganthum* Merr. (1915).

Vernacular names Philippines: piling-liitan (Filipino), belis (Tagalog), malapili (Bikol).

Distribution The Philippines.

Uses The wood is used as kedondong, e.g. for light construction. A valuable volatile oil known under the trade name 'Manila elemi' can be distilled from the resin; it has been commercially exported for the manufacture of varnish and of medicinal ointments. In China, it has been used to manufacture transparent paper used for window panes. The seeds are edible. The bark yields a tannin of satisfactory quality.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 100 cm in diameter, bark surface flaky, greyish, inner bark exuding resin; stipules caducous to subpersistent, inserted on the base of the petiole, orbicular; leaves with 7–11 leaflets, leaflets with a gradually and long blunt-acuminate apex, margin entire, glabrous, with 14–18 pairs of secondary veins; inflorescence axillary, paniculate; male flowers 2.5–4 mm long, female ones 6–8 mm long, stamens 3–6 in the male and 6 in the female flower; fruit broadly ovoid to ellipsoid, circular to bluntly triangular in cross-section, 25–38 mm × 15–20 mm, glabrous. *C. luzonicum* occurs in primary forest at low and medium altitude. See also the table on wood properties.

Selected sources 68, 78, 125, 162, 526, 532, 544, 646.

Canarium maluense Lauterb.

Bot. Jahrb. Syst. 56: 323 (1920).

Vernacular names Indonesia: kapur-barus (Sulawesi), lian (Morotai), nanari laki-laki (Irian Jaya).

Distribution Eastern Borneo, central Sulawesi, the Moluccas (Morotai, Batjan, Aru Islands), New Guinea and the Louisiada Archipelago.

Uses The wood is used as kedondong.

Observations A large to very large tree up to 60 m tall, bole branchless for up to 25 m, up to 75 cm in diameter, with buttresses up to 1.5 m high, bark surface with grey spots, inner bark yellowish-brown, exuding white fragrant resin; stipules caducous to persistent, inserted on or at the very base of the petiole, scaly to auricle-shaped; leaves with 3-9 leaflets, leaflets distinctly shortly bluntly acuminate at apex, acumen often emarginate, margin entire, almost glabrous or rarely tomentose below, with 10–25 pairs of secondary veins; inflorescences terminal and in the upper leaf axils, paniculate; flowers 3–6(–9) mm long, stamens 6; fruit ovoid to ellipsoid, circular or sometimes quadrangular in cross-section, 17–30 mm × 10–18 mm, glabrous. Two subspecies have been distinguished. Subsp. *maluense* (synonyms: *Canarium lian* H.J. Lam, *Canarium quadrangulare* H.J. Lam) occurs from Sulawesi eastward. Five formae have been described within this highly variable subspecies. Subsp. *borneense* Leenh. differs mainly by its 8–9 mm long flowers, and occurs in eastern Borneo. *C. maluense* occurs in primary rain forest, up to 1100 m altitude. The density of the wood is 560–720 kg/m^3 at 15% moisture content.

Selected sources 162, 330, 342, 366, 474.

Canarium megalanthum Merr.

Philipp. Journ. Sci., Bot. 30: 81 (1926).

Vernacular names Malaysia: kedondong keruing (Peninsular), mantus tikus (Sabah).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as kedondong and reported to be hard. *C. megalanthum* is cultivated in Brunei for its edible fruits which are amongst the largest in the genus. The resin has been used for torches.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 80 cm in diameter, sometimes with buttresses up to 1 m high, bark surface flaky and lenticellate, brown, with white and black resin, inner bark laminated, reddish-brown, with clear resin; stipules subpersistent or sometimes caducous, inserted on the petiole or less often down to the twig, deeply 3–4-lobed; leaves with (7–)9–11 leaflets, rachis minutely tomentose, channelled above, leaflets gradually to distinctly shortly acuminate at apex, margin entire or sometimes serrulate near the top, powdery hairy, with (10–)13–19 pairs of secondary veins which are raised below; inflorescence terminal to pseudoterminal, paniculate to narrowly paniculate; male flowers 11 mm long, female ones 13–15 mm long, stamens 6; fruit ellipsoid, sometimes acute, bluntly triangular in cross-section, 50–55 mm × 35–40 mm, tomentose, especially near the apex. *C. megalanthum* is locally common in lowland rain forest and on ridges, up to 350 m altitude. The density of the wood is 625–770 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 9, 77, 99, 162, 342, 366, 463, 465, 705.

Canarium odontophyllum Miq.

Fl. Ind. Bat., Suppl.: 525 (1861).

Synonyms *Canarium beccarii* Engl. (1883), *Canarium palawanense* Elmer (1913), *Canarium multifidum* H.J. Lam (1932).

Vernacular names Indonesia: danau majang (Sumatra), kurihang, dawai (Kalimantan). Malaysia: kedondong (Sabah), dabang (Sarawak).

Distribution Sumatra, Borneo and Palawan.

Uses The wood is used as kedondong. In Sarawak *C. odontophyllum* is grown for its edible fruits.

Observations A medium-sized to fairly large tree up to 35 m tall, bole branchless for up to 18 m, up to 60 cm in diameter, with buttresses, inner bark exuding a little whitish resin; stipules persistent, inserted near or at the base of the petiole, orbicular to oblong and dentate to finely lacerate; leaves with 7–17 leaflets, leaflets distinctly acuminate at apex, margin dentate to serrate, sparsely to densely hairy below and on the midrib above, with 15–28 pairs of secondary veins which are slightly raised or flat above and prominent below; inflorescence axillary, laxly paniculate; male flowers 4–7 mm long, female ones 8–9 mm long, stamens 6; fruit ovoid to ellipsoid, slightly triangular in cross-section, 25–35 mm × 17–20 mm, glabrous. *C. odontophyllum* is locally common in primary forest, up to 450 m altitude. The density of the wood is 530–720 kg/m^3 at 15% moisture content.

Selected sources 77, 99, 162, 342, 366.

Canarium oleosum (Lamk) Engl.

Engl. & Prantl, Nat. Pflanzenfam. 3(4): 241, fig. 136Q–S (1896).

Synonyms *Canarium microcarpum* Willd. (1806), *Canarium laxiflorum* Decne (1834).

Vernacular names Indonesia: rani kalang bahi (Timor), kayu rasamala (Bacan, Obi and Buru), kanari minyak (Ambon). Papua New Guinea: grey canarium (general).

Distribution The Lesser Sunda Islands, northern Sulawesi, the Moluccas, New Guinea and New Britain.

Uses The wood is used as kedondong, e.g. for light construction, mouldings and interior finish. There have been unconfirmed reports that the wood of the buttresses is a component of the aromatic wood 'kayu rasamala'. An oil can be extracted from the resin which is used as a balm on wounds and for hair lotions. In New Guinea, it is mixed with coconut oil for the latter purpose.

Observations A medium-sized to large tree up to 50 m tall, bole up to 50 cm in diameter, sometimes buttressed, bark surface almost black, inner bark exuding a yellow and fragrant resin; stipules absent; leaves with (1–)7(–11) leaflets, leaflets with a gradually narrowing blunt apex, margin entire, glabrous, with 10–15 pairs of secondary veins which are conspicuous on both sides; inflorescence axillary, narrowly and laxly paniculate; flowers 5–7 mm long, stamens 6; fruit ovoid to obovoid, circular in cross-section, 12–20 mm × 7–13 mm, glabrous. *C. oleosum* is found in primary and secondary forest, up to 400(–1200) m altitude. The density of the wood is 560–740 kg/m^3 at 15% moisture content.

Selected sources 145, 162, 342, 366.

Canarium ovatum Engl.

A.DC., Monogr. Phan. 4: 110 (1883).

Synonyms *Canarium pachyphyllum* Perkins (1904), *Canarium melioides* Elmer (1911).

Vernacular names Pilinut (En). Philippines: pili, pilaui (general), liputi (Tagalog).

Distribution The Philippines; also commonly planted there.

Uses The wood is used as kedondong, and as firewood. More important are the pilinuts; the seed of the fruit is used commercially for various confectionary and bakery products. The boiled pulp of the fruit is edible, and contains an oil used for cooking and lighting. The resin is suitable for similar purposes and is also collected as 'Manila elemi'. The shell enclosing the seed also makes an excellent fuel for cooking. The young shoots and young leaves are edible. The trees are planted in wind-breaks, as an ornamental, and as a shade tree.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 100 cm in diameter, not buttressed, bark surface flaky, brown, inner bark pale brown, exuding a white resin; stipules persistent, inserted on the petiole, deltoid to lingulate; leaves with 5–9 leaflets, leaflets with distinctly acuminate apex, margin entire, glabrous, with 8–12 pairs of secondary veins; inflorescence axillary, narrowly paniculate to nearly racemose; flowers up to 13 mm long, stamens 6; fruit ovoid to ellipsoid, triangular in cross-section, 35–63 mm × 20–28 mm, glabrous. *C. ovatum* occurs in primary forest, up to 500 m altitude.

Selected sources 68, 78, 125, 162, 188, 342, 366, 646, 673, 690.

Canarium patentinervium Miq.

Fl. Ind. Bat., Suppl.: 526 (1861).

Synonyms *Canarium nitidum* Benn. (1875), *Canarium parvifolium* Benn. (1875).

Vernacular names Indonesia: madang merpalam (western central Sumatra), kedondong tulang (Palembang, Sumatra). Malaysia: kedondong, kedondong krut (Peninsular), keramoh (Sarawak).

Distribution Peninsular Malaysia, Sumatra, Borneo and intervening islands.

Uses The wood is used as kedondong.

Observations A medium-sized to fairly large tree up to 40 m tall, bole straight, cylindrical, up to 50 cm in diameter, buttresses absent or small, bark surface smooth to fissured, often with inconspicuous hoop marks, grey-white to grey-brown, inner bark loosely fibrous, red to reddish-brown, exuding clear resin; stipules caducous, inserted in the leaf axil, kidney-shaped; leaves with (5–)7–9(–11) leaflets, leaflets with gradually to distinctly shortly acuminate apex, margin entire, glabrous, with 5–15 pairs of secondary veins which arch distinctly at some distance from the margin, midrib flattened or depressed above; inflorescence terminal, male one laxly paniculate, female one more dense; flowers 7–10 mm long, stamens 6; fruit ellipsoid to obovoid, circular to rounded triangular in cross-section, 30–60 mm × 17–30 mm, glabrous. *C. patentinervium* occurs in primary or secondary forest, sometimes in swamp forest, up to 450(–1200) m altitude. In Peninsular Malaysia, it is a common understorey tree. The density of the wood is 500–700 kg/m^3 at 15% moisture content.

Selected sources 9, 77, 78, 99, 162, 342, 366, 463, 705.

Canarium pilosum Benn.

Hook.f., Fl. Brit. India 1: 533 (1875).

Synonyms *Canarium grandiflorum* Benn. (1875), *Canarium hirtellum* Benn. (1875), *Canarium motleyanum* Engl. (1883).

Vernacular names Indonesia: merasam daun alus (Palembang, Sumatra), surian uding (Simeuluë), damar lilin (Kalimantan). Malaysia: kedondong, kejam penggeli (Peninsular), keramoh batu (Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as kedondong, e.g. for house building.

Observations A medium-sized to fairly large tree up to 37 m tall, bole straight, branchless for up to 22 m, up to 65 cm in diameter, sometimes buttressed up to 1 m high, bark surface smooth, grey-white to grey-brown, sometimes mottled, inner bark laminated, brown, exuding greyish to brown or blackish resin; stipules usually persistent, inserted on the petiole, narrow; leaves with (3–)5–9(–13) leaflets, leaflets with gradually to distinctly short to long-acuminate apex, margin entire to minutely serrulate, pubescent or rarely glabrous, with 8–15 pairs of secondary veins, midrib raised above; inflorescence axillary to pseudoterminal, rarely terminal, male one narrowly paniculate, female one racemose; flowers 10–13 mm long, stamens 6; fruit oblong or rarely ovoid, truncate at apex, rounded triangular in cross-section, (17.5–)22.5–32.5 mm × (7.5–)10–15 mm, glabrous except sometimes at apex. *C. pilosum* is highly polymorphic with two subspecies. Subsp. *borneensis* Leenh., occurring in Sabah and Sarawak, differs from subsp. *pilosum* mainly by the absence of stipules, the glabrous leaves and the smaller flowers. *C. pilosum* is fairly common in primary forest, also in swamp forest, up to 350(–1500) m altitude. The density of the wood is 390–815 kg/m^3 at 15% moisture content. The wood is reported not to be susceptible to insect attack.

Selected sources 9, 77, 78, 99, 162, 342, 366, 705.

Canarium pseudodecumanum Hochr.

Pl. bogor. exs.: 61 (1904).

Vernacular names Indonesia: tandikat (eastern central Sumatra), damar likat (Aceh), jelapat gala-gala semut (Kalimantan). Malaysia: kedondong kemasul, damar kangar (Peninsular), pomatodon (Sabah). Thailand: han (Songkhla).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as kedondong. The abundant resin is used for caulking boats. The seeds are edible and yield an edible oil.

Observations A large tree up to 50 m tall, bole straight, cylindrical, branchless for up to 27 m, up to 165 cm in diameter, with buttresses up to 6 m high, bark surface smooth to scaly, grey-white to pale brown, inner bark yellow, white towards the cambium, fragrant, exuding a creamy resin; stipules absent; leaves with (7–)9–13 leaflets, rachis pubescent and swollen and flattened above towards the base, leaflets shortly acuminate at apex, margin minutely serrulate, subglabrous above, nearly glabrous to densely tomentulose below, with 17–25 pairs of secondary veins which are prominent below, tertiary venation giving the lower surface a pitted appearance; inflorescence axillary, narrowly paniculate; flowers 7–9 mm long; fruit ellipsoid, subtrigonous in cross-section, 70–85 mm × 45–60 mm, densely tomentose when young but glabrescent. *C. pseudodecumanum* is uncommon and found scattered in primary forest in undulating or swampy locations and on river banks, up to 280 m altitude. The density of the wood is 330–600 kg/m^3 at 15% moisture content.

Selected sources 9, 77, 99, 162, 342, 366, 474, 705.

Canarium pseudopatentinervium H.J. Lam

Ann. Jard. Bot. Buitenzorg 42: 214, t. 13, fig. 104e (1932).

Vernacular names Indonesia: tetak tunjuk (Sumatra), asam-asam (Bangka), engai (Kalimantan).

Distribution Sumatra, Bangka and Borneo.

Uses The wood is reputed to be used as kedondong.

Observations A medium-sized to fairly large tree up to 38 m tall, bole branchless for up to 16 m, up to 60 cm in diameter, sometimes buttressed, inner bark exuding a little yellowish-white resin; stipules absent; leaves with 3–5(–9) leaflets, leaflets with shortly acuminate apex, margin entire, glabrescent, with 7–14 pairs of secondary veins; inflorescence terminal, female one paniculate, with racemose branches; flowers 7 mm long in bud, petals clawed, stamens 6; fruit ellipsoid, circular to rounded triangular in cross-section, 50–70 mm × 20–30 mm, glabrous. *C. pseudopatentinervium* occurs infrequently in primary forest, up to 700 m altitude. The density of the wood is 500–555 kg/m^3 at 15% moisture content.

Selected sources 77, 162, 342, 366.

Canarium pseudosumatranum Leenh.

Blumea 8: 193, fig. 4 (1955).

Vernacular names Malaysia: kedondong senggeh, lamshu senggi, kala (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as kedondong.

Observations A large tree up to 55 m tall, bole branchless for up to 45 m, up to 120 cm in diameter, with short buttresses, bark surface rough or scaly with smooth patches, fawn with silver-fawn patches, inner bark laminated, pale brown-pink, exuding an oily resin turning black; stipules absent; leaves with 13–21 leaflets, leaflets with gradually long-acuminate apex, margin entire, glabrous, with 12–22 pairs of secondary veins which are visible on both surfaces, midrib raised above; male inflorescence axillary, narrowly paniculate; male flowers 7 mm long; fruit ovoid, circular in cross-section, 50 mm × 25 mm, glabrous. *C. pseudosumatranum* is still imperfectly known, occurring scattered in lowland and hill forest.

Selected sources 162, 366, 463, 465, 705.

Canarium rigidum (Blume) Zipp. ex Miq.

Fl. Ind. Bat. 1(2): 648 (1859).

Synonyms *Canarium polyphyllum* K. Schumann (1889), *Canarium ledermannii* Lauterb. (1920).

Vernacular names Indonesia: hoddjai (Irian Jaya, Manokwari).

Distribution Northern and north-western New Guinea.

Uses The wood is used as kedondong, also for building prahus.

Observations A medium-sized tree up to 30 m tall, bole up to 45 cm in diameter, buttressed, bark surface grey; stipules absent; leaves with 7–25 leaflets, leaflets shortly acuminate to gradually long-acuminate at apex, margin entire, glabrous or minutely pubescent on the midrib above and main veins below, with 11–24 pairs of secondary veins which are prominent below; inflorescence axillary, laxly paniculate; male flowers 6 mm long, female ones 7.5 mm long, stamens 6; fruit ellipsoid, acute, circular to rounded triangular in cross-section, 40–50 mm × 20–25 mm, glabrous. *C. rigidum* occurs in primary and secondary forest, up to 1200 m altitude.

Selected sources 162, 342, 366.

Canarium salomonense B.L. Burtt subsp. papuanum Leenh.

Blumea 8: 188, fig. 5f (1955).

Distribution Papua New Guinea.

Uses The wood is reputed to be used as kedondong. In the Solomon Islands, subsp. *salomonense* is cultivated for its seeds.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 80 cm in diameter, usually buttressed, sometimes with stilt roots; stipules caducous, inserted on the petiole, auricle-shaped; leaves with 5–7 leaflets, leaflets abruptly shortly acuminate at apex, margin entire, glabrous, with 8–14 pairs of secondary veins; inflorescence terminal, male one laxly paniculate, female one more slender; male flowers 4–5.5 mm long, female flowers 10 mm long, stamens 6; fruit flattened ellipsoid, c. 35 mm × 23 mm × 15 mm, glabrous. *C. salomonense* subsp. *papuanum* occurs in rain forest up to 400 m altitude.

Selected sources 162, 366.

Canarium sumatranum Boerl. & Koord.

Koord.-Schum., Syst. Verz. 2: 25 (1910).

Vernacular names Indonesia: damar lang (Palembang, Sumatra), benemil (eastern central Sumatra), anglip batu (Simeuluë). Malaysia: kedondong (Peninsular).

Distribution Peninsular Malaysia and Sumatra.

Uses The wood is used as kedondong. The resin is used for torches.

Observations A large tree up to 50 m tall, bole straight, branchless for up to 21 m, up to 120 cm in diameter, bark surface smooth to roughly scaly, greyish-yellow to green, inner bark exuding a resin turning black, bole and branches thorny when young; stipules absent or early caducous, inserted at the base of the petiole, narrow; leaves with 7–11 pairs of leaflets, often lacking a terminal leaflet, leaflets distinctly to gradually acuminate at apex, margin entire, glabrous, with 20–30 pairs of secondary veins which are visible on both surfaces; inflorescence axillary, laxly paniculate; male flowers 8–9 mm long, female ones 6 mm long, stamens 6; fruit ovoid, rounded triangular in cross-section, 15 mm × 10 mm, glabrous. *C. sumatranum* is found scattered in primary and secondary lowland and hill forest, up to 500 m altitude. The density of the sapwood is 370–650 kg/m^3 at 15% moisture content.

Selected sources 9, 162, 342, 366, 474, 705.

Canarium sylvestre Gaertner

Fruct. sem. pl. 2: 99, t. 102 (1791).

Synonyms *Canarium simplicifolium* Engl. (1883), *Canarium appendiculatum* Lauterb. (1920), *Canarium branderhorstii* Lauterb. (1920).

Vernacular names Indonesia: kai ia (Seram), kenari hutan, kenari janele (Ambon).

Distribution The Moluccas and New Guinea.

Uses The wood is used as kedondong. The seeds are edible. The resin has been used for torches and lighting.

Observations A small to medium-sized tree up to 20 m tall, bole branchless for up to 13 m, up to 40 cm in diameter, bark surface grey-brown, inner bark exuding a white resin; stipules persistent, inserted on the petiole, auricle-shaped; leaves with 1–7 leaflets, leaflets with a long-acuminate apex, margin entire, glabrous, with 8–15 pairs of secondary veins; male inflorescence terminal and sometimes with additional axillary ones, paniculate; male flowers c. 3 mm long, stamens 3–6; fruit ovoid, circular to bluntly triangular in cross-section, 30–55 mm × 15–28 mm, glabrous. *C. sylvestre* is found in mixed primary and secondary forest and sago palm (*Metroxylon sago* Rottb.) forest, up to 850 m altitude. The density of the wood is 470–680 kg/m^3 at 15% moisture content.

Selected sources 162, 342, 366, 474.

Canarium vrieseanum Engl.

A.DC., Monogr. phan. 4: 142, t. 3, fig. 15–18 (1883).

Synonyms *Canarium williamsii* C.B. Robinson (1908), *Canarium tongcalingii* Elmer (1911), *Canarium dolichophyllum* Merr. (1915).

Vernacular names Indonesia: are, kon ne uwal, solo (Minahassa, Sulawesi). Philippines: gisau, Williams gisau (Sulu), gisau-kitid (Tagalog).

Distribution The Philippines (Mindanao), and northern and central Sulawesi.

Uses The wood is used as kedondong, e.g. for construction. The seeds are edible. The resin is used for lighting.

Observations A medium-sized tree up to 31 m tall, bole straight, up to 45 cm in diameter, buttresses absent or small, bark surface grey; stipules persistent, inserted on the petiole, narrow; leaves with 7–11(–15) leaflets, leaflets distinctly and long-acuminate at apex, margin entire, pubescent on the midrib above and on the veins below, with 12–18(–24) pairs of secondary veins which are prominent below; inflorescence axillary, male one narrowly paniculate, female one racemose; flowers 6–10 mm long, stamens 6; fruit ovoid, acute, circular in cross-section, 17–33 mm × 7–23 mm, velvety. *C. vrieseanum* is polymorphic; 3 forms have been recognized: f. *vrieseanum* with slender branches and 3–5-jugate leaves occurring in Sulawesi, f. *williamsii* (C.B. Robinson) Leenh. with pubescent 6–7-jugate leaves in Mindanao, and f. *stenophyllum* Leenh. with nearly glabrous many-jugate leaves restricted to the Davao Province in Mindanao. *C. vrieseanum* is found in primary and secondary forest, up to 500 m altitude. The density of the wood is 610–660 kg/m^3 at 15% moisture content.

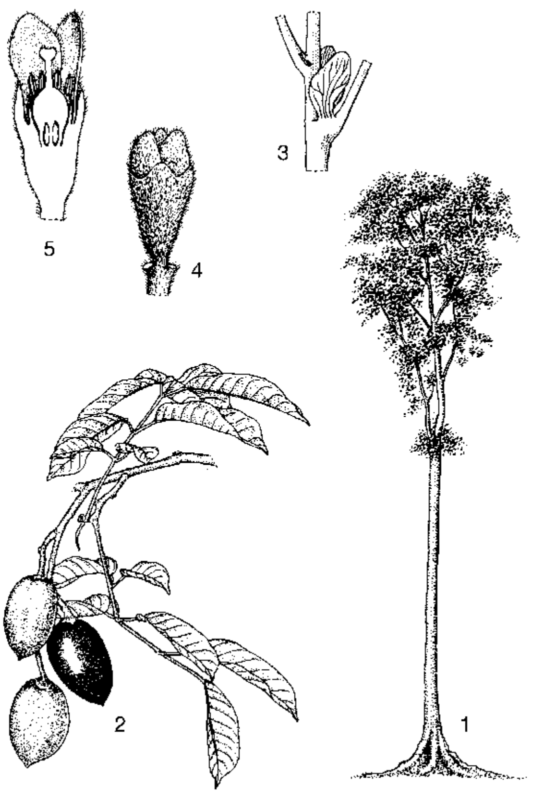
Selected sources 68, 162, 342, 366, 474, 544, 673.

Canarium vulgare Leenh.

Bull. Bish. Mus. 216: 31, fig. 13 (1955).

Synonyms *Canarium commune* L. (1767) p.p.

Vernacular names Java almond (En). Amande de Java (Fr). Indonesia: kanari (general), ki tuwak (Java), jal (Ambon). Malaysia: pokok kenari, rata kukana (Peninsular).



Canarium vulgare Leenh. – 1, tree habit; 2, fruiting twig; 3, stipules; 4, flower; 5, sectioned female flower.

Distribution The Kangean and Bawean Islands, the Lesser Sunda Islands, Sulawesi, the Moluccas and New Guinea. Possibly naturalized elsewhere in the Malesian region. Planted throughout the tropics for its fruits.

Uses The wood is used as kedondong, also for making canoes and as firewood. Paddles have been manufactured from the buttresses. The resin is suitable for varnish and caulking boats, and is used medicinally as a balsam. The seeds are highly valued as a snack, and are sometimes used as a substitute for almonds. The oil from the seeds has been used as a substitute for coconut oil. Trees are planted for shade in nutmeg plantations, and along roadsides.

Observations A large tree up to 45 m tall, bole often gnarled in cultivated specimens, branchless for up to 20 m, up to 70 cm in diameter, buttresses up to 3 m high, bark surface pale greyish, inner bark exuding clear or whitish resin; stipules caducous, inserted at the leaf axil, oblong; leaves with (5–)9–11 leaflets, leaflets gradually to distinctly long-acuminate at apex, margin entire, glabrous, with 12–15 pairs of secondary veins which are slightly prominent below; inflorescence terminal, broadly paniculate; male flowers 5 mm long, female ones 6–7(–12) mm long, stamens 6; fruit ovoid, circular to slightly trigonous in cross-section, 35–50 mm × 15–30 mm, glabrous. *C. vulgare* occurs locally gregariously in primary forest on limestone, up to 1200 m altitude. The density of the wood is 480–680 kg/m^3 at 15% moisture content.

Selected sources 63, 78, 162, 218, 234, 330, 342, 366.

K.M. Kochummen (general part, selection of species),
R.B. Miller (properties, wood anatomy),
M.S.M. Sosef (selection of species)

Castanopsis (D. Don) Spach

Hist. nat. vég. 11: 142, 185 (1841).

FAGACEAE

$x = 12$; for several non-Malesian species: $n = 12$, $2n = 24$.

Trade groups Berangan: medium-weight to heavy hardwood, e.g. *Castanopsis acuminatissima* (Blume) A.DC., *C. argentea* (Blume) A.DC., *C. javanica* (Blume) A.DC., *C. tungurrut* (Blume) A.DC.

It has been reported that locally *Lithocarpus* spp. and *Quercus* spp. are traded as berangan timber as well. This may, however, be due to misidentification of the logs.

Vernacular names Berangan: saninten (En, Fr). Indonesia: saninten. Malaysia: Malayan chestnut (general), jertek tangga (Peninsular), kata (Sabah). Papua New Guinea: New Guinea oak, Papua New Guinea oak, white oak. Philippines: Philippine chestnut (general). Burma (Myanmar): katia. Laos: ko[1]. Thailand: ko, ko-nam. Vietnam: c[af] [oo]i.

Origin and geographic distribution *Castanopsis* consists of about 120 species and is distributed from north-eastern India towards western China, Korea and Japan, through Indo-China and Thailand, and throughout Malesia except for eastern Java and the Lesser Sunda Islands. A single species occurs in south-western North America. Fossil records are available from Europe, North America, Australia and eastern Russia, some of which should, however, be considered with caution, as the genera of *Fagaceae* are not always easily distinguishable from fossil remains. As the most primitive species are found in South-East Asia, the origin of the genus is thought to be located here.

Most species have only a small distribution area; for example, none of the 15 or so commercial species of Vietnam occur within Malesia.

Uses Berangan is suitable for medium to heavy construction under cover, house posts, lining, bridges, furniture, cabinet making, interior fittings, panelling, flooring, plywood, sliced veneer, packing cases, pallets, fence posts, mine props, shingles, shakes and boat building. The wood is also used as firewood.

The nuts of several species are eaten raw, cooked, roasted or are used in chocolates and pastries. The bark or the heartwood sometimes yields tannin and rarely also a dye. The twigs are used for mushroom cultivation.

Production and international trade In Sabah, the log export of berangan in 1987 was 11 500 m^3 with a value of US$ 700 000 (US$ 61/m^3); in 1992 the export amounted to 6200 m^3 (33% as sawn timber and 67% as logs) with a total value of US$ 700 000 (US$ 197/m^3 for sawn timber and US$ 72/m^3 for logs). In Papua New Guinea, the export of logs has been banned and only processed wood, which fetches comparatively high prices, is permitted to be exported.

Properties Berangan is a medium-weight to heavy and moderately hard wood with a rather uniform appearance. The heartwood is generally pale red or pinkish when freshly cut but it turns to yellowish-brown, brown or dark red-brown upon exposure; it is indistinctly demarcated from the sapwood, which is straw-coloured to pale brown, often with a greenish tinge. The density is (550–)610–850(–975) kg/m³ at 15% moisture content. The grain is usually fairly straight but sometimes interlocked, the texture is rather coarse and uneven. The wood is lustrous when freshly cut but it becomes dull with age; it feels somewhat rough, and freshly sawn wood smells of leather.

At 15% moisture content, the modulus of rupture is 75–96 N/mm², modulus of elasticity 11 000–13 400 N/mm², compression parallel to grain 38.5–53.5 N/mm², compression perpendicular to grain c. 5 N/mm², shear 7–8.5 N/mm², cleavage c. 64 N/mm radial and 79.5 N/mm tangential, Janka side hardness 4650 N and Janka end hardness 5500 N.

The rates of shrinkage of berangan are moderate to fairly high: from green to 15% moisture content 1.2–2.3% radial and 2.3–4.5% tangential, and from green to oven dry 3.7–5.1% radial and 6.6–9.6% tangential. The seasoning properties of berangan vary considerably: sometimes the timber seasons fairly rapidly without serious defects, but often it air dries rather slowly and it is liable to splitting, cupping and twisting, especially in wood with interlocked grain. Special care is required with timber of larger dimensions and high initial moisture content. It takes about 2 months to air dry 2 cm thick boards of *C. argentea* to 17% moisture content. In general, thin stickers should be used in seasoning and stacks must be protected. Honeycombing may develop during kiln drying if fast kiln-drying schedules are used. A recommended kiln schedule is a temperature of 37–62°C and corresponding relative humidity of 86% to 38%.

The wood is non-siliceous and easy to fairly difficult to saw. It is very easy to split. Planing is easy to moderately easy and, with some care, the finish is good. When brought to a good finish, the figure is almost invisible, but when polish is applied a fine and beautiful silver-grain figure often becomes visible. Boring, turning, mortising and sanding are rated as easy to moderate. Pre-boring before nailing and screwing is recommended because of the tendency to split. Planed surfaces take paint, varnish and lacquer well; heartwood can be glued satisfactorily. Wood of *C. argentea* can be peeled into 1.5 mm thick veneer at a peeling angle of 92° after boiling for 48 hours, but the veneer is brittle and cannot be rolled. The veneer can be glued with urea-formaldehyde, producing plywood complying with the German standard.

In general, berangan heartwood is rated as moderately durable, but there is a considerable variation between species. In Papua New Guinea the wood is classified as non-durable. Graveyard tests in Malaysia showed severe fungal attack after 2.5 years indicating that this wood is not durable under exposed conditions or in contact with the ground in wet tropical areas. In Indonesia, the fungus *Paecilomyces variotis* has recently been identified attacking *C. javanica* wood in graveyard tests. Termite attacks are also recorded, and pinhole borers may attack standing trees. The wood is not resistant to marine borers. The heartwood is reported to vary in resistance to preservative treatment: from extremely resistant to unevenly permeable. The sapwood is easy to treat by the pressure treatment; generally the penetration is complete.

Wood of *C. argentea* contains 55% cellulose, 26% lignin, 19.5% pentosan and 0.5% ash. The solubility is 5.2% in alcohol-benzene, 3.1% in cold water, 5.2% in hot water and 19.4% in a 1% NaOH solution. The energy value is 19 240 kJ/kg.

Description Evergreen monoecious small to large trees up to 45 m tall; bole sometimes hoop-marked, branchless for up to 25 m, up to 150 cm in diameter, sometimes buttressed; slash often with bluish discolouring wood; bark surface smooth with shallow fissures and prominent lenticels often in lines, usually grey, inner bark not penetrating the wood. Rooting is superficial and most trees have several suckers growing from their base. Leaves arranged spirally, simple, margin entire or rarely serrulate (but frequently serrulate outside Malesia), glabrous above, sometimes hairy or scaly below; stipules deltoid to linear-acute, small, caducous or rarely persistent. Inflorescence an erect spike, male, female, androgynous or mixed, densely stellate-pubescent, with flowers solitary or in clusters of 3–7 along a rachis; rachis axillary, usually simple, solitary or in dense paniculate clusters on the lateral or subterminal young shoots. Flowers with campanulate perianth, (5–)6(–7)-lobed; male flowers with (10–)12(–15) stamens, with globose anthers and a woolly pubescent rudimentary pistillode; female flowers with 10–12 staminodes and 3–5 styles, conical to terete, with a terminal and punctiform stigma. Cupule completely enclosing the 1–7 fruits, splitting irregularly or into a regular number of segments, variously spiny or warty or with a few undulating ridges, the processes more or less in rings. Fruit an indehiscent nut, more or less rounded with the adjoining sides flat, with a part (the scar) adnate to and a part free from the cupule; wall bony to woody, glabrous to densely yellowish-brown to fulvous tomentulose. Seedling with hypogeal germination; cotyledons non-emergent, hypocotyl not elongated; leaves conduplicate, often reduced to scales at the first few nodes.

Wood anatomy

- Macroscopic characters:

Heartwood yellowish-brown to brown, not distinctly demarcated from the pale yellowish or pale brownish sapwood. Grain straight or shallowly interlocked. Texture moderately coarse to coarse. Growth rings indistinct to fairly distinct. Vasicentric tracheids and paratracheal parenchyma visible with a hand lens as thin white sheaths around the vessels. Apotracheal parenchyma visible with a hand lens on moistened surfaces.

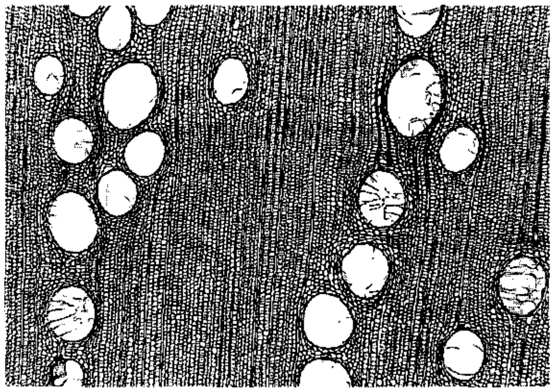
- Microscopic characters:

Growth rings, if present, usually marked by flattened fibres. Vessels in a radial pattern, 2–8/mm^2 to 6–18/mm^2, depending on the sample, exclusively solitary, oval, 120–270 μm or 90–170 μm in tangential diameter; perforations simple; vessel-tracheid pits more or less diffuse, 6–8 μm in diameter; vessel-ray and vessel-parenchyma pits gash-like or palisade-like, with strongly reduced borders; tyloses present. Fibres 930–1800 μm long, thin-walled to thick-walled (walls 2–6 μm thick in *C. acuminatissima*, 2–3 μm thick in *C. javanica*), pits scarce and indistinct, minutely bordered, in the radial walls. Vasicentric tracheids, associated with scarce paratracheal parenchyma, with numerous distinctly bordered pits. Paratracheal parenchyma scarce; apotracheal parenchyma reticulate, bands sometimes interrupted, partly 2–3 cells wide; in strands of 4–8 cells. Rays (7–)9–12 (–15)/mm, usually uniseriate, but occasionally 2-seriate, 120–440 μm high, homocellular (Kribs type homogeneous uniseriate), exclusively composed of procumbent cells. Prismatic crystals present in chambered axial parenchyma cells, usually in chains of 4–8, and in ray cells, where they usually appear single. Silica bodies absent.

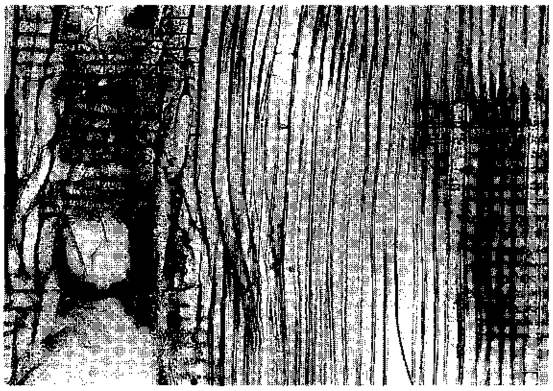
Species studied: *C. acuminatissima*, *C. javanica*.

Growth and development Berangan grows slowly. In natural forest, seedlings are about 25 cm tall after 1 year, 2–3 m after 3 years, and 3–4 m after 5 years.

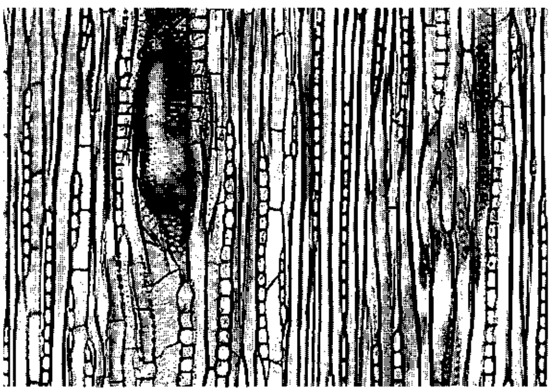
In Sarawak, trees of *C. foxworthyi* and *C. motleyana* start flowering at the end of the wet season or early in the dry season, which is around May-June. Anthesis follows in 4–6 weeks, and fruits are mature by October. Generally a large portion



transverse section (×25)



radial section (×75)



tangential section (×75)

Castanopsis javanica

of the female flowers does not mature into fruits. In Java the four most common *Castanopsis* species (*C. acuminatissima*, *C. argentea*, *C. javanica* and *C. tungurrut*) flower from (July–)September–October(–November) and ripe fruits can be found in January–April.
Castanopsis species are entomophilous, and during anthesis the flowers produce fetid odours that attract small insects.

Other botanical information In the past many specimens were misidentified, mainly due to confusion between *Castanopsis*, *Lithocarpus* and *Quercus*. The latter genus differs from the first two genera in having the umbo of the acorn ringed, and having a lamellate cupule and pendulous male inflorescences. *Lithocarpus* differs from *Castanopsis* in having an indehiscent cupule which does not completely enclose the fruit. The broad bark rays penetrating the wood are characteristic of *Lithocarpus* and *Quercus* but are absent in *Castanopsis*.
Often the various species of *Castanopsis* can only be correctly identified from ripe chestnuts.

Ecology Berangan occurs in primary or old secondary forest from the lowland to the mid-montane zone. It is usually most common between 1000 m and 1500 m altitude, but may ascend up to 2500 m. The individual species occur on a variety of soils, but not on limestone and rarely tolerate a seasonal climate. The trees are usually found scattered in the lowland and more gregarious or even in pure stands at medium and higher altitudes. In New Guinea, *C. acuminatissima* sometimes forms almost pure stands or occurs as a co-dominant together with *Lithocarpus* or *Nothofagus* species between 1000 and 1500 m, elsewhere also with *Anisoptera* or *Intsia* species.

Propagation and planting The number of seeds varies from 280–1850/kg. The viability of the seeds varies among species and ranges from 20–75%. Germination is 'delayed'; 50% of the viable seeds do not germinate until after 31–52 weeks. Germination starts after 4 weeks in *C. megacarpa*, after 14 weeks in *C. javanica* and after 32 weeks in *C. foxworthyi*. Covering the seeds with damp cloth or horse manure for 5–6 days enhances the rate and speed of germination. Seeds should be sown in polybags under shade. When the seedlings attain 25 cm they can be planted out in the field at 4 m × 3 m. When planted in containers in the nursery the survival of wildlings after four months will be nearly 100%.

Silviculture and management Natural regeneration of berangan is very poor; seeds are readily attacked by insect larvae or by fungi and may be eaten by animals. Although seedfall is profuse in mountainous areas of Java, the maximum number of seedlings 15 months after seedfall is no more than 16 per 100 m^2. Natural regeneration cannot develop in artificial gaps of 1000–3000 m^2, but in gaps smaller than 1000 m^2 seedlings may develop and the young trees attain 10 m in height 12 years after cutting. The coppicing ability of *C. acuminatissima* is good and provides potential for regeneration. *C. acuminatissima*, *C. argentea*, *C. javanica* and *C. tungurrut* have been planted in mountainous areas of West and Central Java.
C. argentea and *C. javanica* trees with a bole diameter of 80 cm are still very vigorous. The length of the branchless part of the bole varies considerably depending on the growing conditions.
In lowland Peninsular Malaysia, some *Castanopsis* species are considered to be weed species, because they suppress regeneration of meranti. Weed species are very fast growing, have large and dense crowns and are persistent, but do not develop into acceptable timber trees.
The litter of *Castanopsis* decomposes very slowly. In Thailand, in evergreen hill forest consisting mainly of *Fagaceae*, including *C. acuminatissima*, only about 60% of the litter decomposed during one year.

Diseases and pests The roots of young plants are vulnerable to fungal attack. The fungus *Paecilomyces variotis* causes soft-rot disease and has been identified recently attacking the wood of *C. javanica*. *Dendrophtoe magna* Danser is a mistletoe parasitic on *C. acuminatissima*. *Castanopsis* fruits are eaten by various animals.

Harvesting As most berangan species grow on hills or mountain slopes, exploitation should be carried out carefully because of the danger of erosion. Small-scale exploitation followed by immediate planting is advisable.

Yield In a mixed forest stand in East Kalimantan the timber volume of *C. javanica* was only 1.3–2.5 m^3/ha, while in an almost pure *C. acuminatissima* stand in montane forest in Papua New Guinea it was 38 m^3/ha.
The timber volume was estimated at 8.9 m^3 for large *C. argentea* trees (31.5 m tall and 110 cm in diameter), and 4.8 m^3 for *C. tungurrut* (29.5 m tall and 80 cm in diameter).

Genetic resources Several *Castanopsis* species have very limited areas of distribution and are vulnerable to genetic erosion. Although berangan is generally not cut for timber on a very large scale, deforestation may easily endanger these species, especially in mountainous areas where natural regeneration is very limited.

Prospects Berangan does not seem to have good prospects for timber production as the wood is not in great demand and is generally not easy to handle. Moreover, the trees are often slow growing.

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Selection of species

Castanopsis acuminatissima (Blume) A.DC.

Journ. Bot. 1: 182 (1863).

Synonyms *Quercus junghuhnii* Miq. (1856), *Quercus fagiformis* Jungh. (1858), *Castanopsis schlenkerae* Bailey (1909).

Vernacular names Indonesia: ki riung, riung anak (Sundanese, Java), meranak (Javanese, Java). Papua New Guinea: New Guinea oak, Papua New Guinea oak, white oak. Thailand: ko-duai, ko-soi (Chiang Mai), ko-mat (Phetchabun, Loei).

Distribution North-eastern India, Indo-China, China, Taiwan, Thailand, Peninsular Malaysia, northern Sumatra (rare), western Java, Borneo (Sabah), Sulawesi, New Guinea (quite common) and New Britain.

Uses *C. acuminatissima* is an important source of berangan timber in New Guinea. The bark yields tannin and the nuts are edible.

Observations A medium-sized to fairly large tree up to 36 m tall, bole often coppicing, up to 90(–150) cm in diameter, buttresses up to 2 m high, bark surface rough, fissured, greyish-brown, outer bark reddish, inner bark granular, pale brown to reddish-brown; leaves 4.5–17 cm × 2.5–6 cm, with 10–14 pairs of secondary veins, dull brown or sometimes silvery with a dense cover of minute scales below; cupule 1–1.5 cm × 0.7–1.2 cm, enclosing a single fruit, more or less globose with the fruit partly emerging, densely grey-fulvous puberulous, rather densely set with scales or flat spines tending to be in rows, about one quarter of the fruit adnate to the cupule. *C. acuminatissima* is one of the few species of *Castanopsis* with an extensive distribution. It occurs in primary or old secondary forest, often on loamy sandy soils, at 300–2500 m altitude. In New Guinea it often forms almost pure stands, especially on the boundary between grassland and mid-montane forest. The wood is reported to be less hard than that of *C. argentea* and has a density of 580–705 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 60, 72, 81, 99, 145, 162, 234, 369, 404, 412, 574, 673, 705.

Castanopsis argentea (Blume) A.DC.

Journ. Bot. 1: 182 (1863).

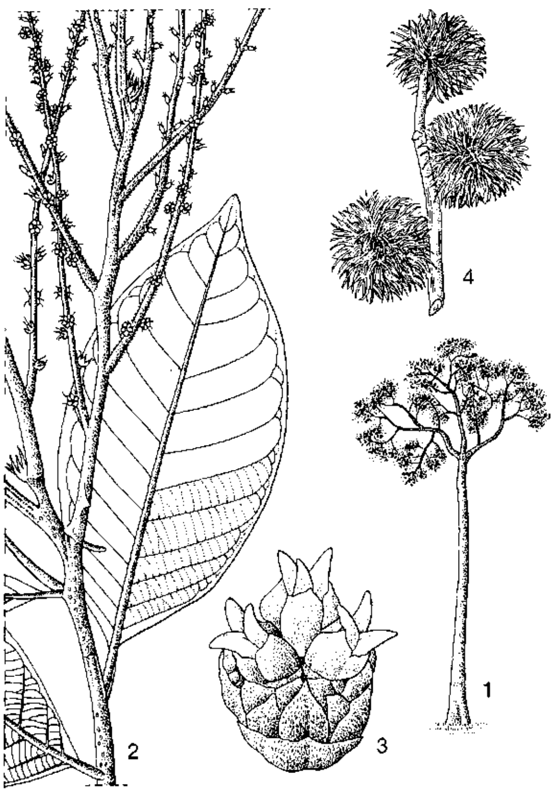
Synonyms *Fagus argentea* Blume (1824), *Castanea argentea* (Blume) Blume (1826).

Vernacular names Indonesia: saninten, berangan (general), kandik kurus (Sumatra), sarangan (Java).

Distribution Sumatra and Java (western and central).

Uses *C. argentea* is an important source of berangan timber. The bark yields a blackish dye which has been used to dye debarked rattan. Tannin can be extracted from the heartwood. The fruits are edible and collected and sold locally.

Observations A medium-sized to fairly large



Castanopsis argentea (Blume) A.DC. - 1, tree habit; 2, flowering branch; 3, female inflorescence; 4, branchlet with fruits.

tree up to 35(–40) m tall, bole branchless for up to 25 m, up to 100(–155) cm in diameter, not buttressed, bark surface fissured and lenticellate, dark grey; leaves (9–)13–16(–20) cm × (3–)5–7(–12) cm, with (9–)11–13(–15) pairs of secondary veins, silvery-grey with dense stellate scales below; cupule 3–4 cm in diameter, enclosing 3 fruits, densely fulvous puberulent, with dense bundles of sturdy and unbranched spines, fruit with a small part adnate to the cupule. *C. argentea* is found in primary or old secondary forest, often on dry or fertile soils, at 150–1400(–1750) m altitude, and is locally dominant in Java. The density of the wood is 550–850 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 41, 81, 162, 234, 332, 369, 404, 504.

Castanopsis borneensis King

Ann. Roy. Bot. Gard. Calc. 2: 99, t. 90 (1889).

Distribution Borneo (Sarawak, Brunei and Sabah).

Uses The wood is reputed to be used as berangan.

Observations A medium-sized tree up to 33 m tall, bole up to 85 cm in diameter, sometimes with stout buttresses, bark surface smooth or slightly fissured, shallowly flaky, pale ochre-brown to dark brown; leaves 5–13 cm × 2–4 cm, with 5–8 pairs of secondary veins, brownish-green and glabrous below; cupule 2.5–3 cm × 2–2.5 cm, enclosing the single fruit, subglabrous, very densely set with bundles of slender to rather sturdy, unbranched spines, fruit completely adnate to the cupule. *C. borneensis* occurs in primary or disturbed heath forest on peat or deep yellow sand, on hills below 450 m altitude.

Selected sources 81, 99, 162, 412.

Castanopsis buruana Miq.

Ann. Mus. Bot. Ludg.-Bat. 1: 120 (1863).

Synonyms *Castanea buruana* (Miq.) Oerst. (1871).

Distribution Borneo (Sabah, rare), Sulawesi and the Moluccas.

Uses The wood is used as berangan.

Observations A small to medium-sized tree up to 30 m tall, bole up to 30 cm in diameter, bark surface shallowly fissured or scaly, greyish-brown; leaves (7–)10–15(–24) cm × (2.5–)4–5(–8) cm, with 8–15 pairs of secondary veins, with a dense cover of chocolate-brown fimbriate scales and stellate hairs below; cupule 1–2 cm in diameter, enclosing the single fruit, glabrous, sparsely set with 4–5 rows of sharp spines, fruit with the larger part free from the cupule. *C. buruana* is found in primary and secondary forest on hills up to 1000 m altitude and is locally dominant in South Sulawesi. The wood is reported to be less hard and less heavy than that of *C. argentea*.

Selected sources 81, 99, 162, 404, 412.

Castanopsis costata (Blume) A.DC.

Journ. Bot. 1: 182 (1863).

Synonyms *Castanopsis brevicuspis* (Miq.) A.DC. (1863), *Castanopsis spectabilis* (Miq.) A.DC. (1863), *Castanopsis trisperma* R. Scheffer (1870).

Vernacular names Malaysia: berangan bukit (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Borneo and intervening islands.

Uses The wood is reputed to be used as berangan. The fruits are edible.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 80 cm in diameter, often buttressed, bark surface smooth and peeling off profusely, yellowish to reddish-brown, inner bark fibrous, ochre; leaves (9–)14–17(–25) cm × (4–)5–8(–10) cm, with (14–)16–17(–20) pairs of secondary veins, dull brown and densely covered with stellate scales below, sometimes also with 2–3-fid hairs; cupule 2.5–3 cm × 3–4 cm, enclosing 1–3 fruits but these remaining visible on one side, densely fulvous or silvery hairy, more or less densely set with bundles of sturdy and more or less recurved spines, fruit adnate to the cupule for about one quarter of its surface. *C. costata* grows in lowland to submontane forest up to 1800 m altitude. It has been erroneously regarded as conspecific with *C. javanica* by several authors.

Selected sources 78, 81, 99, 162, 234, 412, 673, 705.

Castanopsis densinervia Soepadmo

Reinwardtia 7: 389 (1968).

Distribution Borneo (Sabah and north-eastern Kalimantan).

Uses The wood is reputed to be used as berangan.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 60 cm in diameter, bark surface rather smooth, slightly cracked; leaves 6–17 cm × 3–8 cm, with 12–18 pairs of secondary veins, brownish and densely covered with appressed, stellate scales, often interspersed with stellate hairs below; cupule about 3 cm × 4 cm, enclosing the single fruit, glabrous, with 3–4 bands of bundles of unbranched, slender spines, fruit adnate to the cupule except for its top. *C. densinervia* is found in primary montane oak forest at 1000–1800 m altitude.

Selected sources 99, 162, 412, 582.

Castanopsis evansii Elmer

Leafl. Philip. Bot. 5: 1778 (1913).

Synonyms *Castanopsis woodii* Merr. (1926), *Castanopsis elmeri* Merr. (1929).

Vernacular names Malaysia: berangan (Sabah). Philippines: gasa (general).

Distribution Borneo (Sabah and south-eastern Kalimantan) and the Philippines (Palawan).

Uses The wood is reputed to be used as berangan.

Observations A small to medium-sized tree up to 25 m tall, bole up to 65 cm in diameter, sometimes with buttresses, bark surface smooth or very slightly fissured, grey or grey-green; leaves 10–21 cm × 3.5–7 cm, with 9–14 pairs of secondary veins, below greyish with wax and with appressed stellate scales and sparse longer hairs mostly only on the veins; cupule 4–4.5 cm × 3–3.5 cm, enclosing the single fruit, with some brown puberulence, sparsely to densely set with bundles of sturdy and blackish to slender and brownish spines branched at the base, fruit adnate to the cupule. *C. evansii* occurs in lowland forest on brown soil and clayey loam up to 500 m altitude.

Selected sources 81, 99, 162, 412.

Castanopsis foxworthyi Schottky

Bot. Jahrb. Syst. 49: 358 (1913).

Synonyms *Castanopsis kinabaluensis* A. Camus (1928).

Distribution Peninsular Malaysia (rare) and Borneo (Sabah and Sarawak).

Uses The wood is reputed to be used as berangan.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 50 cm in diameter, sometimes fluted or with stout buttresses, bark surface smooth or finely fissured, flaky, greyish-brown; leaves 8–22.5 cm × 4–8 cm, with 9–14 pairs of secondary veins, brownish-green and glabrous below; cupule 3–3.5 cm × 2–3 cm, enclosing the 3 fruits, velvety, with 4–5 concentric bands of simple or tree-like branched sturdy spines, fruit with the smaller part adnate to the cupule. *C. foxworthyi* is found in primary and secondary peat-swamp and kerangas forest, and also in montane forest, up to 2500 m altitude.

Selected sources 81, 99, 162, 288, 463.

Castanopsis fulva Gamble

Kew Bull.: 179 (1914).

Distribution Peninsular Malaysia, central Sumatra and Borneo (Sarawak, Brunei, Sabah and western Kalimantan).

Uses The wood is reputed to be used as berangan.

Observations A medium-sized tree up to 24 m tall, bole straight, up to 50 cm in diameter, without buttresses, outer bark brittle, inner bark granular, red-brown; leaves 9–17 cm × 3–6.5 cm, with 10–15 pairs of secondary veins, dull brown and sparsely to densely covered with stellate scales below and especially on the veins with some 2–3-fid hairs; cupule 2–2.5 cm in diameter, enclosing the 3 fruits, of which often only 1 is well developed, fulvous pubescent and with 4–6 concentric rows of bundles of dense sturdy recurved spines, fruit with the larger part not adnate to the cupule. *C. fulva* occurs in primary lowland dipterocarp forest, on poor sandy soil, up to 450 m altitude.

Selected sources 81, 99, 162, 705.

Castanopsis hypophoenicea (von Seemen) Soepadmo

Reinwardtia 7: 392 (1968).

Synonyms *Quercus hypophoenicea* von Seemen (1897), *Castanopsis dispersispina* Merr. (1929), *Lithocarpus hypophoenicea* (von Seemen) Barnett (1944).

Distribution Borneo.

Uses The wood is reputed to be used as berangan.

Observations A medium-sized to large tree up to 43 m tall, bole up to 60 cm in diameter, buttresses absent or up to 1.8 m high, bark surface smooth or finely fissured, grey-brown to brown; leaves (6–)10–15(–19) cm × (2.5–)4–6(–8.5) cm, with (9–)11–13(–15) pairs of secondary veins, with a dense cover of yellowish-brown simple and stellate hairs below; cupule 7–10 cm × 5–7 cm, enclosing the single fruit, glabrous, with 6–8 lines of much-branched needle-shaped spines, fruit completely adnate to the cupule. *C. hypophoenicea* is found in lowland forest up to 1000 m altitude.

Selected sources 99, 162, 412.

Castanopsis javanica (Blume) A.DC.

Journ. Bot. 1: 182 (1863).

Synonyms *Castanea javanica* (Blume) Blume (1826), *Quercus discocarpa* Hance (1874), *Castanopsis penangensis* A. Camus (1947).

Vernacular names Spiny oak (En). Indonesia: ki hiur, ki riung, kalimorot (Sundanese, Java), palele (Kalimantan). Malaysia: berangan duri, berangan haji (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Borneo and western Java.

Uses *C. javanica* is an important source of berangan timber which is used for house building (e.g. posts). The bark is used to make kegs for storing rice and has tanning properties. The fruits are eaten locally, but are not very tasty.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 100(–150) cm in diameter, sometimes fluted or with steep buttresses, bark surface minutely or sometimes deeply fissured, dark grey or brown, distinctly lenticellate, inner bark fibrous, pale yellow to brown; leaves (6–)10–13(–18) cm × (2–)3–6(–8) cm, with (7–)9–11 (–13) pairs of secondary veins, below pale brown and sometimes with a distinct wax layer and small scales, often also with simple or 2–3-fid hairs; cupule 2.5–5 cm × 1.3–4 cm, enclosing the single fruit, densely fulvous-velvety, with 4–5 rows of tree-like branched spines to densely set with these, the smaller part of the fruit adnate to the cupule. *C. javanica* is fairly common in primary or sometimes secondary forest up to 1650 (–2000) m altitude. The density of the wood is 440–800 kg/m^3 at 15% moisture content.

Selected sources 41, 78, 81, 99, 104, 162, 332, 412, 463, 705.

Castanopsis lucida (Nees) Soepadmo

Reinwardtia 7: 394 (1968).

Synonyms *Alseodaphne lucida* Nees (1831), *Castanopsis hullettii* King ex Hook.f. (1888).

Vernacular names Malaysia: berangan papan, berangan babi, kertak tangga (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo (south-western and north-eastern Kalimantan).

Uses The wood is used as berangan. The nuts are edible. The bark yields tannin.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 60 cm in diameter, buttresses absent or up to 1.6 m high, bark surface fissured, pale brown, inner bark soft fibro-granular, khaki-brown; leaves (10–)16–30 cm × (3.5–)8–10 cm, with 14–20 pairs of secondary veins, with a dense, brownish, scale-like tomentum below; cupule 3.5–4 cm in diameter, enclosing the 2–4 fruits of which often only 2 are well developed, glabrous, covered with 3–4 prominent ridges bearing sharp short spines, fruit with the smaller part adnate to the cupule. *C. lucida* is found in forest below 1200 m altitude. The density of the wood is about 660 kg/m^3 at 15% moisture content.

Selected sources 78, 81, 140, 162, 705.

Castanopsis megacarpa Gamble

Kew Bull.: 180 (1914).

Vernacular names Greater Malayan chestnut (En). Malaysia: gertek tangga, berangan gajah (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo.

Uses The wood is used as berangan. The fruits are edible. The bark yields tannin.

Observations A medium-sized to large tree up to 45 m tall, bole up to 105 cm in diameter, with buttresses up to 2 m high, bark surface smooth to fissured, not flaking, pale greyish-brown, inner bark soft fibro-granular, pale yellow; leaves 10–20(–25) cm × 3–10 cm, with 8–16 pairs of secondary veins, below with a thick cover of reddish-brown stellate hairs; cupule 8–10 cm × 6–7 cm, enclosing the single fruit, glabrous, densely but irregularly set with much-branched spines, fruit almost completely adnate to the cupule. *C. megacarpa* is common and occurs in primary forest up to 1800 m altitude. The density of the wood is 710–820 kg/m³ at 15% moisture content.

Selected sources 78, 81, 99, 104, 140, 162, 412, 463, 705.

Castanopsis microphylla Soepadmo

Reinwardtia 7: 395 (1968).

Distribution Borneo (Sarawak, Sabah and western Kalimantan).

Uses The wood is reputed to be used as berangan.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter; leaves 5–9 cm × 1.5–3 cm, with 8–10 pairs of secondary veins, densely to very sparsely set with stellate scales below and simple hairs on the veins; cupule enclosing the 3 fruits, glabrous, with 4 clusters of short spines alternating with the sutures. *C. microphylla* is still incompletely known and occurs in lowland dipterocarp forest to submontane forest, often on slopes, up to 1600 m altitude.

Selected sources 162, 582.

Castanopsis motleyana King

Ann. Roy. Bot. Gard. Calc. 2: 96, t. 86 (1889).

Synonyms *Castanopsis pearsonii* Merr. (1926).

Vernacular names Philippines: malagasa (general).

Distribution Borneo and the Philippines (Mindanao).

Uses The wood is reputed to be used as berangan.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 70 cm in diameter, with buttresses up to 4 m high, bark surface rough, fissured or flaky, chocolate or reddish-brown; leaves (7–)15–23(–35) cm × (2.5–)7–10(–16) cm, with (11–)14–18(–21) pairs of secondary veins, below dull brown and glabrous to densely set with stellate scales and/or simple or 2–3-fid hairs; cupule 2.5–4 cm across, enclosing the single fruit, densely hairy, densely set with bundles of simple or branched spines, fruit with the smaller part adnate to the cupule. *C. motleyana* occurs in primary forest, rarely secondary or disturbed forest, on sandy-clayey soil in hilly country up to 500 m altitude.

Selected sources 81, 99, 162, 288, 412, 544.

Castanopsis nephelioides King ex Hook.f.

Fl. Brit. India 5: 624 (1888).

Vernacular names Malaysia: berangan babi (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as berangan.

Observations A medium-sized tree up to 21 m tall, bole up to 60 cm in diameter, rarely buttressed, inner bark granular, soft, pale yellow; leaves 8–15 cm × 3–6 cm, with 8–14 pairs of secondary veins, greenish-grey and with a dense cover of appressed stellate hairs below; cupule 2–3.5 cm × 1.5–3 cm, enclosing the single fruit, often golden hairy, densely set with short, pyramidal tubercles, fruit completely adnate to the cupule. *C. nephelioides* occurs in primary forest up to 1200 m altitude. The density of the wood is about 610 kg/m³ at 15% moisture content.

Selected sources 78, 81, 140, 162, 705.

Castanopsis oviformis Soepadmo

Reinwardtia 7: 397 (1968).

Distribution Borneo.

Uses The wood is reputed to be used as berangan.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 95 cm in diameter, with small buttresses or fluted, bark surface smooth to shallowly fissured or cracked, lenticellate, greyish-brown; leaves 6–15 cm × 3–7 cm, with 8–13 pairs of secondary veins, below brownish-green and sparsely to densely set with stellate scales, sometimes with a few stellate hairs on the veins; cupule 2.5–5 cm × 1.5–3 cm, enclosing the single fruit, sparsely puberulous, sparsely to densely set with arching lines of unbranched, solitary or grouped sturdy spines, fruit completely adnate to the cupule. *C. oviformis* occurs in primary forest, sometimes in kerangas, on sandy or sandy-loamy soil up to 1200 m altitude.

Selected sources 99, 162, 412, 582.

Castanopsis paucispina Soepadmo

Reinwardtia 7: 398 (1968).

Distribution Borneo (Sabah and Sarawak).

Uses The wood is reputed to be used as berangan.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, bark surface smooth or cracked, dark grey; leaves 8–14 cm × 3–5.5 cm, with 9–10 pairs of secondary veins, below cinnamon-brown with a thick cover of stellate scales and on the veins some branched hairs; cupule 4–4.5 cm × 3–3.5 cm, enclosing the single fruit, sparsely fulvous puberulent, very sparsely set with 3–4 rows of mostly solitary sturdy spines, fruit completely adnate to the cupule. *C. paucispina* is found in mixed dipterocarp forest on basalt derived soil at 700–1100 m altitude.

Selected sources 162, 412, 582.

Castanopsis philipensis (Blanco) S. Vidal

Rev. pl. vasc. filip.: 265 (1886).

Synonyms *Castanopsis glabra* Merr. (1914), *Castanopsis javanica* auct. non (Blume) A.DC., *Castanopsis sumatrana* auct. non (Miq.) A.DC.

Vernacular names Philippine chestnut (En). Philippines: talakatak (Tagalog).

Distribution The Philippines.

Uses The wood is used as berangan for general construction. The fruits are edible.

Observations A medium-sized tree up to 30 m tall, bole cylindrical, up to 100 cm in diameter, bark surface smooth but densely lenticellate, yellowish or greyish-brown; leaves 6–16 cm × 2–5 cm, with 7–10 pairs of secondary veins, brownish and with a scale-like stellate tomentum below; cupule 2–3 cm × 3–4 cm, enclosing the 3 fruits, fulvous to brownish velvety, with undulate ridges of short pointed tubercles, fruit adnate to the cupule for about half of its surface. *C. philipensis* grows on forested slopes at 400–1800 m altitude. The density of the wood is about 815 kg/m^3 at 15% moisture content.

Selected sources 68, 81, 125, 162, 527, 544.

Castanopsis philipensis (Blanco) S. Vidal – 1, flowering twig with male flowers; 2, side view of cupule; 3, cupule seen from above.

Castanopsis psilophylla Soepadmo

Reinwardtia 7: 401 (1968).

Distribution Borneo and the Philippines (Palawan).

Uses The wood is reputed to be used as berangan.

Observations A medium-sized tree up to 27 m tall, bole up to 60 cm in diameter, sometimes with buttresses up to 2 m high, bark surface smooth or scaly or slightly fissured, greyish-brown; leaves 6–16 cm × 1–5 cm, with 7–12 pairs of secondary veins, glabrous throughout; cupule 1.5–2.5 cm in diameter, enclosing the 2–4 fruits which are golden velvety and covered with several ridges of short, sometimes recurved, pointed tubercles, fruits adnate to the cupule for less than half to about 80% of their surface. *C. psilophylla* occurs in primary forest on sandy or basaltic soil, in undulating country up to 1000 m altitude.

Selected sources 99, 162, 412, 582.

Castanopsis rhamnifolia (Miq.) A.DC.

Prodr. 16, 2: 113 (1864).

Synonyms *Callaeocarpus rhamnifolia* (Miq.) Miq. (1861), *Castanea rhamnifolia* (Miq.) Oerst. (1871), *Castanopsis pachycarpa* A. Camus (1934).

Vernacular names Indonesia: pasang berangan babi (Sumatra), ketembon (Bangka).

Distribution Peninsular Malaysia, Sumatra and Bangka.

Uses The wood is used as berangan, formerly for e.g. wheels and tool handles. The fruits are edible.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 100 cm in diameter, occasionally buttressed with small buttresses, bark surface smooth, grey, inner bark granular to fibrous inwards, ochre to pale yellow; leaves (5–)8–10(–13) cm × (2–)3–4(–5) cm, with 8–11 pairs of secondary veins, brown and sparsely stellate hairy below; cupule 3.5–4 cm × 2.5–3.5 cm, enclosing the single fruit, tomentose, covered with widely spaced rigid flat sharp spines, fruit completely adnate to the cupule. *C. rhamnifolia* is uncommon in lowland to submontane forest up to 1500 (–1850) m altitude. The density of the wood is 765–845 kg/m^3 at 15% moisture content.

Selected sources 81, 140, 162, 234, 705.

Castanopsis schefferiana Hance

Journ. Bot. 16: 200 (1878).

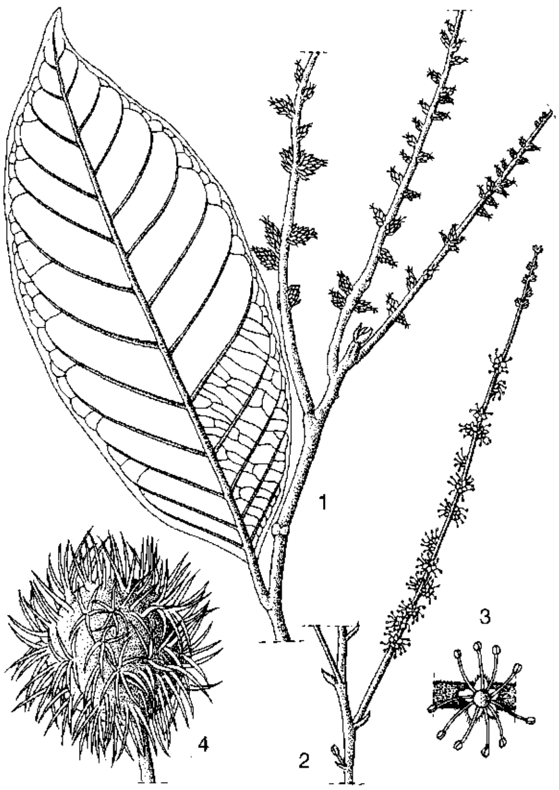
Synonyms *Castanopsis andersonii* Gamble (1914).

Distribution Peninsular Malaysia, Singapore, the Riau and Lingga Archipelago and north-eastern Sumatra.

Uses The wood is reputed to be used as berangan.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, sometimes with buttresses up to 1.2 m high, bark surface smooth, grey, inner bark soft, granular, pink to yellow; leaves (6–)8–12(–18) cm × (1–)3–5(–7) cm, with 10–15 pairs of secondary veins, glabrous throughout; cupule 3.5–4 cm wide, enclosing the 2–3 fruits, more or less densely hoary puberulous or felty, densely set with single or bundles of sturdy spines, fruit with the smaller part adnate to the cupule. *C. schefferiana* is fairly common and occurs up to 1000 m altitude.

Selected sources 81, 162, 705.



Castanopsis tungurrut (Blume) A.DC. – 1, twig with female flowers; 2, twig with male inflorescence; 3, male flower; 4, cupule.

Castanopsis tungurrut (Blume) A.DC.

Journ. Bot. 1: 182 (1863).

Synonyms *Castanea tungurrut* Blume (1826), *Castanopsis ridleyi* Gamble (1914), *Castanopsis conspersispina* Merr. (1934).

Vernacular names Indonesia: kalimorot, tunggurut (Sundanese, Java), karaka (Sumatra).

Distribution Peninsular Malaysia, Sumatra, Simalur, Bangka and western Java.

Uses The wood is used as berangan. The fruits are edible and eaten boiled or roasted but may be toxic when eaten in more than small quantities.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 100 cm in diameter, cylindrical, bark surface rough, fissured; leaves (8–)12–15(–23) cm × (3.5–)5–6(–9) cm, with 11–19 pairs of secondary veins, faintly greyish and with a waxy mass of closely appressed stellate scales below, sometimes also with some longer hairs; cupule 5–6 cm × 3–4 cm, enclosing the single fruit, fulvous puberulous, set all over with scattered bundles of slender branched and often reflexed spines, fruit completely adnate to the cupule. *C. tungurrut* occurs commonly but always scattered in swampy lowland forest to submontane forest up to 1500 m altitude. The density of the wood is 810–975 kg/m^3 at 12% moisture content.

Selected sources 41, 81, 162, 234, 332, 705.

B. Sunarno (general part, selection of species),
P.B. Laming (properties),
S. Sudo (wood anatomy),
M.S.M. Sosef (selection of species)

Castanospermum A. Cunn. ex Hook.

Bot. Misc. 1: 241 (1830).

LEGUMINOSAE

x = unknown; *C. australe*: $2n = 26$

Trade groups Black bean: medium-weight to moderately heavy hardwood, a single species, *Castanospermum australe* A. Cunn. & C. Fraser ex Hook., Bot. Misc. 1: 241, t. 51 (1830), synonym: *Castanospermum cunninghamii* J. Wood (1903).

Vernacular names Black bean, Moreton Bay chestnut (En).

Origin and geographic distribution *Castanospermum* has only a single species which is native in north-eastern Australia, New Caledonia and Vanuatu. It was probably introduced into New Britain during the earliest days of European settlement. Nowadays, it is extensively planted in a few other tropical countries, e.g. in Sri Lanka. In

Papua New Guinea, it is cultivated near Port Moresby and at Lae. Fossil remains of *Castanospermum* date back to the Eocene (44–50 million years ago) in New South Wales (Australia).

Uses Black bean timber is highly valued and is used for furniture, cabinets and high-quality fittings. The wood is suitable for the manufacture of luxury articles such as fancy veneer, inlay work and fancy woodwork. Furthermore, it has been used for moulding, boat building, vehicle bodies, musical instruments, interior trim, carvings, toys and novelties, and turnery. Some specific applications are gun stocks and electrical equipment, the latter due to its high electrical resistance.

The tree is widely cultivated (but not commonly) as an ornamental and shade tree. The leaves are used for fodder, but may be toxic to livestock. The fruit is sometimes eaten roasted or made into a coarse flour. The seeds may be toxic, but small amounts do not seem to have any severe effects on livestock and humans. Chemical components of the seed may show some potential in the treatment of AIDS.

Production and international trade Black bean is exported from Papua New Guinea to Japan and fetches high prices but only very limited amounts are available. The export of black bean logs from Papua New Guinea has been banned since 1991.

Properties Black bean is a medium-weight to fairly heavy hardwood. The heartwood is deep brown to blackish-brown, sharply differentiated from the yellowish-white sapwood. Yellow streaks of tissue (parenchyma) contrast with the dark heartwood; the wood has a prominent figure and is decorative. The density is (575–)750–815(–1000) kg/m^3 at 15% moisture content. The grain is usually straight but sometimes slightly interlocked, texture rather coarse. Black bean is valued for its mechanical properties and durability but the dimensional stability in use is poor.

At 12% moisture content, the modulus of rupture is 80–103 N/mm^2, modulus of elasticity 9200–13 500 N/mm^2, compression parallel to grain 57 N/mm^2, compression perpendicular to grain 8.5 N/mm^2, shear 12.5–15.5 N/mm^2, cleavage 40–71.5 N/mm (direction unknown), Janka side hardness 6895 N and Janka end hardness 8230 N. See also the table on wood properties.

The rates of shrinkage are usually moderate to high, but occasionally very low figures have been reported: from green to 15% moisture content 0.9–5.8% radial and 1.6–10.3% tangential, from green to 12% moisture content 1.8–8.1% radial and 5.8–12.1% tangential, and from green to oven dry 3.0–9.3% radial and 5.1–14.9% tangential. The moisture content of green wood is high: 115–126%. Black bean seasons very slowly, often with serious distortion. It requires careful drying because it is very prone to collapse and tends to check internally if dried quickly in large cross-section. Thin strips, close spacing of strips and possible baffling of the stack can help to slow down drying and reduce the tendency to check. Kiln drying should also be done slowly. Air drying before kiln drying is recommended.

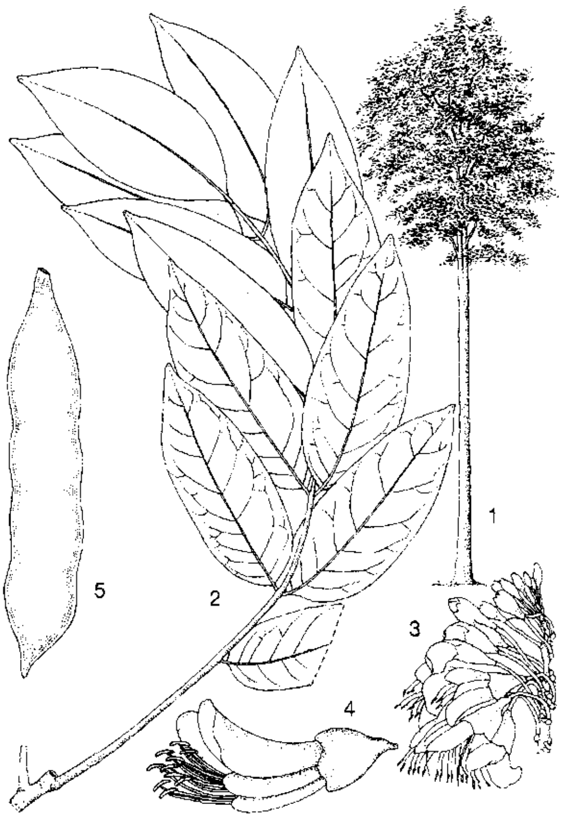
The working properties are generally satisfactory but may be affected by alternating soft and hard patches. The wood moderately blunts cutting edges. The logs have a reputation for having brittle heart, leading to low recovery figures in milling. Wood dust may cause nasal irritation. The wood can be nailed satisfactorily. It is easy to glue, but occasionally gluing is problematic because of the slightly greasy nature of the wood. The wood stains and polishes well. The bending properties are moderate. Tests on the suitability for the production of veneer, plywood and fibreboard showed moderate results; black bean is not suitable for making particle board and cement board or for pulp production.

Black bean heartwood is durable. It is moderately to highly resistant to termite and other insect attacks. The sapwood is liable to attack by powder-post beetles. The heartwood is extremely resistant to preservative treatment, the sapwood is permeable. The retention by the pressure treating method is 27 kg/m^3 for heartwood and 440 kg/m^3 for sapwood.

The wood contains 72.5% holocellulose, 40% α-cellulose, 26.5–27.5% lignin, 15.5% pentosan and 0.2–0.3% ash. The solubility is 9.1–12.4% in alcohol-benzene, 7.3–11.8% in cold water, 9.0–12.2% in hot water and 22.2–27.3% in a 1% NaOH solution. Black bean wood is not suitable for the production of charcoal. The frothing test is positive; the wood fluoresces in ultraviolet light.

The seeds of black bean yield castanospermine and 1-deoxynojirimycin which may show some potential in the treatment of AIDS. The unpleasant purgative effects and indigestibility of the fresh seeds have been attributed to their high saponin content of about 7%. The astringency is reduced by soaking and roasting.

Description A medium-sized to fairly large tree up to 40 m tall; bole unbranched for up to 20 m, up to 135 cm in diameter, buttresses absent; bark surface with fine vertical and horizontal cracks,



Castanospermum australe A. Cunn. & C. Fraser ex Hook. - 1, tree habit; 2, leaf; 3, inflorescence; 4, flower; 5, pod.

grey-white or grey-brown, outer bark 0.5–1 cm thick, inner bark rather hard and brittle, pale brown or pale red-brown, sometimes partially yellow; crown compact. Leaves alternate, imparipinnate, with opposite or alternate leaflets; stipules absent; leaflets 7–19, elliptical-oblong to oblong, 6–16 cm × 2.5–5.5 cm, acuminate, glabrous, dark green and shining, stipels absent. Inflorescence terminal or axillary, usually on older branches, rather large; racemes 4–25 cm long. Flowers on 2.3–3 cm long pedicel, without bracteoles; calyx thick, with 5 broad short lobes, yellow; corolla papilionaceous, fleshy, 3–4 cm long, yellow becoming orange-red; wings and keel shorter than standard, lacking the usual auricle at base; stamens 10, free, with linear versatile anthers; ovary superior, stipitate, 1-locular, with 6–7 ovules, style long, glabrous, with a small terminal stigma. Fruit a large, woody pod, 2-valved, oblong, 18–25 cm × 4–6 cm, acute, with spongy tissue, dark brown. Seeds 2–5, depressed oblong-ovoid, 4 cm × 3.5 cm × 2.2 cm, dark brown, with a soft seed-coat, without albumen.

Wood anatomy

– Macroscopic characters:

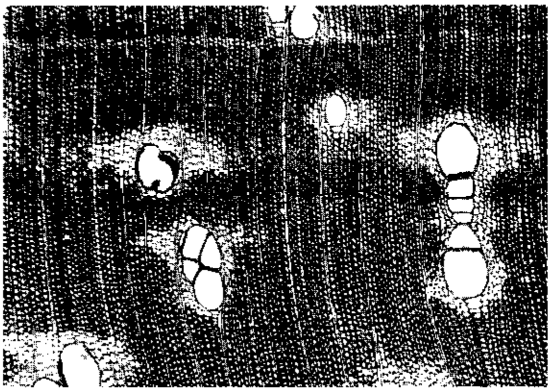
Heartwood pale brown to dark chocolate-brown with irregular black streaks, clearly demarcated from the white to yellowish sapwood. Grain usually straight, occasionally interlocked. Texture coarse and even; wood with prominent streaky figure due to abundant parenchyma and dark streaks, sometimes greasy to the feel. Growth rings not evident; vessels large and distinct to the naked eye, evenly distributed, mostly white, sometimes yellow or rarely pink chalky deposits present; parenchyma abundant, aliform tending to confluent, occasionally irregular bands of parenchyma present; rays small, barely visible to the naked eye as individual rays, inconspicuous on radial surface; ripple marks present, variable (20–30/mm).

– Microscopic characters:

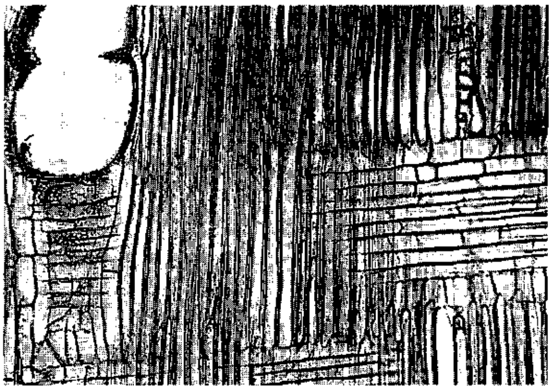
Growth rings inconspicuous. Vessels diffuse, 2–6/mm^2, solitary and in radial multiples of (2–)3–6(–9), round to mostly oval, average maximum tangential diameter 170–270 μm; perforations simple; intervessel pits alternate, vestured, mostly rounded to polygonal, sometimes loosely arranged, (6–)7–9 μm in diameter; vessel-ray pits similar to intervessel pits but half-bordered, apertures rounded; helical thickenings absent; tyloses absent. Fibres 1.1–1.2 mm long, non-septate, moderately thin-walled to moderately thick-walled, with minutely bordered to simple pits mainly confined to the radial walls. Parenchyma abundant, paratracheal, aliform to confluent, occasionally in confluent bands, in 2–4-celled strands, with a tendency to storied arrangement. Rays 9–10/mm, 1–2(–3)-seriate, 0.3–0.7 mm (5–25 cells) high, heterocellular with 1–2 marginal rows of square or upright cells (Kribs type heterogeneous II), uniseriate rays often made up of upright cells. Prismatic crystals in chambered parenchyma strands, usually at margins, some in diffuse strands. Silica absent.

Heartwood from plantation-grown black bean tends to be considerably paler than from naturally growing trees in Australia. Black bean wood may show similarity to wood of *Albizia procera* (Roxb.) Benth. and *Intsia* spp. However, it can be differentiated by consistently lacking pink tints, lack of lustre and its tendency to have storied rays.

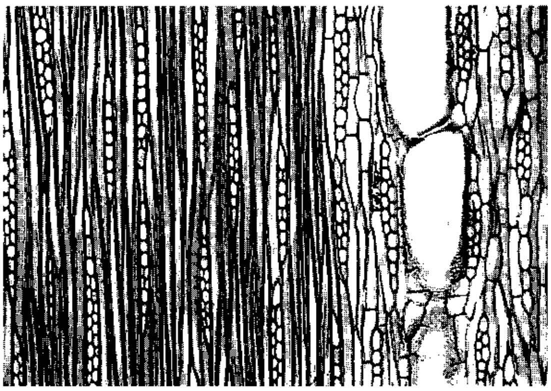
Growth and development Seed germinates below-ground and seedlings may still be alive and vital even after 2 years of burial. The seeds float and are dispersed by streams or the sea.



transverse section (×25)



radial section (×75)



tangential section (×75)

Castanospermum australe

Other botanical information *Castanospermum* belongs to the tribe *Sophoreae* and is most closely related to *Angylocalyx* (tropical Africa) and *Xanthocercis* (Madagascar and southern Africa). Castanospermine has also been found in seeds of *Alexa* spp., suggesting a close relationship with black bean.

Ecology Black bean occurs in primary coastal rain forest and along beaches; it is classified as a primary species. In its natural area of distribution the mean annual rainfall is 1000–1500 mm. It thrives on wet soils of moderate fertility, and is not tolerant of a long dry season.

Propagation and planting The seeds are large, weighing about 30 g. They are viable for a short period but can be stored longer in air-tight containers at 3–5°C. No pretreatment is needed to initiate germination. Seeds germinate from within the pod. When buried, viability remains 100% for 6 weeks, then drops to 40% after 6 months and to 0% after one year. However, germinated seeds which are buried in the ground may be dormant but viable for a long time.

Silviculture and management As black bean coppices well, replanting after harvesting may not be necessary.

Harvesting Logs often have brittle heart.

Yield The 13 m long unbranched bole of a 34 m tall tree had a volume of 11.7 m^3.

Genetic resources Black bean has been cut for its valuable timber throughout its natural area of distribution, and stands may have been seriously depleted. However, black bean has been planted in many areas outside its natural area of distribution.

Prospects As black bean timber fetches high prices there may be scope for increased cultivation in South-East Asia. However, research is needed on its silvicultural aspects before extension of its cultivation can be considered.

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Other selected sources 110, 605, 682, 713, 736.

E. Boer (general part),
M.S.M. Sosef (general part),
S.I. Wiselius (properties),
J. Ilic (wood anatomy)

Cedrela P. Browne

Civ. nat. hist. Jamaica: 158 (1756).
MELIACEAE
x = unknown; *C. odorata*: $2n$= 50, 56

Trade groups Spanish cedar: lightweight hardwood, a single species in South-East Asia, *Cedrela odorata* L., Syst. nat. ed. 10: 940 (1759), synonyms: *Cedrela guianensis* Adr. Juss. (1830), *Cedrela mexicana* M.J. Roemer (1846), *Cedrela glaziovii* C.DC. (1878).

Vernacular names Spanish cedar: cedar, West Indian cedar, cigarbox cedar (En). Cedrela (Fr). Cedro (Sp). Indonesia: cederwood (En), surian, suren. Malaysia: stinking mahogany (En). Burma (Myanmar): thit kado. Thailand: yom-hom.

Origin and geographic distribution *Cedrela* consists of about 8 species and is naturally confined to the New World tropics. As a well-known plantation tree it is, however, planted in all tropical regions. Timber plantations have been established in Costa Rica, Uganda, Tanzania, Madagascar, South Africa, the Solomon Islands and Western Samoa, for example. Within South-East Asia it is known to be planted in Thailand, Peninsular Malaysia, Singapore, Indonesia, and the Philippines.

Uses The best known use of the timber of *Cedrela* is for cigar boxes, but it is also used for light construction, mouldings, cabinets, furniture, panelling, boxes, exterior joinery, weatherboards, louvred doors, boat building (especially racing boats), canoes, musical instruments, turnery, matchboxes, household implements, face veneer and plywood. Lower grades are suitable for crates, fencing, and animal pens. The repellent smell of the wood makes it particularly suitable for the manufacture of clothing chests and wardrobes.

Cedrela is occasionally planted for shade and sometimes as an ornamental along roads and in parks, e.g. in Peninsular Malaysia, Singapore and Papua New Guinea, and also in cocoa and coffee plantations. In Papua New Guinea, the bark has been used for twine.

Production and international trade In South-East Asia only small-scale plantations exist and production and international trade of Spanish cedar is of no importance. Most of the timber is consumed locally.

Properties Spanish cedar is a lightweight and comparatively soft wood. The heartwood is pale creamy immediately after sawing, turning pinkish-brown upon exposure; it is clearly demarcated from the narrow band of sapwood. The density is 410–525 kg/m^3 at 12% moisture content. The grain is usually interlocked, sometimes straight, sometimes woolly indicating the presence of tension wood, texture moderately fine to moderately coarse; the figure is attractive in flat-sawn boards. Freshly cut wood has a distinct onion-like odour, which disappears after 2–3 days.

At 12% moisture content, the modulus of rupture is 64–67 N/mm^2, modulus of elasticity 5950–7600 N/mm^2, compression parallel to grain 27.5–34 N/mm^2, compression perpendicular to grain 3.5–4

N/mm^2, shear 6.5–8.5 N/mm^2, Janka side hardness 1765–1940 N and Janka end hardness 2490–2740 N. See also the table on wood properties.

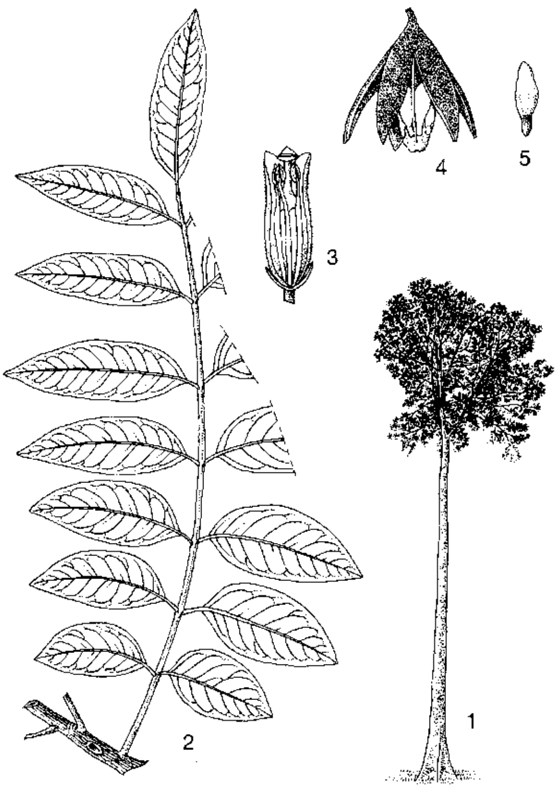
The rates of shrinkage may vary from low (e.g. 1.5% radial and 2.2% tangential from green to 12% moisture content as reported for plantation-grown wood in Western Samoa) to fairly high (as reported for the Philippines). Spanish cedar dries moderately fast with a slight risk of checking and deformation. Air drying to about 30% is recommended prior to kiln drying. A temperature of 65–75°C is recommended for kiln drying. Boards 25 mm thick take about 8 weeks to air dry and 2 days to kiln dry, boards 50 mm thick 14 weeks and 3 days, respectively. The sapwood is susceptible to staining and an anti-sapstain treatment is recommended. The wood has a good reputation for stability once dry.

Spanish cedar is easy to work. It saws, bores, turns and sands without problems and produces a good finish; it is easy to glue. However, growth stresses may cause severe end splitting of logs and warping and splitting of the central cant during saw milling. Tests in Western Samoa showed that the timber can be rotary peeled with good results without pretreatment, producing attractively figured veneer; veneer slicing also gave good results. Kraft pulping gave less good results: a yield of 54% with a Kappa number of 71; brightness was low.

The heartwood is rated as moderately durable and moderately resistant to termites, but the sapwood is non-durable and susceptible to staining and powder-post beetles. The heartwood is difficult to treat with preservatives, even by a pressure treatment.

The fine dry dust can be irritant to mucous membranes.

Description A monoecious, deciduous, medium-sized to fairly large tree up to 40 m tall (in South America up to 60 m); bole straight, cylindrical, branchless for up to 25 m, up to 120(–300) cm in diameter, buttresses absent or small and up to 2 m high; bark surface fissured, reddish-brown especially near the base of the bole, greyish higher up, inner bark pink or purplish-red; branchlets finely to conspicuously lenticellate. Leaves alternate, paripinnate with (5–)6–12(–15) pairs of leaflets; leaflets opposite to alternate, entire, ovate to oblong-lanceolate, oblique at base, 5–16 cm long, usually glabrous, apex acute to short-acuminate. Inflorescence terminal, paniculate. Flowers unisexual, but with well-developed vestiges of the opposite sex, actinomorphic, 5-merous, subsessile, 6–9 mm long, smelling of garlic; calyx cup-shaped, split on one side, shallowly to deeply toothed; petals free, imbricate and adnate for one-third of their length to a long columnar androgynophore by a medium carina (therefore preventing their spreading in open flowers), white or cream tinged red near the margin; stamens 5, free but adnate to the androgynophore below, anthers dorsifixed, opening by longitudinal slits; ovary 5-locular, pubescent, each locule with 10–14 ovules, style short, stigma discoid. Fruit a pendulous capsule with 5 thinly woody valves, oblong-ellipsoid to obovoid, (1.5–)2.0–3.5(–4.0) cm long, with a sharply angled or winged columella. Seed flat, with a terminal wing, attached by the seed end to the apical part of the columella; cotyledons collateral, flattened and leaf-like. Seedling with epigeal germination; first pair of leaves opposite, 3-foliolate, next leaves alternate.



Cedrela odorata L. – 1, tree habit; 2, branch with leaf; 3, sectioned flower; 4, dehisced fruit; 5, seed.

Wood anatomy

– Macroscopic characters:

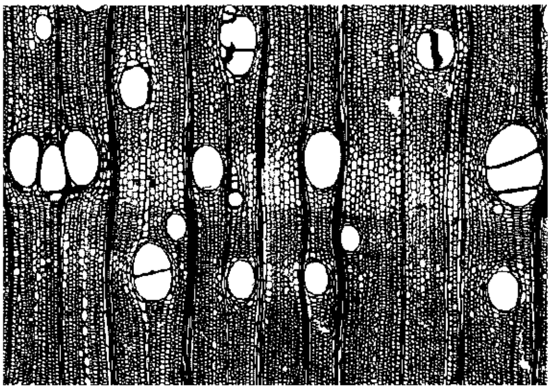
Heartwood pale pinkish to reddish-brown, sapwood creamy yellow, pale brown or yellowish-brown. Grain usually interlocked or sometimes straight. Texture moderately coarse; wood moderately to highly lustrous. Growth rings distinct, lined with large earlywood vessels and initial parenchyma, latewood vessels small but visible; vessels often occluded with dark deposits, tyloses indistinct; rays almost invisible to the naked eye; ripple marks absent.

– Microscopic characters:

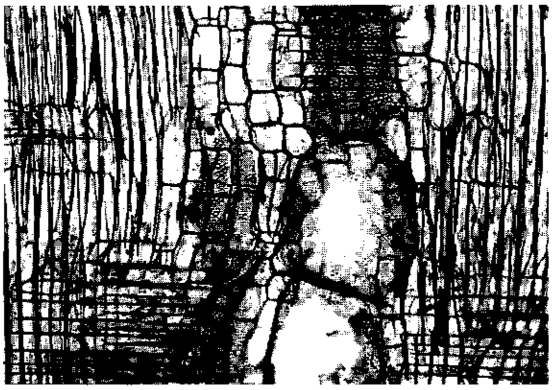
Growth rings distinct, marked by differences in pore size and initial parenchyma. Wood diffuse porous to weakly semi-ring porous; vessels 1–3/mm^2, gradually reducing in size through growth ring, uniformly distributed, solitary (35–90%) or in multiples of 2–3(–8), generally oval, average tangential and radial diameter 130–160 μm and 160–200 μm, respectively, and maximum tangential and radial diameter 200–305 μm and 290–355 μm, respectively, walls 3–6 μm thick; perforation plates simple; intervessel pits alternate, 6–10 μm; vessel-ray pits alternate to opposite, 5–8 μm; brown deposits present; tyloses absent. Fibres 0.8–1.5 mm long, non-septate, tangential diameter 8–40 μm, thin-walled (c. 2 μm), with sparse slit-like pits mainly in the radial walls; brown deposits occasionally present. Axial parenchyma paratracheal, vasicentric; apotracheal parenchyma diffuse and initial, strand length 3–7 cells or more. Rays 4–12/mm, mostly (c. 90%) multiseriate, 2–5 cells wide, up to 0.8 mm high, heterocellular, usually with one row of upright marginal cells, uniseriate rays few, short, mostly less than 0.2 mm high. Large prismatic crystals occasionally present in apotracheal parenchyma cells. Silica bodies absent. Horizontal intercellular canals and axial gum canals absent.

Growth and development Seedlings grow very quickly and may attain 40–50 cm height after 3 months and 130–150 cm after 12 months. Early annual growth may be up to 2.3 m in height and up to 4.8 cm in diameter under favourable site conditions and when not attacked by *Hypsipyla* shoot borers. Dormancy of the shoot may be signalled by the abscission of the whole terminal shoot tip, leaving lateral buds to continue axial growth. First flowering can be expected after 10–15 years. Flowering is annual, but good seed crops occur every 1–2 years. Seeds of *C. odorata* in the Philippines ripen in March–June.

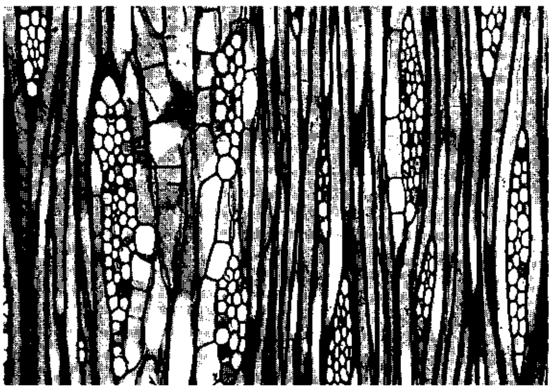
Other botanical information The genus *Cedrela* is included in the tribe *Cedreleae* of the subfamily *Swietenioideae*, together with *Toona*. All Old World species of *Cedrela* have been trans-



transverse section (×25)



radial section (×75)



tangential section (×75)

Cedrela odorata

ferred to the genus *Toona*. *Cedrela* differs from the latter by its prominent androgynophore with petals and filaments adnate to it, the cup-like calyx, the bigger and more woody capsule, and seedlings having entire leaflets.
The formerly recognized species *C. glaziovii* has recently been found to be identical to *C. odorata*.

Ecology In its natural area of distribution Spanish cedar is found in both primary and secondary, evergreen to semi-deciduous lowland or lower montane rain forest. It demands light and does not tolerate waterlogging or flooding. It occurs on a variety of soils but is usually more common on limestone, especially in areas with a high annual rainfall (2000–3000 mm).
Spanish cedar can best be planted in regions with very fertile soils and with perfect drainage that results in the good aeration of the soil required by the root system. Drought for part of the year does not adversely affect the health of the tree. In Java it is recommended to plant Spanish cedar in regions at 400–800 m altitude and with an annual rainfall of 2500–3000 mm without a marked dry season. In Bulolo, Papua New Guinea, Spanish cedar is common at 800–1400 m altitude.

Propagation and planting Propagation may be done by seed, wildlings, cuttings or air layering. One kg contains 40 000–60 000 dry seeds without wings, or 31 000–48 000 seeds with wings. Seed should be collected from capsules still on the tree after the first capsules burst, rather than from capsules laying on the ground. The seed should be spread out in the sun to complete the ripening process. Fresh seed germinates readily, but when stored under ambient conditions it rapidly loses its viability. However, seed can retain its viability for about 2 years if stored dry, cool (2–4°C) and airtight. When stored airtight at room temperature in the Philippines, the germination rate fell to 0% in less than 6 months. Well-dried seed (moisture content 6–9.5%) stored in paper bags showed no decrease in germination after 3 months, irrespective of the temperature during storage ranging from −30°C to 30°C. Germination of seed kept in closed glass bottles at 4–6°C was 82% after 2 months and 78% after 14 months.
Seeds are broadcast or sown in lines in level nursery beds and lightly covered with soil, sand, sawdust or charcoal. Where there is adequate moisture, shade is not necessary as it increases the risk of damping-off. Germination takes 2–4 weeks. It is fastest at temperatures between 30–35°C, but seed also germinates at 15°C. Direct seeding is feasible, as the young plants develop very quickly. Successful vegetative propagation of *C. odorata* by air layering and by cuttings is known from West Africa.
Collected wildlings of *C. odorata* in the Philippines had a survival rate of 94% and after some months had a shorter taproot and more lateral roots than the original seedlings growing under the mother tree. Height increment of these wildlings was 50 cm during the first 6 months after transplanting. In Papua New Guinea transplanted wildlings showed 100% survival under about 60% relative light intensity. Stumps, striplings, and container seedlings are used for planting; occasionally wildlings may be used. Stumps 20 cm tall and with a diameter of 1–2 cm planted 10 cm deep showed nearly 100% survival in Indonesia. Spanish cedar seems to experience a rather severe planting shock and therefore direct seeding is recommended when there is no shortage of seed.
As Spanish cedar is highly vulnerable to *Hypsipyla* attack, it is generally recommended to plant it in mixed plantations, e.g. with *Leucaena leucocephala* (Lamk) de Wit, *Cordia* sp. and/or *Anthocephalus chinensis* (Lamk) A. Rich. ex Walp. or under light shade, e.g. of *Eucalyptus deglupta* Blume.

Silviculture and management Spanish cedar is a fast-growing, light-demanding species. Under natural conditions it is a 'long-lived' pioneer; it tolerates shade only temporarily. In enrichment planting, it is important to ensure sufficient overhead light. As the root system is superficial, there is some risk of windthrow and therefore thinnings should be executed carefully. In Fiji, *C. odorata* proved to be very vulnerable to windbreak and windthrow. In mixed stands it is realistic to raise only 10–20 high-quality trees/ha. Well-formed straight stems are usual except in trees grown in open places. Trees affected by *Hypsipyla* attack may need pruning to remove the multiple leaders formed. The tree does not coppice. Trial plantations in Peninsular Malaysia have been a failure.
In its natural habitat, natural regeneration can be encouraged by removing trees around the seed tree and gradually opening up the canopy in the natural forest. In research plots in Papua New Guinea, the latter method has been shown to encourage growth; however, it increases the risk of insect attack.

Diseases and pests The most serious pest of Spanish cedar is the shoot borer (*Hypsipyla robusta*), which is a pest for many *Meliaceae*. The main damage is caused by the larvae, which destroy the succulent terminal shoots by boring into the tip and tunnelling in the juvenile stem of saplings and seedlings. Resprouting of the plants, followed by repeated attacks of the insect, generally results in the development of numerous side branches and consequently in badly formed trees with multiple leaders, unsuitable for timber production. In India and Australia the complete seed crop has been ruined by *Hypsipyla* larvae. The Solomon islands are still free from *Hypsipyla*, and in Nigeria *C. odorata* is not attacked by *Hypsipyla robusta* and pure plantations are possible.

There is some evidence that *Hypsipyla* attack is reduced by planting under shade, possibly because this suppresses the lateral shoots which provide the best conditions for the multiplication of the borer, or because predators prefer shaded conditions. Trees which are sufficiently vigorous tend to exude sufficient gum to entrap the invading larvae. Even repeated attacks on vigorous trees do not cause any real damage. *C. odorata* is highly susceptible to *Hypsipyla grandella* in South America, but when grafted on *Toona ciliata* M.J. Roemer, it became resistant. In Papua New Guinea, Spanish cedar has been attacked by the termite *Coptotermes elisae*.

Damping-off recorded in Philippine nurseries was mainly due to *Pythium ultimum* and to a lesser extent to *Rhizoctonia* spp. and *Fusarium* spp. Fungi, including *Armillaria mellea*, may cause damage to the roots of young trees during the first few years, but this has not yet been recorded in South-East Asia. Dieback has been observed, but is possibly an indication that climatic or soil conditions are not optimal and that the root system is suffering from insufficient aeration.

Yield During the first 9 years in trial plantations of Spanish cedar in Java the mean annual increment was 17 m^3/ha at 650 m altitude and 28 m^3/ha at 800 m altitude. A 40-year-old plantation in Nigeria could yield a timber volume of 455 m^3/ha.

Genetic resources The natural distribution of Spanish cedar has been greatly diminished by excessive exploitation over its entire range in tropical Latin America. Since it has been the subject of great commercial interest for over 200 years, large trees of the desired form and size are now rare. On the other hand, Spanish cedar has been planted throughout the tropics. In international provenance trials of *C. odorata* 14 provenances are being tested in Latin America and Africa.

Breeding A breeding programme for *C. odorata* started in Ghana, but is only at the tree selection stage. A clonal orchard comprising 23 clones was established in 1970–1972.

Prospects Spanish cedar shows potential for timber plantations as it is fast growing and produces a multipurpose timber. Trials in mixed plantations, similar to those conducted with the closely related *Toona* species, should be implemented.

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R.C.K. Chung (general part),
E. Boer (general part),
R.H.M.J. Lemmens (properties),
S. Noshiro (wood anatomy)

Chukrasia A.H.L. Juss.

Mirb. & Cass. apud Guill., Bull. Sci. Nat. Géol. 23: 239 (1830).

MELIACEAE

x = unknown; *C. tabularis*: $n = 13$, $2n = 26$

Trade groups Surian batu: medium-heavy hardwood, a single species, *Chukrasia tabularis* A.H.L. Juss. in Mirb. & Cass. apud Guill., Bull. Sci. Nat. Géol. 23: 239 (1830), synonyms: *Chickrassia tabularis* (A.H.L. Juss.) A.H.L. Juss. (1832), *Chukrasia velutina* (Wallich) Roemer (1846).

Vernacular names Surian batu: chickrassy, chittagong wood, Burma almondwood (En). Malaysia: cherana puteh, repoh, suntang puteh. Burma (Myanmar): yinma, tawyinma, kinthatputgyi. Cambodia: voryong. Laos: nhom, nhom hin, nhom khao. Thailand: siat-ka (south-eastern), yom-hin (general), fakdap (Chanthaburi). Vietnam: l[as]t hoa.

Origin and geographic distribution *Chukrasia* consists of one or possibly two species and is distributed from Pakistan eastward through India, Sri Lanka, Bangladesh, Indo-China, southern China and Thailand towards Peninsular Malaysia, northern and eastern Sumatra, and Borneo. Major stands of *C. tabularis* are found in India (e.g. western Ghats, Assam), Bangladesh, western Thailand and northern Peninsular Malaysia. *C. tabularis* has been planted in many countries outside South-East Asia, e.g. in Nigeria, Cameroon, South Africa, Hawaii, Puerto Rico and Costa Rica.

Uses The timber is highly prized for high grade cabinet work, decorative panelling, interior joinery such as doors, windows and light flooring, and for carving, toys and turnery. Besides, it is used for railway sleepers, ship and boat building, furniture, musical instruments (including pianos), packing cases, sporting goods, lorry bodies, mallet heads, anvil blocks, brush wares, drawing equipment, rifle butts, veneer and pulp. In India the timber is also used for light to medium-heavy construction work, e.g. for posts, beams, scantlings and planks.

An extract of the bark has powerful astringent properties and has been used as a febrifuge. The bark also produces a gum, but this is apparently not used. The flowers yield a red or yellow dye.

Production and international trade Surian batu is traded in small amounts and often together with timbers from other *Meliaceae* genera such as Spanish cedar (*Cedrela*) and surian (*Toona*). The total export of this combined group from Sabah in 1992 was only 92 m^3 with a value of US$ 33 000. In Peninsular Malaysia surian batu may be marketed under mixed hardwood with a variety of other timbers.

Surian batu has at least some economic value in Vietnam, Bangladesh and Sri Lanka, but no production and trade figures are available. In Thailand a production of 3160 m^3 was reported in 1966, increasing to 9800 m^3 in 1989, whereas a production of less than 350 m^3/year is reported for India.

Properties Surian batu is a moderately heavy and moderately hard wood. The heartwood is pale reddish-brown, yellowish-red to red, darkening to dark yellowish-brown, reddish-brown to medium dark brown on exposure, sharply differentiated from the yellowish-white, pale yellowish-brown, pinkish-brown or greyish-brown sapwood; dark streaks may be rather prominent. The density is 625–880 kg/m^3 at 15% moisture content. The grain is interlocked and sometimes wavy, producing a roe figure, texture moderately fine but uneven. Freshly cut wood has a fragrant odour, but dried wood has no characteristic odour or taste. Planed surfaces have a high lustrous satiny sheen.

At 15% moisture content, the modulus of rupture is 82–101 N/mm^2, modulus of elasticity 10 800–14 300 N/mm^2, compression parallel to grain 47–64 N/mm^2, compression perpendicular to grain 11–12 N/mm^2, shear 15–18 N/mm^2, cleavage c. 60 N/mm radial and 71 N/mm tangential and Janka side hardness 8990–9230 N. See also the table on wood properties.

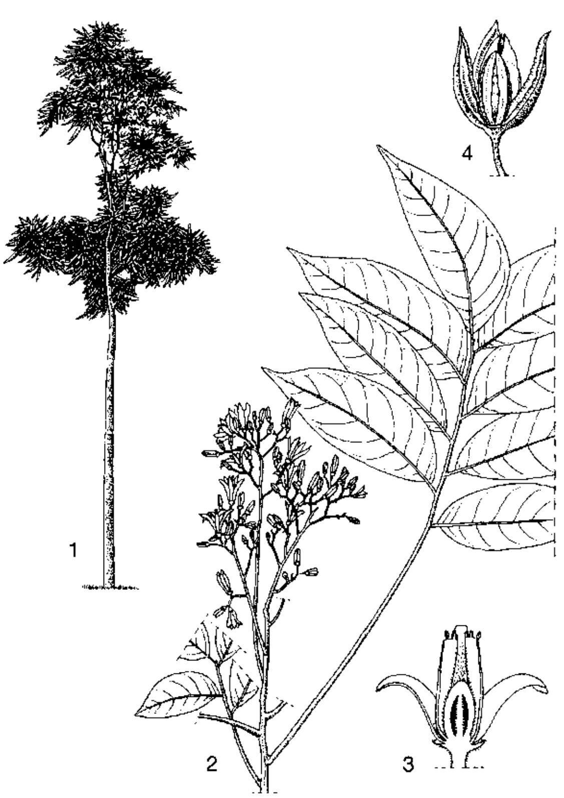
The rates of shrinkage are rather low: from green to 15% moisture content c. 1.3% radial and 1.7% tangential, from green to oven dry 3.9% radial and 6.0% tangential. Usually the wood dries fairly rapidly without degrade, but a slight tendency to check and warp and some liability to collapse have been reported. Fine hair surface checks may develop when drying thick boards. In Malaysia kiln schedule E is recommended.

Tests in Malaysia showed that the wood is difficult to very difficult to saw and cross cut, slightly difficult to turn, very difficult to bore, but easy to plane. It produces a moderately smooth finish, but some picking up of grain may occur on quartersawn material during planing and moulding. However, tests in other areas showed that the wood can be easily sawn and machined. Surian batu has good nailing and screw-holding properties, it can be stained effectively and polished excellently. The steam bending properties are rated as good. It can be readily peeled and sliced into veneers and the veneers can be glued satisfactorily to produce decorative plywood.

In Malaysia surian batu is considered as moderately durable under exposed conditions, but elsewhere it is sometimes classified as non-durable. The resistance to termite attack varies from good to poor. The wood is moderately resistant to extremely resistant to preservative treatment.

Young leaves and bark have a high tannin content, and the bark yields a reddish gum.

Description Deciduous, monoecious, medium-sized, sometimes fairly large trees up to 30(–40) m tall; bole branchless for up to 18(–32) m, with a diameter of up to 110(–175) cm, without buttresses; bark surface rusty brown or deep brown, deeply fissured or cracked, with lenticels, inner bark reddish. Leaves paripinnate, with alternate, entire, asymmetrical and acuminate leaflets (imparipinnate and lobed or incised when juvenile), glabrous or with simple hairs. Flowers unisexual, in axillary (sometimes appearingly terminal) thyrses, 4- or 5-merous, up to 16 mm long; calyx lobed; petals free, contorted, reflexed in open flowers, white; staminal tube cylindrical, narrowing towards the apex, entire or weakly lobed, with the anthers attached to the margin; disk small; ovary flask-shaped, 3–5-locular, each locule with many ovules, style slender. Fruit an erect, woody, ovoid or ellipsoid capsule opening by 3–5 valves from the apex; valves separating into a woody outer and inner layer, apex of those of the inner layer deeply bifid; locules appearing as 1 locule due to the breaking down of the septae; columella with sharp ridges. Seeds 60–100 per locule, flat, with terminal wings, arranged in layers, alternately 'head-to-toe'; embryo with thin cotyledons. Seedling with epigeal germination; cotyledons leafy; first 2 leaves opposite, subsequent ones arranged spirally; terminal leaflet present in seedling leaves but abortive in mature plants.



Chukrasia tabularis A.H.L. Juss. – 1, tree habit; 2, flowering twig; 3, sectioned flower; 4, dehisced fruit.

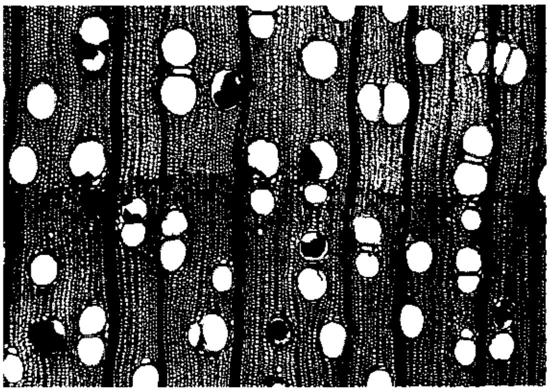
Wood anatomy

– Macroscopic characters:

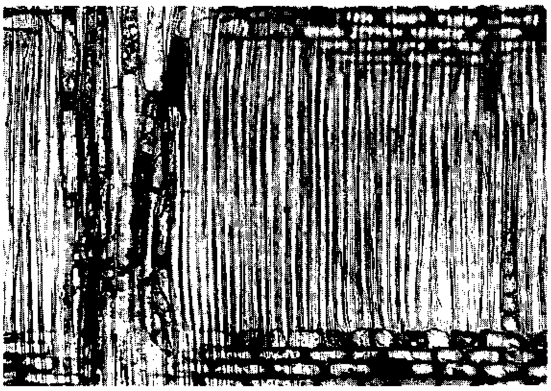
Heartwood medium dark brown, occasionally with pink tinge, sapwood pale or greyish-brown, usually lustrous. Grain weakly to strongly interlocked. Texture moderately fine. Growth rings distinct or indistinct; vessels small, barely visible to the naked eye, often occluded by black deposits, tyloses indistinct; parenchyma in very fine marginal tangential bands; rays almost invisible to the naked eye; ripple marks absent; axial intercellular canals smaller than vessels, in tangential bands.

– Microscopic characters:

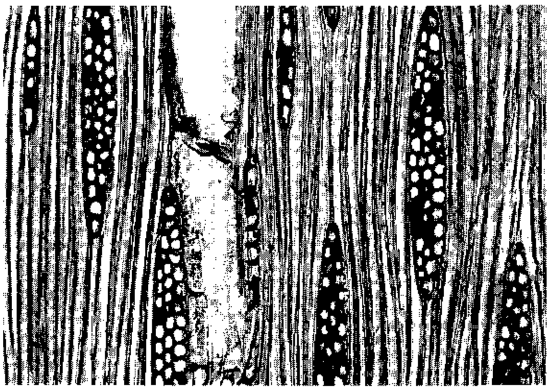
Growth rings present, defined by pore size and marginal parenchyma bands. Vessels diffuse, 13–16/mm^2, solitary (15–30%) or in multiples of 2–5, uniformly distributed, generally oval, average tangential and radial diameter c. 90 μm and 95–105 μm respectively, maximum tangential and radial diameter 145–160 μm and 205–255 μm respectively, walls 3–8 μm thick; perforation plates simple; intervessel pits alternate, dense, with a pit border diameter of 3–4 μm; vessel-ray pits alternate to opposite, half-bordered, dense, with a pit border diameter of 3 μm; brown deposits present; tyloses absent. Fibres 0.8–1.5 mm long, non-



transverse section (×25)



radial section (×75)



tangential section (×75)

Chukrasia tabularis

septate, tangential diameter c. 25 μm, thin-walled (c. 2.5 μm), with sparse minutely bordered pits mainly in the radial walls. Axial parenchyma paratracheal, vasicentric; apotracheal parenchyma diffuse and marginal, strand length 7–11 cells or more. Rays mostly (more than 70%) multiseriate, 2–4 cells wide, up to 0.5 mm high, heterocellular with 1–2 rows of square to upright marginal cells, uniseriate rays few, short, mostly less than 0.2 mm high. Horizontal intercellular canals absent; axial gum canals of the traumatic type occasionally in tangential series, 40–130 μm in tangential diameter. Silica bodies absent.

Growth and development In India, growth of seedlings proved moderately fast in the first 2 years. After 2 years the plants had reached a height of 1.2–2.1 m, after 3 years 2.8–3.4 m with a diameter of 4–5 cm and after 6 years 5.5 m tall and a diameter of 15 cm, indicating a mean annual diameter increment of 2.5 cm. Another source from India records a height of 6.6 m and a diameter of 5.2 cm for 5-year-old plants. A planting trial in western Java, using seeds from Sumatra, showed a mean height of 13 m and a mean diameter of 18 cm 10 years after planting. In the arboretum of the Forest Research Institute Malaysia the largest tree, aged 33 years, had attained a height of 33 m, a clear bole of 16 m and a diameter of 58 cm; trees may reach a diameter of 66 cm after 40 years. The tree also grows well in plantations on exposed sites: over 1 cm diameter increment annually.

C. tabularis flowers and fruits annually, seeds are ripe in January–March. The winged fruits are disseminated by wind.

Other botanical information *Chukrasia* is a very distinctive genus among the genera of the tribe *Swietenieae* of the subfamily *Swietenioideae*. It is characterized by the large flowers, the more or less entire staminal tube, and the arrangement and number of the seeds.

Some authors regard *C. velutina* from Thailand as a species distinct from *C. tabularis* (being a smaller tree and more hairy, and having harder wood), whereas others treat it as a mere form of the latter.

Ecology Surian batu is usually found scattered in lowland evergreen dipterocarp rain forest, moist semi-evergreen forest or deciduous forest at 300–800 m altitude. In Peninsular Malaysia it occasionally occurs as a colonist of bare land, including road cuttings. In Sarawak it is notably found on limestone. Surian batu usually avoids heavy and wet soils. In its natural habitat the annual rainfall is 1800–3800 mm and even more; the average maximum temperature is 36–40.5°C and the average minimum temperature is 2.5–15.5°C.

Propagation and planting There are about 100 000 seeds per kg. Seeds retain their viability for a relatively short period, about 3 months. They can be separated by threshing sun-dried woody capsules. Seeds require no pretreatment and are sown with overhead shade in light porous soil. Best results have been obtained by raising seedlings in well-drained boxes and pots before transplanting. Germination is fair to easy: in tests in Malaysia 35% of the seeds sown germinated in 1–2.5 weeks, in India 80–90% in 1–4 weeks. Watering of seedlings should be sparse. Seedlings are pricked out and transplanted when about one month old and 6–8 cm high. *C. tabularis* should not be planted on sites with heavy soil or excessive moisture. In Hawaii the presence of an impenetrable soil layer at 30–60 cm seemed to cause failure of a trial plantation of this species.

Silviculture and management Natural regeneration of *C. tabularis* in the evergreen forests of India is adequate, but it is sparse in the semi-evergreen forests. It is regarded as a pioneer species, and common in former shifting cultivation areas. Young trees coppice well.

Diseases and pests Like most species of the subfamily *Swietenioideae*, *C. tabularis* is attacked by the shoot borer *Hypsipyla robusta*. It is also attacked by *Hypsipyla* spp. in plantations in Africa and Central and South America.

Genetic resources In India a germplasm bank and a seed orchard have been established after selection of superior trees.

Prospects Surian batu timber is of high quality for various uses. It is thus a plantation species with good potential. In Peninsular Malaysia it is rated as having high plantation potential on exposed sites with frequent water stress. Research should focus on silviculture and propagation.

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K.S. Ho (general part, properties),
S. Noshiro (wood anatomy)

Cinnamomum Schaeffer

Bot. exped.: 74 (1760).
LAURACEAE
$x = 12$; $2n = 24$ for all species studied

Trade groups Camphorwood: lightweight to medium-weight hardwood, e.g. *Cinnamomum iners* Reinw. ex Blume, *C. porrectum* (Roxb.) Kosterm., *C. sintoc* Blume.
Cinnamomum wood is often traded as medang together with other *Lauraceae* timber from e.g. *Alseodaphne*, *Beilschmiedia*, *Cryptocarya*, *Dehaasia*, *Litsea*, *Persea* and *Phoebe*.

Vernacular names Camphorwood: cinnamon (En). Indonesia: medang, huru.

Origin and geographic distribution *Cinnamomum* consists of about 250 species (estimates of about 150 species have also been published) occurring in continental Asia, Malesia, Australia, the Pacific, and a few species in Central and South America. Within the Malesian area some 90 species have been recognized.

Uses The timber is used for decorative work such as interior finish and panelling, for furniture, cabinet making, lining chests, wardrobes, and is suitable for plywood manufacture. The heavier timber is used for medium-heavy construction under cover. The fragrant wood is suitable for making moth-proof chests.

The mucilage of one species (*C. iners*) has found technical applications, e.g. in the manufacture of mosquito coils, fragrant joss-sticks, plastic products, formica, glue, inner layering of tyres, coating of high-quality paper products, paints and fibre glass.

The major use of several *Cinnamomum* species is as a spice, like cinnamon, the bark of *C. verum* J. Presl (synonym: *C. zeylanicum* Blume), and cassia or cassia vera. The principal sources of cassia bark are *C. cassia* J. Presl (Chinese cinnamon), *C. tamala* (Buch.-Ham.) T. Nees & Eberm. (Indian cassia), *C. loureirii* C. Nees and *C. burmannii* (C. Nees & T. Nees) Blume (Padang cassia). Cinnamon and cassia are widely used for culinary purposes and flavouring of processed foods. Cinnamon oil is employed in perfumes and as flavouring ingredients in foods and drinks. *C. camphora* (L.) J. Presl, introduced in South-East Asia from Japan, is an important source of camphor and camphor oil and is used in many industrial products.

The bark, leaves and roots are used medicinally and the bark and fruits are used in local perfumes. The trees are planted as ornamentals along roads and as shade trees.

Production and international trade *Cinnamomum* timber is traded in Malaysia in the trade group medang together with the timber of other *Lauraceae* genera. The total export of medang in 1984 from Peninsular Malaysia to Singapore was 1500 m^3 with a value of US$ 62 000, the export from Sabah in 1992 was 52 000 m^3 (about 10% as sawn timber) with a total value of US$ 4.3 million.

In Papua New Guinea, camphorwood is ranked in MEP (Minimum Export Price) group 4, together with other *Lauraceae* timbers (medang); in 1992, saw logs fetched a minimum price of US$ 43/m^3.

Cassia vera is an important export product from Indonesia: in 1989 the export was 12 000 t with a value of US$ 38.2 million.

Properties Camphorwood is a lightweight to medium-weight hardwood. The heartwood varies in colour from greyish-green to pinkish, reddish or pale brown, sometimes turning to red-brown or walnut-brown on exposure, and is usually not distinctly demarcated from the straw-coloured, pale pink or pale brown sapwood. The density is (350–)370–860 kg/m^3 at 15% moisture content. The grain is straight to moderately interlocked, texture moderately fine and even. Usually the wood has a persistent camphor-like odour.

At 12% moisture content, the modulus of rupture is 44–93.5 N/mm^2, modulus of elasticity 7315–12 570 N/mm^2, compression parallel to grain 28–52 N/mm^2, compression perpendicular to grain c. 5.5 N/mm^2, shear 5.5–7.5 N/mm^2, cleavage 33.5–57.5 N/mm tangential, and Janka side hardness 1580–4390 N.

The rates of shrinkage are small to moderate: from green to 12% moisture content 1.6% radial and 4.8% tangential, from green to oven dry 3.3% radial and 5.7% tangential. The wood generally air dries readily with little or no degrade, but some species have a tendency to warping; wood of *C. mercadoi* warps badly unless very carefully seasoned. It is recommended to treat the timber with anti-stain chemicals before drying. The wood is stable in use.

The working properties are good. The wood is easy to saw and works well with hand tools and machines, but it is sometimes weak and brittle. It finishes smoothly. The nail-holding properties are good, and the wood takes paint, varnish and lacquer well. However, in Taiwan several species are reported to be corrosive to ferrous metals.

Camphorwood is rated as non-durable to moderately durable when exposed to the weather or in contact with the ground; *C. porrectum* wood is ranked amongst the more durable woods. The wood of many species is resistant to insect attack, but in Papua New Guinea camphorwood is reported to be susceptible to *Lyctus* attack. The heartwood is very difficult to treat with preservatives, even when using a pressure treatment.

Camphor is obtained by steam distillation of the heartwood. It is a translucent mass with crystalline fracture. The essential oils contain predominantly eugenol and safrol. *C. mercadoi* wood extract markedly inhibits the development of two types of cancer.

Description Evergreen or deciduous shrubs or small to large trees up to 50 m tall; bole branchless for up to 30 m, up to 125 cm in diameter, buttresses short or absent; bark surface smooth, rarely fissured, lenticellate, grey-brown to reddish-brown, inner bark granular, pale brown to pink or reddish-brown, with a strong aromatic smell; sapwood whitish to pale yellow. Leaves usually opposite, subopposite, alternate or arranged spirally, simple and entire, with glandular dots and aromatic when crushed, 3-veined, rarely pinnately veined (*C. porrectum*); stipules absent. Inflorescence consisting of axillary or terminal cymose panicles of clusters or umbellules of flowers. Flowers bisexual, rarely unisexual (and then polygamous), trimerous; tepals 6, subequal, united into a tube at base, usually hairy; fertile stamens 9, rarely 6, in 3 whorls, stamens in the outer 2 whorls introrse, in the inner whorl extrorse and with a pair of stalked or sessile glands, anthers 4-celled, rarely 2-celled; ovary superior, sessile, 1-celled, with a single, pendulous, anatropous ovule, style slender, with a discoid or obscurely 3-lobed stigma. Fruit a 1-seeded berry, globose or ovoid to cylindrical, the basal part surrounded by the enlarged and indurated perianth tube often carrying persistent perianth lobes; pedicel usually not enlarged. Seed without albumen, with a thin testa; cotyledons large, flat, convex and pressed against each other; embryo minute.

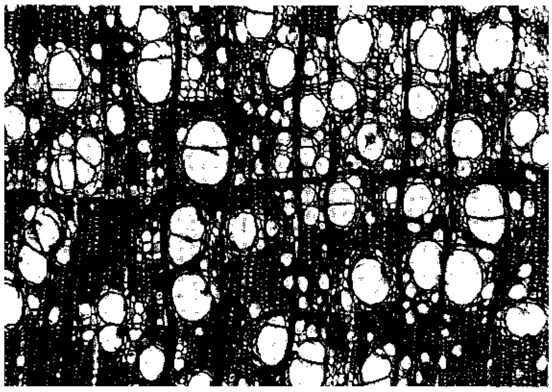
Wood anatomy

– Macroscopic characters:

Heartwood yellowish-brown to red-brown, not distinctly demarcated from the paler sapwood. Grain straight to moderately interlocked. Texture moderately fine and even; planed surfaces greasy to the touch; a persistent camphor-like odour present in most species (but reportedly absent in e.g. *C. javanicum* and *C. scortechinii*). Growth rings usually present but indistinct; vessels hardly visible to the naked eye or only visible with a hand lens; parenchyma and rays usually not distinct to the naked eye; ripple marks absent.

– Microscopic characters:

Growth rings indistinct to vague, marked by thick-walled and flattened latewood fibres, occasionally also by discontinuous marginal parenchyma bands (e.g. in *C. porrectum*). Vessels diffuse, 20–50/mm^2, solitary and in radial multiples of 2–3(–4), rarely in small clusters, angular to round or oval, average tangential diameter 80–170(–200) μm; perforations predominantly simple, but sporadic scalariform plates with few bars occurring in all species; intervessel pits alternate, non-vestured, round to polygonal, 8–12 μm; vessel-ray and vessel-parenchyma pits with reduced borders to simple, horizontally elongated (gash-like); helical thickenings and deposits absent; ty-



transverse section (×25)

radial section (×75)

tangential section (×75)

Cinnamomum iners

loses usually present. Fibres 1130–1580 μm long, all non-septate or partly septate in some species (e.g. *C. porrectum* and *C. sintoc*), thin-walled to thick-walled, depending on the species, with simple to minutely bordered pits mainly confined to the radial walls. Parenchyma sparse to abundant, vasicentric to weakly aliform; apotracheal parenchyma diffuse and rarely (*C. porrectum*) additionally in marginal bands of 1–2 cells wide, in 3–6-celled strands. Rays 6–7/mm, 2–3(–5) cells wide, up to 0.7 mm high, heterocellular with 1(–2) rows of square to upright marginal cells. Crystals absent in most species, but minute crystals of various shapes present in ray cells in some species. Silica bodies absent. Secretory (oil or mucilage) cells associated with ray and axial parenchyma.

Species studied: *C. iners*, *C. porrectum*, *C. sintoc*, *C. verum*.

Growth and development *Cinnamomum* trees are reported to grow rapidly. In 24–28-old trial plantations in Java, the mean annual increment was 1.2 cm in diameter and 0.7–1.0 m in height for *C. porrectum*. *C. camphora* grows fast under favourable conditions in its natural habitat (e.g. in Japan), and can reach a height of 10 m and a diameter of 15 cm in 10 years.

Flushes of young leaves are often strikingly reddish. The flowers are pollinated by various small insects (e.g. flies and beetles). The fruits are eaten by monkeys, squirrels, bats and birds; the seeds are probably often dispersed by birds.

Other botanical information *Cinnamomum* can be distinguished from other *Lauraceae* genera by the often 3-veined leaves and the enlarged perianth tube at the base of the fruit.

Ecology *Cinnamomum* occurs scattered, although sometimes locally abundant, in primary lowland and hill forest or sometimes in montane forest up to 2000(–3000) m altitude. It is usually found in evergreen, but sometimes in semi-evergreen forest on both fertile and poor soils, sometimes in kerangas, swamp or coastal forest.

Propagation and planting *Cinnamomum* can be propagated by seed, but the species producing cinnamon, cassia or camphor are also propagated by various methods of vegetative propagation such as air layering, root cuttings, cuttings from root suckers and by division of the root stock.

The number of dry seed per kg is about 6400 for *C. iners* and 20 000 for *C. porrectum*. Seeds cannot be stored, as they very rapidly lose their viability; however, seed of *C. camphora* may be stored for up to 6 months. After depulping, seed should be dried for only a short time and then sown directly afterwards under shade. Viability of fresh seed is about 40% for *C. iners*, 80% for *C. verum* and 40–60% for *C. camphora*.

Stumping of *C. iners* has been found to be rather successful: 85% of the stumps of 20 cm long and 0.5 cm in diameter developed into healthy plants; 20 cm long stumps of *C. sintoc* with a diameter of less than 0.5 cm did not survive at all.

Soil requirements depend on the species. *C. iners* in Sarawak is very tolerant of poor soils and still grows fairly rapidly. *C. sintoc*, however, planted on poor marl soils in Java does not grow well; the trees reached a mean height of 2 m 9 years after planting. *C. sintoc* is successfully planted on very permeable soils. In Peninsular Malaysia, *C. camphora* thrives on poor lateritic soils with good drainage.

Silviculture and management In Peninsular Malaysia, 'medang' includes a very large number of species which do not grow to timber size and which cannot yet be differentiated from those *Lauraceae* species which do reach timber size. All medang species must therefore be excluded from preferential treatment at present.

A mixed plantation of *C. iners* and teak (*Tectona grandis* L.f.) was not satisfactory, as *C. iners* did not nurse the teak trees to develop a longer clear bole. Seven years after planting the height of *C. iners* was only 2–3 m.

Cinnamomum trees resprout after fire. The cinnamon and cassia producing species are managed by coppicing; *C. camphora* in particular has a strong coppicing capacity.

Diseases and pests In Java, dieback of *C. iners* was caused by a fungus identified as *Aecidium cinnamomi* producing black-brown spots on leaves and twigs.

Yield In the *Elmerrillia ovalis* (Miq.) Dandy forest in North Sulawesi, the estimated timber volume of *C. iners* was 4.5–15 m^3/ha.

Genetic resources *Cinnamomum* seems not to be particularly endangered by genetic erosion, as the trees are not usually subjected to selective logging. However, rarer endemic species may be easily endangered by forest clearings. The species producing cinnamon and cassia barks are widely cultivated and therefore their genetic diversity is well maintained.

Prospects The demand for the spices cinnamon and cassia has always been satisfactory, and the prospects are still promising as the competition with synthetic alternatives does not noticeably affect the trade. The prospects for the essential oils seem to be slightly less bright as there are many alternatives. Little attention has been paid to the production of camphorwood, as plantation trees are merely valued for cinnamon, cinnamon oil or cassia. However, the wood is suitable for special decorative purposes, and there may be scope for multipurpose plantations including timber production. More research is needed on silvicultural management of camphorwood plantations.

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Selection of species

Cinnamomum altissimum Kosterm.

Reinwardtia 10: 439 (1988).

Distribution Peninsular Malaysia and Sumatra.

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 39 m tall, bole up to 60 cm in diameter, with short buttresses up to 1.5 m high, bark surface smooth, with faint hoop marks, lenticellate, grey-brown, inner bark pale brown to reddish-brown or pinkish; leaves opposite or subopposite, 9–29 cm × 3.5–10 cm, base cuneate to rounded, apex acuminate to blunt, glabrous below, 3-veined, main veins slightly raised above, tertiary venation faint to distinct below, petiole 1–1.5 cm long; inflorescence an axillary or terminal panicle, up to 23 cm long; flowers pale yellow, hairy; fruit ellipsoid to subovoid, up to 2.5 cm × 1 cm, perianth cup large, bell-shaped, woody, with a lobed rim. *C. altissimum* is widely distributed in lowland and hill forest, rarely in montane forest, up to 1800 m altitude.

Selected sources 327, 705.

Cinnamomum celebicum Miq.

Ann. Mus. Bot. Lugd.-Bat. 1: 264 (1864).

Vernacular names Indonesia: balisu (Sulawesi).

Distribution Northern Sulawesi.

Uses The wood is reputed to be used as medang. The bark is used in local medicine.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 55 cm in diameter, with buttresses up to 0.8 m high, bark surface smooth, brown, inner bark brown-red; leaves opposite or subopposite, 12–21 cm × 3–7 cm, base cuneate, apex attenuate-acuminate, glabrous below, 3-veined, main veins slightly prominent above, tertiary venation densely reticulate, slightly prominent below, petiole 1–1.5 cm long; inflorescence an axillary or pseudo-terminal slender panicle, up to 11 cm long; flowers grey sericeous; fruit ellipsoid, up to 1.5 cm × 0.9 cm, perianth cup rather thin, cup-shaped with an entire margin. *C. celebicum* occurs up to 700 m altitude.

Selected sources 316, 321, 322, 326.

Cinnamomum eugenoliferum Kosterm.

Reinwardtia 8: 40 (1970).

Synonyms *Cinnamomum gigaphyllum* Kosterm. (1970), *Cinnamomum hentyi* Kosterm. (1970).

Vernacular names Indonesia: insan (Hattam, Manokwari, Irian Jaya), timipikiri (Irian Jaya, Aidua).

Distribution New Guinea.

Uses The wood is reputed to be used. The bark ('kulit lawang') is an important source of eugenol. It has commercial value and is used against diferent types of dysentery. The local people chew it and spit it on the belly. The bark has also proved to be effective against cholera; apparently it acts as an antibacterial agent.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 23 m, up to 75 cm in diameter, with buttresses up to 2 m high, bark surface smooth, with rows of lenticels, brown, inner bark reddish-brown, with a strong clove odour; leaves opposite or subopposite, (9–)11–35 cm × (3–)5–20 cm, base rounded but cuneate in the centre, apex obtuse to broadly shortly acuminate, glabrous below, 3-veined, main veins slightly prominent, tertiary venation laxly reticulate below, petiole (0.6–)1–1.8 cm long; inflorescence an axillary or pseudo-terminal racemose panicle, up to 8 cm long; flowers with perianth pilose inside; fruit ellipsoid, 0.8–1.5 cm × 0.8–1 cm, with a funnel-shaped perianth cup with an entire or slightly undulate margin. *C. eugenoliferum* occurs in coastal and lowland forest, up to 1000 m altitude.

Selected sources 145, 322, 326.

Cinnamomum grandiflorum Kosterm.

Ginkgoana 6: 89 (1986).

Synonyms *Cinnamomum massoia* Schewe (1925, nom. ill.).

Vernacular names Indonesia: masoyi (Java), toom (Kebar, Irian Jaya), mehau (Namtoo mountains, Irian Jaya), moso (Mooi language, Irian Jaya).

Distribution New Guinea.

Uses The wood is reputed to be used. The bark is one of the sources of the commercially traded 'massoi', which is used against various ailments and diseases of the intestines on account of its aromatic properties and because it contains an irritating oil. Massoi is also used as a body rub to warm the muscles and because of its odour.

Observations A large tree up to 50 m tall, bole branchless for up to 25 m, up to 125 cm in diameter, often with buttresses up to 2 m high, bark surface smooth or persistently flaky, lenticellate, pale brown, inner bark dark pink; leaves opposite to alternate, (8–)14–25 cm × (3.5–)4–8 cm, base cuneate to rounded, apex obtuse to broadly shortly acuminate, glabrous below, 3-veined, main veins slightly prominent above, tertiary venation laxly reticulate below, petiole 1.5–2 cm long; inflorescence an axillary or pseudo-terminal panicle often reduced to a raceme; flowers minutely sericeous; fruit ovoid-ellipsoid, up to 2 cm × 1.3 cm, perianth cup-shaped and with a slightly wavy truncate rim. *C. glandiflorum* is common, occurring in lowland and lower montane rain forest, up to 1300 m altitude. The density of the wood is about 385 kg/m^3 at 15% moisture content.

Selected sources 145, 234, 316, 322, 326, 330.

Cinnamomum grandis Kosterm.

Reinwardtia 10: 443 (1988).

Distribution Borneo (Sabah).

Uses The wood is reputed to be used as medang.

Observations A large tree up to 42 m tall, bole branchless for up to 30 m, up to 75 cm in diameter, with buttresses up to 0.9 m high, bark surface smooth, inner bark pale; leaves opposite or subopposite, 10–15 cm × 2.5–4.5 cm, base cuneate, apex tapering, densely appressed pilose but glabrescent, 3-veined, main veins slightly prominent above, tertiary venation scalariform, faint below, petiole 1–1.5 cm long; inflorescence an axillary or pseudo-terminal panicle, up to 14 cm long; fruit ellipsoid, up to 2 cm × 0.8 cm, the perianth cup-shaped, with a comparatively thick wall and an entire margin. *C. grandis* is still imperfectly known and occurs in montane forest at 1500–2000 m altitude.

Selected sources 327.

Cinnamomum iners Reinw. ex Blume

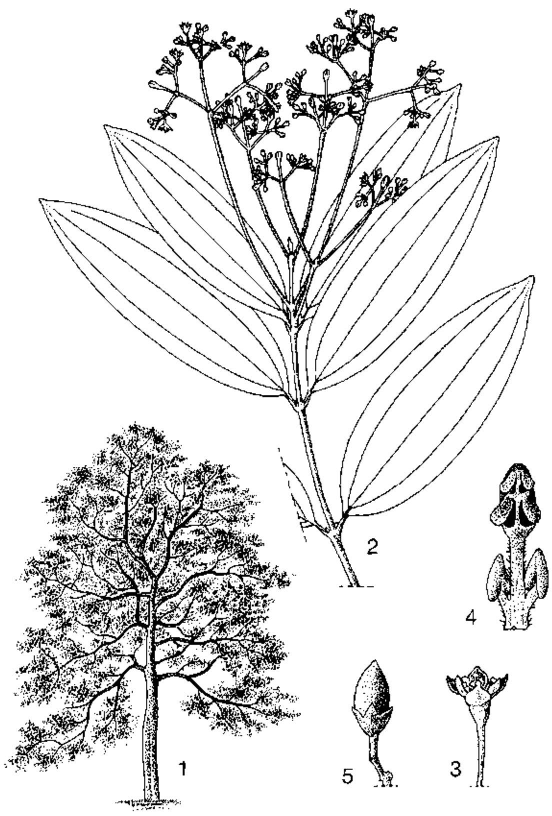
Bijdr. fl. Ned. Ind. 11: 570 (1826).

Synonyms *Cinnamomum eucalyptoides* T. Nees (1831), *Cinnamomum nitidum* Blume (1834), *Cinnamomum paraneuron* Miq. (1858).

Vernacular names Clove cinnamon, wild cinnamon (En). Indonesia: ki teja (Sundanese, Javanese, Java), medang kalong (Belitung), kacengal (Madurese). Malaysia: medang teja (Peninsular, Sarawak), kayu manis hutan, teja lawang (Peninsular). Philippines: namog (Filipino). Burma (Myanmar): hmanthin. Laos: chouang, 'si khai t[oox]n^2. Thailand: chiat (peninsular), kradangnga (Kanchanaburi), phayaprap (Nakhon Ratchasima). Vietnam: qu[ees] l[owj]n.

Distribution India, Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi and the southern Philippines.

Uses The wood is used as medang, e.g. for house



Cinnamomum iners Reinw. ex Blume – 1, tree habit; 2, flowering twig; 3, flower; 4, stamen; 5, fruit.

building and cabinet work. The mucilage has found technical applications, e.g. in the manufacture of mosquito coils, fragrant joss-sticks, plastic products, formica, glue, inner layering of tyres, coating of high-quality paper products, paints and fibre glass. The bark is sometimes traded and called 'mesni' in Sarawak; it is used as a medicine, or together with the leaves in tea, and also as a substitute for cinnamon. The oil from the leaves is used for flavouring sweets and confectionery. The tree is sometimes planted as a shade tree.

Observations A medium-sized tree up to 24 m tall, bole up to 60 cm in diameter, bark surface smooth, lenticellate, greyish-brown, inner bark pinkish; leaves opposite or subopposite, (5–)7.5–30 cm × 2–13 cm, base cuneate, rarely rounded, apex blunt to acute, often glaucous below, 3-veined, main veins prominent above, tertiary venation scalariform to scalariform-reticulate, faint to distinct below, petiole 1–2 cm long; inflorescence an axillary or terminal panicle, up to 18 cm long; flowers sometimes partly unisexual, densely silky hairy; fruit oblong to narrowly ovoid, c. 1.5 cm × 1 cm, seated on a perianth cup with persistent perianth lobes. *C. iners* is common, occurring in primary and secondary lowland and hill forest, often in moist, rather open locations, up to 1200(–2400) m altitude. The density of the wood is 380–685 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 35, 63, 69, 77, 80, 104, 125, 140, 147, 218, 303, 316, 326, 330, 426, 522, 574, 600, 604, 676, 705, 734.

Cinnamomum javanicum Blume

Bijdr. fl. Ned. Ind. 11: 570 (1826).

Synonyms *Cinnamomum sulphuratum* C. Nees (1831), *Cinnamomum neglectum* Blume (1836).

Vernacular names Indonesia: kayu tuha (Sumatra), huru gading, sintok lancang (Sundanese, Java). Malaysia: medang wangi, medang teja, kulit lawang kechil (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra, Java and Borneo.

Uses The wood is used as medang, e.g. for house construction. The bark is used in local medicine. A decoction of the leaves is sometimes used like massoi, similar to that of *C. grandiflorum*. The root is used, sometimes in combination with oil, as a vesicant over an enlarged spleen.

Observations A small to medium-sized tree up to 21 m tall, bole up to 50 cm in diameter, with buttresses up to 1 m high, bark surface smooth, lenticellate, grey, inner bark pink; leaves opposite or subopposite, 13–40 cm × 3–15 cm, base cuneate, apex acuminate, velvety hairy below, 3-veined, main veins prominent above, tertiary venation scalariform, prominent below, petiole 1–2 cm long; inflorescence terminal, 15–30 cm long; flowers velvety hairy; fruit ovoid, c. 1.5 cm × 1 cm, the lower half enclosed in the hairy and lobed perianth cup. *C. javanicum* is locally common in lowland and hill forest, up to 1100 m altitude. The density of the wood is 460–620 kg/m^3 at 15% moisture content.

Selected sources 35, 78, 80, 104, 140, 234, 303, 316, 322, 474, 705, 734.

Cinnamomum mercadoi S. Vidal

Rev. pl. vasc. Filip.: 224 (1886).

Vernacular names Philippines: kalingag (Filipino), samiling (Tagalog), kaningag (Samar-Leyte Bisaya).

Distribution The Philippines.

Uses The wood is used e.g. for house construction, cabinet work, lining chests, and wardrobes. The bark yields cinnamon which is used internally to improve digestion and is applied in root beer. It has successfully been applied against headache and rheumatism, and is also used against stomach troubles and tuberculosis.

Observations A small to medium-sized tree up to 30 m tall, bole straight, cylindrical, up to 100 cm in diameter, with small pronounced buttresses, bark surface grey, inner bark red; leaves opposite or subopposite, 5–13 cm × 1.5–4.5 cm, base shortly acute, apex attenuate-acuminate, glaucous below, 3-veined, main veins slightly prominent to slightly sunken, tertiary venation scalariform, indistinct, petiole 1–1.5 cm long; inflorescence a pseudo-terminal panicle, up to 15 cm long; flowers with the perianth segments pilose inside; fruit ellipsoid, up to 1.3 cm × 0.8 cm, seated on a deep perianth cup bearing the bases of the perianth segments. *C. mercadoi* is fairly common in lowland and hill forest, sometimes up to 2000 m altitude. The density of the wood is about 540 kg/m^3 at 15% moisture content.

Selected sources 78, 125, 202, 316, 326, 330, 414, 426, 527.

Cinnamomum mollissimum Hook.f.

Fl. Brit. India 5: 131 (1886).

Vernacular names Malaysia: medang wangi, medang lawang, teja (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as medang, e.g. for house construction. The bark has been used as a spice in the betel quid, in the belief that it serves as a tonic; it is also taken after childbirth.

Observations A small tree up to 15 m tall, bole up to 20 cm in diameter, with small buttresses, bark surface smooth, greyish, inner bark brown; leaves opposite, 10–20 cm × 3.5–7.5 cm, base cuneate, apex pointed, woolly hairy, 3-veined, main veins sunken above, tertiary venation scalariform-reticulate, prominent below, petiole 0.5–2 cm long; inflorescence an axillary or terminal panicle, c. 10 cm long; flowers woolly hairy; fruit ovoid, c. 0.7 cm long, seated on a cup-shaped, wavy-margined perianth. *C. mollissimum* is fairly common in lowland and hill forest, including swamp and riverine forest, also in dry *Dryobalanops* forest, up to 1600 m altitude. The density of the wood is about 665 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 140, 316, 322, 705.

Cinnamomum pendulum Cammerl.

Bull. Jard. Bot. Buitenzorg, sér. 3, 7: 461 (1925).

Synonyms *Cinnamomum endlicheriaecarpum* Kosterm. (1969).

Vernacular names Brunei: balong, belong (Iban), lawang (Tutong Iban). Malaysia: batunuk (Idahan, Sabah), tatagas bo kabuaan (Murut, Sabah), kayu manis (Malay, Sabah).

Distribution Borneo, possibly also in western Sumatra.

Uses The wood is reputed to be used as medang. The bark is traded as 'sintok' or 'kulit lawang' and is applied medicinally against coughs, stomach pains and flatulence. Both bark and fruits are used in local (Dayak) perfumes. The aromatic roots are applied to wounds.

Observations A small to medium-sized tree up to 25 m tall, bole branchless for up to 18 m, up to 100 cm in diameter, with small buttresses, bark surface smooth, sometimes cracked, pale brown, inner bark orange-yellow; leaves 4–9 cm × 9–27 cm, base shortly acute, apex distinctly acuminate, glabrous below, 3-veined, main veins slightly prominent above, tertiary venation scalariform, faint below, petiole 0.5–1 cm long; inflorescence an axillary or pseudo-terminal panicle, up to 16 cm long; flowers silvery hairy; fruit narrowly subovate-ellipsoid, c. 2 cm × 0.8 cm, the perianth cup with long persistent perianth segments. *C. pendulum* is found up to 600 m altitude.

Selected sources 80, 316, 321, 322.

Cinnamomum politum Miq.

Ann. Mus. Bot. Lugd.-Bat. 1: 265 (1864).

Synonyms *Cinnamomum xylophyllum* Kosterm. (1969).

Distribution Borneo (Brunei, Sarawak, Kalimantan).

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 37 m tall, bole up to 30 cm in diameter, buttresses up to 1.5 m high, bark surface smooth or slightly cracked at the base, brown and grey or purple mottled, inner bark pale orange-brown; leaves opposite, 5–14 cm × 2.5–5 cm, base acute to cuneate, apex broadly to prominently acuminate, glabrous, 3-veined, main veins slightly prominent above and sunken below, petiole slender; inflorescence an axillary shortly branched slender panicle; flowers grey sericeous; fruit unknown. *C. politum* occurs on leached, sandy soils in kerangas or mossy, primary or old secondary forest, up to 800 m altitude.

Selected sources 80, 316, 321, 322.

Cinnamomum porrectum (Roxb.) Kosterm.

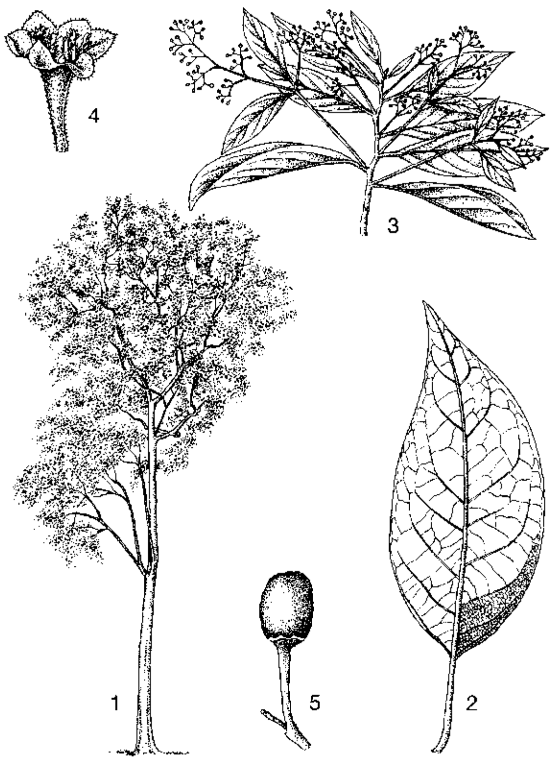
Journ. Sci. Research Indon. 1: 126 (1952).

Synonyms *Cinnamomum glanduliferum* C. Nees (1831), *Cinnamomum parthenoxylon* (Jack) C. Nees (1831), *Cinnamomum sumatranum* (Miq.) Meissner (1864).

Vernacular names Safrol laurel (En). Indonesia: medang lesah (general), ki sereh (Sundanese, Java), selasihan (Javanese, Java), rawali (Kalimantan). Malaysia: medang kemangi (Peninsular), keplah wangi (Sarawak), bunsod (Sabah). Burma (Myanmar): karawa. Thailand: thep-tharo (central). Vietnam: re huong.

Distribution India, Burma (Myanmar), through Indo-China, Thailand and southern China, towards Peninsular Malaysia, Singapore, Sumatra, Java and Borneo.

Uses The wood is used as medang. It is considered fairly durable, is valued for general construction, and is also suitable for cabinet work. The wood-oil contains safrol which can be used in soaps, and in local medicine. The aromatic bark is used for flavouring food and is considered an excellent tonic. The roots are used medicinally against fever, and applied after childbirth, as those of other cinnamon species.



Cinnamomum porrectum (Roxb.) Kosterm. – 1, tree habit; 2, leaf; 3, flowering twig; 4, flower; 5, fruit.

Observations A medium-sized to large, more or less deciduous tree up to 45 m tall, bole straight, cylindrical, up to 105 cm in diameter, sometimes buttressed, bark surface deeply irregularly fissured or cracked, dark grey or greyish-brown, inner bark reddish-brown, laminated; leaves subopposite to spiral, 5–15 cm × 2.5–8 cm, base cuneate to rounded, apex blunt to acuminate, glabrous, with 3–8 pairs of lateral veins, main veins prominent above, tertiary venation reticulate, faint on both surfaces, petiole 1.2–3 cm long; inflorescence an axillary or pseudo-terminal panicle, 2.5–15 cm long; flowers glabrous or sparingly hairy; fruit globose to slightly depressed globose, 0.8–1 cm across, seated on a funnel-shaped perianth cup with an entire margin. *C. porrectum* is widely distributed and locally common in lowland to montane forest, sometimes in regions with a pronounced dry season, on both fertile and poor soils, usually in well-drained locations, up to 2000 (–3000) m altitude. The density of the wood is 400–860 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 35, 69, 77, 78, 80, 104, 140, 218, 303, 316, 322, 330, 403, 405, 474, 526, 574, 676, 705, 734.

Cinnamomum scortechinii Gamble

Kew Bull.: 219 (1910).

Vernacular names Malaysia: medang teja (Peninsular).

Synonyms *Cinnamomum velutinum* Ridley (1920).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 65 cm in diameter, with buttresses up to 2 m high, bark surface smooth with patches of large lenticels, grey-brown, inner bark brownish; leaves opposite, subopposite or alternate, 6–15 cm × 2.5–6 cm, base cuneate to broadly cuneate, apex acute to obtusely acuminate, velvety hairy below, 3-veined, main veins sunken above, tertiary venation scalariform, sunken above, distinct below, petiole 1–1.5 cm long; inflorescence an axillary or terminal panicle, 7–14 cm long; flowers with the perianth hairy on both surfaces; fruit oblong to ovoid, c. 1 cm × 0.5 cm, seated on a shallow perianth cup with an entire margin. *C. scortechinii* is fairly common in lower montane forest, at 1200–1500 m altitude. The density of the wood is about 515 kg/m^3 at 15% moisture content.

Selected sources 140, 182, 316, 322, 529, 705, 734.

Cinnamomum sintoc Blume

Bijdr. fl. Ned. Ind. 11: 571 (1826).

Synonyms *Cinnamomum camphoratum* Blume (1826), *Cinnamomum calophyllum* Reinw. ex C. Nees (1836), *Cinnamomum cinereum* Gamble (1910).

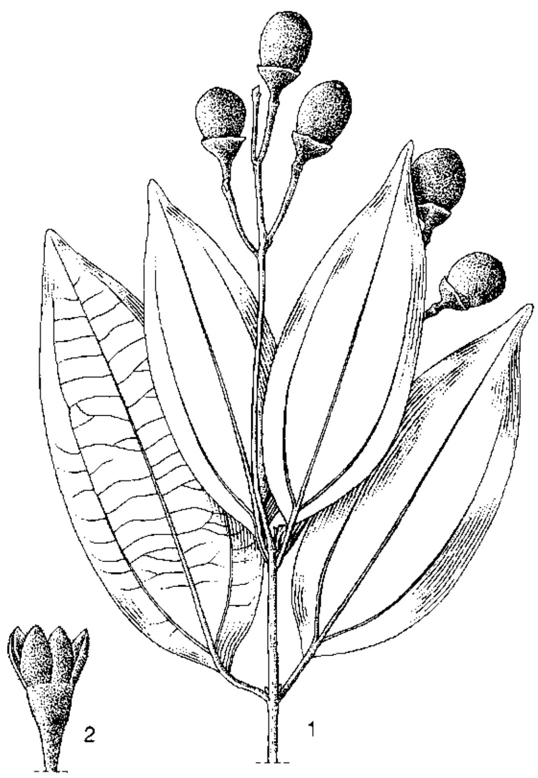
Vernacular names Indonesia: huru sintok, wuru sintok (Java). Malaysia: medang teja lawang (Peninsular). Thailand: luk kha.

Distribution Thailand, Peninsular Malaysia, Sumatra, Java, the Lesser Sunda Islands and Borneo.

Uses The wood is used as medang. Perhaps still more important is the medicinal use of the bark, which is called 'sintok', against diarrhoea, and other intestinal complaints. It is also regarded as a vermifuge and applied to wounds. The pleasant smell of cloves, caused by eugenol oil, has led to its use in cosmetics.

Observations A medium-sized to fairly large tree up to 39 m tall, bole up to 70 cm in diameter, with buttresses up to 2 m high, bark surface smooth to shallowly fissured, lenticellate, grey-brown, inner bark red with white striations; leaves opposite or subopposite, 7–22.5 cm × 2.5–8.5 cm, base narrowly to broadly cuneate, apex blunt to acuminate, hirsute below but glabrescent, 3-veined, main veins prominent above, tertiary venation reticulate, very faint on both surfaces, petiole 0.8–1.8 cm long; inflorescence an axillary or pseudo-terminal panicle, 10–15 cm long; flowers grey tomentose; fruit oblong to ellipsoid, c. 1.8 cm × 0.8 cm, seated on a cup-shaped perianth with an entire margin. *C. sintoc* is common in hill forest, but does occur in lowland and montane forest, up to 2400 m altitude. The density of the wood is 350–820 kg/m^3 at 15% moisture content.

Selected sources 35, 77, 78, 80, 107, 140, 219, 220, 234, 303, 316, 322, 522, 705.



Cinnamomum sintoc Blume – 1, fruiting twig; 2, flower.

Cinnamomum subavenium Miq.

Fl. Ind. Bat. 1: 902 (1858).

Synonyms *Cinnamomum cyrtopodum* Miq. (1858), *Cinnamomum borneense* Miq. (1864), *Cinnamomum ridleyi* Gamble (1910).

Vernacular names Indonesia: medang lawang, medang melang sumpan (Bangka), madang kulit manis (Sumatra). Thailand: cha-em (Loei), suramarit (Nakhon Ratchasima), se-ko-le (Karen-Chiang Mai).

Distribution India, Indo-China, Formosa, Thailand, Peninsular Malaysia, Sumatra, western Java, Borneo and Sulawesi.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 65 cm in diameter, with buttresses up to 2 m high, bark surface smooth, pustular, grey-brown to reddish-brown, inner bark pale brown, soon becoming red on exposure; leaves opposite to alternate, 5.5–15 cm × 2–6 cm, base cuneate, apex pointed, drying reddish on both surfaces, glabrescent below, 3-veined, main veins slightly raised above, tertiary venation scalariform, faint below, petiole 0.6–1 cm long; inflorescence an axillary panicle, 10 cm long; flowers with the perianth densely hairy inside; fruit ovoid, 1–1.2 cm × 0.6–0.7 cm, seated on a cup-shaped perianth with an entire or slightly wavy margin. *C. subavenium* is locally abundant in lowland and montane forest, both evergreen and semi-evergreen, up to 1700 m altitude. The density of the wood is 540–690 kg/m^3 at 15% moisture content.

Selected sources 78, 80, 303, 316, 322, 574, 705.

Cinnamomum subcuneatum Miq.

Fl. Ind. Bat. 1: 895 (1858).

Vernacular names Indonesia: kulit manis tupai, kulit lawang, rang ganjai (Sumatra).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sabah).

Uses The wood is reputed to be used as medang.

Observations A small to medium-sized tree up to 20 m tall; leaves opposite or subopposite, 7.5–17(–25) cm × 3–6(–8) cm, base cuneate, apex tapered and acuminate, slightly glaucous and finely hairy below, 3-veined, main veins raised above, tertiary venation scalariform, very faint, petiole c. 1 cm long; inflorescence an axillary or pseudo-terminal lax panicle, 10–20 cm long; flowers hairy; fruit ellipsoid, 0.5–0.7 cm × 1–1.5 cm, seated on a cup-shaped perianth with a lobed margin. *C. subcuneatum* is uncommon in lowland to montane rain forest, up to 1600 m altitude. Fresh logs sink in water.

Selected sources 316, 322, 705.

Cinnamomum subtetrapterum Miq.

Fl. Ind. Bat. 1: 902 (1858).

Distribution Sumatra.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 32 m tall, bole up to 70 cm in diameter; leaves opposite or subopposite, 17.5–23 cm × 13 cm, base acute, apex attenuate-subacuminate, 3-veined, petiole 0.8–1 cm long; inflorescence an axillary or pseudo-terminal panicle; flowers with sparsely puberulous or glabrous perianth; fruit ellipsoid, seated on a large, semiglobose perianth cup. *C. subtetrapterum* is still imperfectly known and occurs up to 1000 m altitude.

Selected sources 316, 322, 433.

Ibrahim bin Jantan (general part, selection of species),
S.I. Wiselius (properties),
S.C. Lim (wood anatomy),
M.S.M. Sosef (selection of species)

Coelostegia Benth.

Benth. & Hook.f., Gen. pl. 1: 213 (1862).

BOMBACACEAE

x = unknown

Trade groups Punggai: lightweight to medium-weight hardwood, e.g. *Coelostegia borneensis* Becc., *C. griffithii* Benth.

The timber is often traded as durian, together with timber of the related genus *Durio*, and sometimes small amounts of *Kostermansia* (krepal) and *Neesia* (bengang).

Vernacular names Punggai: black durian (En). Brunei: durian isa. Indonesia: durian hantu (Sumatra). Malaysia: durian isa, serangap (Sarawak).

Origin and geographic distribution *Coelostegia* consists of 5 species. All species are found in Borneo, and only *C. borneensis* and *C. griffithii* also occur in Peninsular Malaysia, Sumatra, and Bangka.

Uses The timber is used for making clogs, coffins, furniture, joinery, construction under cover, light flooring, door and window frames, joists, panelling and partitioning, interior trim, boat building, vehicle bodies, agricultural implements, boxes, poles, veneer, blockboard, hardboard and particle board.

The bark is used for tanning and yields a reddish-brown dye used to dye fishing nets and lines. The roasted seeds are edible.

Production and international trade Punggai timber is usually traded as durian or as 'mixed light hardwood'. No separate trade and export statistics are available. The export of durian from Sabah in 1992 was 8500 m^3 (90% as logs and 10% as sawn timber) worth US$ 660 000 (US$ 68/m^3 for logs and US$ 170/m^3 for sawn timber); the contribution of punggai to this total amount was probably comparatively small.

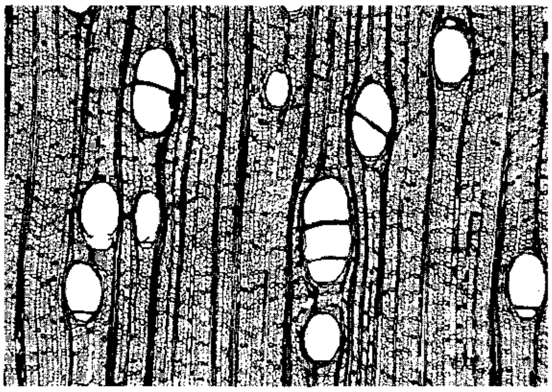
Properties Punggai is a lightweight to medium-weight hardwood. The heartwood is orange-brown to orange-red or reddish-brown and poorly defined from the pale yellow-orange sapwood. The density is 605–795 kg/m^3 at 15% moisture content. The grain is slightly interlocked, texture coarse and uneven. The wood is not lustrous and has no figure; fresh wood has a fetid smell.

A test on wood from one *C. griffithii* log in Malaysia at 16.5% moisture content showed the following mechanical properties: the modulus of rupture 95 N/mm^2, modulus of elasticity 15 800 N/mm^2, compression parallel to grain 54 N/mm^2, compression perpendicular to grain 5.5 N/mm^2, shear 9 N/mm^2, cleavage 37 N/mm radial and 42 N/mm tangential, and Janka side hardness 5340 N.

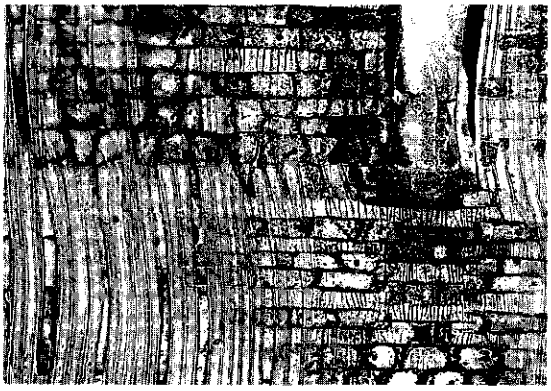
The rates of shrinkage of *C. griffithii* wood are fairly low: from green to 18% moisture content 1.3% radial and 1.6% tangential. The wood dries rapidly without much degrade except that it is prone to staining during seasoning. Boards of 15 mm thick take about 2.5 months to air dry, and boards of 40 mm thick 3.5 months. The wood can

be kiln dried moderately fast, just like other durian timber, using schedule D (Malaysia), with only slight twisting. It is recommended to air dry sawn timber for at least 2 weeks before kiln drying.
Wood of *C. griffithii* is fairly easy to saw when green but slightly difficult when air-dry. This is probably due to the presence of silica, which may cause rapid blunting of saw teeth and cutting edges and heating of the saw. Planing is easy, giving a moderately smooth finish, but boring and turning may give less good results. The nailing and gluing properties are rated as good. No peeling trial has been conducted on punggai wood, but as durian logs are widely used in plywood production, it is probably suited for this purpose.
Punggai wood is classified as non-durable. Test stakes of *C. griffithii* wood with dimensions of 50 mm × 50 mm × 600 mm showed an average service life in contact with the ground of 1.5 years in Malaysia. The wood is prone to termite, pinhole borer and marine borer attack. It is easy to treat with preservatives.

Description Medium-sized to large trees up to 50 m tall, with cylindrical, straight bole up to 110 cm in diameter, usually having prominent plank buttresses; bark surface smooth or rough, longitudinally fissured or scaly, greyish-brown, dark grey, rich purplish-brown or dark brown, inner bark cream-coloured to pinkish-brown or meat-red; crown usually spreading and rather open. Young twigs, inflorescences and leaf undersurfaces more or less densely scaly. Leaves alternate, simple and entire, usually elliptical-oblong, secondary veins slender, curving and anastomosing near the margin; petiole usually slender, prominently kneed near apex; stipules present but small and soon shed. Inflorescence short, usually a much-branched panicle on older branches or from leaf axils. Flowers small (up to 10 mm in diameter), having short pedicels with short caducous bracts and 3-lobed, cup-shaped epicalyx; calyx consisting of 5 sepals connate at base forming a cup-like structure, with saccate lobes; petals 5, shorter than sepals, coherent and forming a cap around the ovary, caducous and shed as a whole; c. 20 stamens, with short filaments united at base, each bearing 3 one-celled anthers; ovary superior but partly embedded in the calyx tube, 5-celled with few to many ovules in each cell, style 1, filiform, longer than stamens, stigma conspicuous and peltate. Fruit a large, woody, globose, ellipsoid or ovoid capsule, spiny to almost smooth, dehiscent on the tree for half of its length or more into 5 very hard valves, finally becoming black and slowly de-



transverse section (×25)



radial section (×75)

tangential section (×75)

Coelostegia griffithii

caying. Seeds in 2 rows in each compartment of the fruit, with small, usually orange-yellow or creamy aril, with rather thin seed-coat, thin foliaceous cotyledons and thick endosperm. Seedling with epigeal germination, cotyledons remain in the seed-coat, hypocotyl strongly elongated; first two leaves opposite, subsequent leaves alternate, conduplicate.

Wood anatomy

– Macroscopic characters:

Heartwood orange-brown to orange-red or reddish-brown and indistinctly differentiated from the paler sapwood. Grain slightly interlocked. Texture coarse and uneven. Growth rings absent or very faint; vessels visible to the naked eye, axial parenchyma and rays indistinct without a hand lens.

– Microscopic characters:

Growth rings absent or very faint and then marked by very slight differences in fibre wall thickness. Vessels diffuse, c. 4/mm^2, solitary and in radial multiples of 2–4(–6), the longer multiples usually including narrow vessels, round to oval, average tangential diameter 210 μm; perforations simple; intervessel pits non-vestured, alternate, polygonal, 4–6 μm, occasionally with coalescent apertures; vessel-ray and vessel-parenchyma pits similar but half-bordered; helical thickenings, deposits and tyloses absent. Fibres c. 1300 μm long, non-septate, thin-walled, with simple to minutely bordered pits mainly confined to the radial walls. Parenchyma scanty paratracheal, diffuse, diffuse-in-aggregates and in longer radial lines, in 6–8-celled strands. Rays c. 9/mm, uniseriate and 2–6-seriate, 0.4–2.0 mm high, composed of procumbent cells alternating with rows of tile cells of the Durio type (similar in height to the procumbent ray cells). Prismatic crystals present in non-chambered axial parenchyma cells. Silica bodies present in axial and ray parenchyma cells.

Species studied: *C. griffithii*.

Growth and development Branching in young trees is dimorphic, the stem being orthotropic with leaves arranged spirally, and the branches plagiotropic with leaves in distichous arrangement. The crown of *C. griffithii* is open and may spread up to over 20 m; it makes up less than half of the total height of the tree.

Flowers develop on the older twigs and branches; this may be referred to as ramiflory. Flowering in Peninsular Malaysia is in January–May and September whereas ripe fruits are found from January–May and in September and December. The fruits dehisce on the tree. After falling, they decay very slowly (more than one year) in the natural forest because of the hard rind.

Other botanical information *Coelostegia* is closely related to *Durio*, *Neesia* and the monotypic genus *Kostermansia*. It differs from *Durio* in the usually smaller flowers with epicalyx not completely covering the flower bud and the calyptriform corolla being shed as a whole. It differs from *Neesia* by the absence of irritant hairs inside the fruit wall, and from *Kostermansia* by the saccate sepals, the coherent, calyptrate petals and the presence of an aril.

Ecology Punggai occurs scattered in mixed dipterocarp lowland forest (up to 700 m altitude), often on clay-rich soils but sometimes on semi-swampy soils. It is nowhere really common, and only very seldom can an average of 0.7 tree of commercial size per ha be found; generally not more than one tree occurs per 40 ha.

Propagation and planting The viability of fresh seeds of *C. griffithii* is 70–95% and seeds germinate in 22–48 days. Natural regeneration seems to be sufficient to maintain the low density of punggai in natural forest.

Silviculture and management Since punggai trees occur only in very small quantities in natural forest, no particular silvicultural measures are taken with regard to this group of species.

Genetic resources As the density of punggai in natural forest is very low, it seems to be easily liable to genetic erosion when harvested. Only *C. griffithii* is locally more common and is probably not at risk of depletion of stands but other species are scarce and seem more vulnerable.

Prospects Punggai timber can be used for various purposes and should receive more attention in research. In particular, attention should be devoted to the silviculture and propagation of punggai, since extremely little is known about these aspects.

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Lumpur. pp. 152–153. |**5**| Grewal, G.S., 1979. Air-seasoning properties of some Malaysian timbers. Malaysian Forest Service Trade Leaflet No 41. Malaysian Timber Industry Board, Kuala Lumpur. 26 pp. |**6**| Keating, W.G. & Bolza, E., 1982. Characteristics, properties and uses of timbers. Vol. 1: South-east Asia, Northern Australia and the Pacific. Division of Chemical Technology, Commonwealth Scientific and Industrial Research Organization. Inkata Press, Melbourne, Sydney and London. p. 93. |**7**| Kochummen, K.M., 1972. Bombacaceae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. A manual for foresters. Vol. 1. Forest Research Institute Malaysia. Longman Malaysia SDN Berhad, Kuala Lumpur. pp. 100–120. |**8**| Lee, Y.H., Engku Abdul Rahman & Chu, Y.P., 1979. The strength properties of some Malaysian timbers. Revised edition. Malaysian Forest Service Trade Leaflet No 34. Malaysian Timber Industry Board, Kuala Lumpur. 107 pp. |**9**| Reksodihardjo, W.S., 1960. The genus Coelostegia Benth. (Bombac.). Reinwardtia 5(3): 269–291. |**10**| Wong, W.C. & Lim, S.C., 1990. Malaysian timbers – durian. Timber Trade Leaflet No 113. Malaysian Timber Industry Board and Forest Research Institute Malaysia, Kuala Lumpur. 12 pp.

Selection of species

Coelostegia borneensis Becc.

Malesia 3: 272, t. 29 (1889).

Vernacular names Indonesia: duren enggang (Aceh, Sumatra), apon (Dayak, Kalimantan). Malaysia: punggai daun besar (Peninsular), durian antu (Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The timber is reputed to be used as punggai.

Observations A large tree up to 45 m tall, with columnar bole up to 90 cm in diameter having steep plank buttresses, bark surface finely rugose, fissured to dippled and scaly, greyish-brown to dark brown; leaves elliptical-oblong to slightly obovate, 10–23 cm × 4–8.5 cm, densely scaly below and often also above, midrib prominent above and with 14–20 pairs of secondary veins, petiole 2.5–4.5 cm long; flowers in panicles on old branches; fruit globose, c. 15 cm in diameter, covered with conical spines. *C. borneensis* usually occurs scattered in mixed dipterocarp lowland forest. The density of the wood is 700–750 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 576, 578, 705.

Coelostegia griffithii Benth.

Benth. & Hook.f., Gen. pl. 1: 213 (1862).

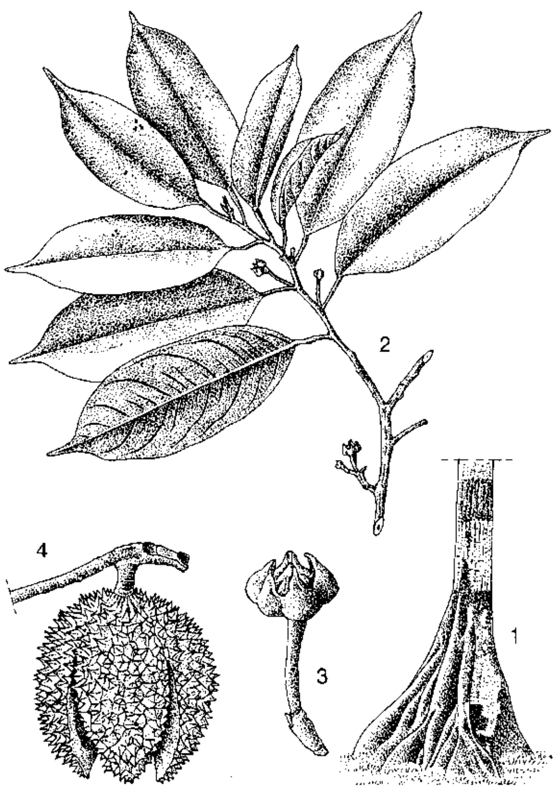
Synonyms *Coelostegia sumatrana* Becc. (1889).

Vernacular names Black durian (En). Indonesia: punggai, durian hantu, durian unggeh (Sumatra). Malaysia: punggai, durian badak, durian tuang (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Bangka and Borneo (Brunei).

Uses The wood is used as punggai, e.g. for making clogs, coffins, furniture and for construction under cover. The bark is used for tanning and to dye fishing nets.

Observations A large tree up to 45 m tall, with bole branchless up to 24 m and up to 110 cm in diameter having large plank buttresses up to 3.5 m high, bark surface smooth to distantly shallowly fissured, dark grey to dark brown; leaves elliptical-oblong to narrowly ovate, 5–10(–15) cm × 2–4(–6) cm, with dense silvery scales below, glabrous above, midrib more or less flattened



Coelostegia griffithii Benth. – 1, trunk base; 2, flowering twig; 3, flower; 4, branch with fruit.

above and with 6–10 pairs of secondary veins, petiole 1–2.5 cm long; flowers in panicles on branches and in leaf axils; fruit globose, c. 17 cm in diameter, covered with slender pyramidal spines. *C. griffithii* usually occurs scattered in flat lowland forest, sometimes up to 700 m altitude. The wood is deep orange-yellow, often turning reddish-brown on exposure; the density is 605–795 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 26, 44, 77, 78, 96, 99, 104, 140, 175, 206, 234, 364, 431, 463, 465, 576, 578, 705, 724.

Coelostegia kostermansii Soegeng

Reinwardtia 5(3): 277 (1960).

Vernacular names Indonesia: tabun, tabut (Kalimantan).

Distribution Borneo (Kalimantan).

Uses The timber is reputed to be used as punggai. The seeds are eaten and taste like groundnut.

Observations A large tree up to 50 m tall, with bole branchless up to 35 m and up to 80 cm in diameter, having very large buttresses up to 6 m high, bark surface rough and fissured; leaves elliptical-oblong, 6–10(–17) cm × 2.5–3.5(–7.5) cm, laxly scaly below, glabrous above, with 7–13 pairs of secondary veins, petiole 1.5–2.5 cm long; flowers in panicles, fascicled on bare twigs; fruit somewhat asymmetrical pentagonal-ovoid, c. 16 cm long, covered with warts but not with spines. *C. kostermansii* occurs in primary forest on sandy loams at 200–300 m altitude.

Selected sources 578.

Salma Idris (general part, selection of species),
W.C. Wong (properties),
Usmansyah (wood anatomy)

Copaifera L.

Sp. pl., ed. 2: 557 (1762).

LEGUMINOSAE

For several species from tropical America and Africa: $2n = 24$; *C. palustris*: $2n$ = unknown

Trade groups Swamp sepetir: medium-weight hardwood, a single species in South-East Asia, *Copaifera palustris* (Sym.) de Wit, Webbia 9: 462 (1954), synonym: *Pseudosindora palustris* Sym. (1944).

The timber is often traded as sepetir, together with the timber of *Sindora*.

Vernacular names Swamp sepetir. Brunei: sepetir paya, sepetir, petir. Malaysia: sepetir paya, petir umbut, tepih (Sarawak).

Origin and geographic distribution The genus *Copaifera* consists of 25–30 species. Most species occur in tropical America, 4 species in tropical Africa, and 1 species in Borneo (Sarawak, Brunei, Sabah and north-western Kalimantan).

Uses The uses of swamp sepetir are quite similar to sepetir. It is used for the manufacture of furniture, cabinet-making, ornamental work, handles, general construction such as planking, ceiling, flooring, doors and windows, shingles, packing cases and crates and for plywood manufacture. It is also of local importance for boat building and is used for masts.

Production and international trade *Copaifera* timber is generally marketed as sepetir together with the timber of *Sindora* species. No specific data on trade are available, but swamp sepetir has some importance in Sarawak as it is more common than *Sindora* and produces the bulk of the timber traded as sepetir there; it is mainly exported to Japan.

Properties Swamp sepetir is a medium-weight hardwood. The heartwood is pale pink with pale brown veining when freshly cut, darkening to a rich reddish-brown on exposure; it is usually distinctly demarcated from the pale greyish-brown or beige (sometimes with a pink tinge) sapwood, which is often comparatively wide, up to 12.5 cm. The wood often shows dark brown to black streaks on longitudinal surfaces, producing handsomely figured wood. The density is 530–865 kg/m^3 at 15% moisture content. The grain is straight to shallowly interlocked, texture moderately fine and even. The wood is not lustrous and is oily to the touch.

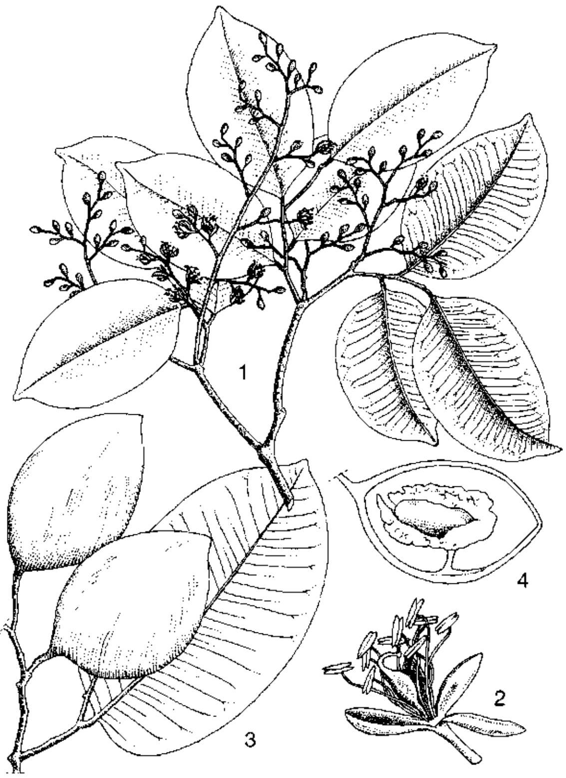
At 12% moisture content, the modulus of rupture is 125 N/mm^2, modulus of elasticity 12 700 N/mm^2, compression parallel to grain 64 N/mm^2, shear 16 N/mm^2, cleavage 24.5 N/mm radial and 42 N/mm tangential, and Janka side hardness 6275 N. See also the table on wood properties.

The rates of shrinkage are moderately low: from green to 12% moisture content 2.0% radial and 3.0% tangential. The timber dries well but moderately slowly; it has a tendency to end-splitting but distortion is small. It can be kiln dried rapidly, but a mild kiln schedule is required. In Malaysia, kiln schedule G is recommended. Pre-drying before kilning is advised to reduce warping. The form stability is good when dry; movement is small.

In general, swamp sepetir may be difficult to work. However, conversion in a modern mill pre-

sents little difficulty. Although the wood does not contain silica, the heartwood has a moderate blunting effect on tools. Although resin builds up on the blades, the heartwood can usually be worked to a smooth finish, providing the tools are kept sharp. Air-dried wood is rated as difficult to saw and cross-cut and requires careful support where breaking through on end-grain may occur. It planes and bores easily, producing smooth surfaces; it turns easily but with a slightly rough surface. Finishing is satisfactory, but filling is required. The wood can be polished satisfactorily, since the amount of resin is apparently insufficient to interfere seriously with this operation. It is only moderately suitable for bending purposes; it is liable to buckle during bending and the bending properties are improved by using a supporting strap. The resistance to splitting upon nailing and screwing is generally satisfactory, but sometimes there is a tendency to split unless pre-bored. The gluing properties are very good. The timber is moderately easy to cut into a smooth and tight veneer of uniform thickness; the recommended temperature during rotary cutting is 95°C. The veneer can be dried flat and split-free, and it is suitable for construction plywood and for inner layers of plywood since it is generally not decorative.
Swamp sepetir is rated as non-durable to moderately durable. Stake tests showed an average service life in contact with the ground of 2.6 years under tropical conditions. The heartwood is rated as durable under temperate conditions. The wood is susceptible to powder-post beetle, termite and fungal attack. Attack by pinhole borers is rare, but the wood is not resistant to marine borers. The heartwood is difficult to treat with preservatives. Using a standard open tank treatment, the average absorption of a mixture of creosote and diesel fuel is 96 kg/m^3, but the wood may be preserved very well when treated with 100% creosote, the absorption being 140 kg/m^3. Under the full-cell process, swamp sepetir heartwood absorbs only about 75 kg/m^3 using a 3% copper-chrome-arsenic solution, whereas the average dry salt retention is only 2.2 kg/m^3.

Description A medium-sized to sometimes fairly large tree, up to 30(–39) m tall, with straight and cylindrical bole up to 60(–180) cm in diameter; buttresses absent; bark surface finely and shallowly longitudinally fissured, with weakly raised transverse rings, greyish to red-brown. Leaves alternate, imparipinnate, (2–)4(–6)-foliolate, petiole and rachis 4.5–12 cm long; stipules auriculate to subfalcate, caducous; leaflets alter-



Copaifera palustris (Sym.) de Wit – 1, flowering twig; 2, flower; 3, twig with fruits; 4, fruit in longitudinal section.

nate, elliptical-oblong, often unequally sided, 5–9(–14) cm × 3.5–6(–8) cm, leathery, with rounded base and acute or short-acuminate apex, glossy and with pellucid dots, glabrous, with numerous, fairly distinct secondary veins and often 1–3 glands at the base of the blade, petiolule 4–7 mm long. Inflorescence axillary, paniculate, 4–11 cm long, pubescent. Flowers bisexual, actinomorphic, pedicelled, pearl-fawn coloured; calyx lobes 4, narrowly imbricate or subvalvate in bud, elliptical, 4–7.5 mm × 2–4 mm, puberulous outside, densely tomentose inside; petals and disk absent; stamens 10, free, alternately long and short, filaments 7–10 mm long, with dorsifixed, c. 2 mm long anthers; ovary superior, stipitate, pilose along the ventral suture and on the stipe, 2-ovuled, style 4.5–5 mm long, with small capitellate stigma. Fruit an ellipsoid pod, 4.5–7.5 cm × 3.5–4 cm, rather smooth, 2-valved, valves thick coriaceous, 1–2-seeded. Seeds oblong, c. 2.5 cm × 1.5 cm, lacking albumen, glossy brown or black, enclosed by narrowly 2-lobed pinkish arils. Seedling with epigeal germination; cotyledons plano-convex; first 2 leaves opposite.

Wood anatomy

– Macroscopic characters:

Heartwood dark reddish-brown and clearly demarcated from the sapwood which is often wide and pale grey-brown or beige in colour, sometimes with a pink tinge. Grain straight to shallowly interlocked. Texture moderately fine and even; prominent dark-coloured streaks are usually present on longitudinal surfaces. Growth rings distinct, marked by terminal parenchyma; vessels medium-sized and visible to the naked eye, vessel lines conspicuous on longitudinal surfaces, deposits common, tyloses sparse to absent; parenchyma visible as narrow terminal layers; rays moderately fine, visible to the naked eye; ripple marks absent.

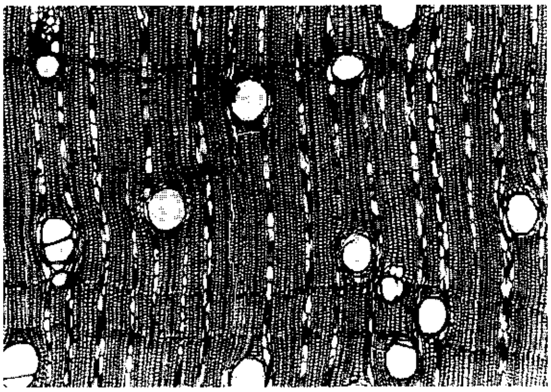
– Microscopic characters:

Growth rings distinct, marked by irregularly spaced terminal parenchyma. Vessels diffuse, 2–4 (–5)/mm^2, solitary and in radial groups of 2–4 and with some irregular clusters, oval to almost round, average tangential diameter (50–)100–200 μm; perforation plates simple; intervessel pits alternate, vestured, 6–10 μm in diameter; vessel-ray and vessel-parenchyma pits similar but half-bordered, 5–8 μm in diameter; deposits common; tyloses rare or absent. Fibres 0.7–1.4 mm long, non-septate, thin-walled, with small simple pits mainly confined to the radial walls. Parenchyma paratracheal and apotracheal; paratracheal parenchyma vasicentric, forming sheaths of several cells wide around the vessels, with a tendency to aliform; apotracheal parenchyma diffuse and in terminal bands; in strands of 2(–4) cells. Rays (4–)5–10(–12)/mm, mostly multiseriate and (1–)2–3 cells wide, less than 2 mm high, heterocellular with 1–5 rows of square to upright marginal cells (Kribs type heterogeneous II to III) but sometimes vaguely homocellular. Prismatic crystals in chains in chambered cells, 3–14 crystals per chain. Silica bodies absent.

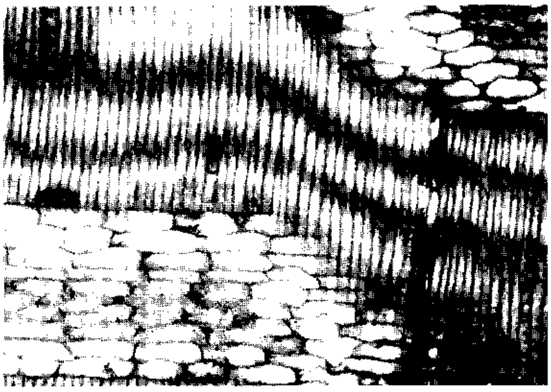
Swamp sepetir wood is very similar to sepetir (*Sindora* spp.) but differs in the absence of axial resin canals.

Growth and development When still young, swamp sepetir is fairly tolerant of shade.

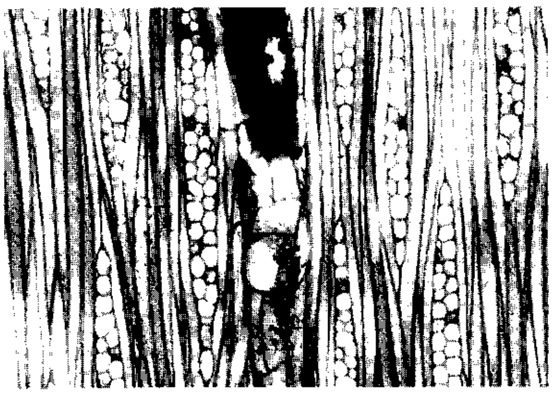
Other botanical information The species has originally been described as *Pseudosindora palustris* Sym. Later, after comparison with American and African species, it was reduced to *Copaifera*. In some characters *C. palustris* agrees with American *Copaifera* species (e.g. dehiscence of fruits),



transverse section (×25)



radial section (×75)



tangential section (×75)

Copaifera palustris

in others it agrees with African species (e.g. seedling characters).
Copaifera is allied to *Sindora* and *Crudia* but differs from the former in the alternate leaflets and lacking petals, and from the latter by the paniculate inflorescence, the absence of a hypanthium and by having distinctly arillate seeds.

Ecology Swamp sepetir grows scattered in coastal freshwater peat-swamp forest, also called mixed swamp forest. It is especially found on the periphery of the swamp together with *Gonystylus bancanus* (Miq.) Kurz (ramin), *Dryobalanops rappa* Becc. (swamp kapur) and the red merantis *Shorea albida* Sym. (alan), *Shorea platycarpa* Heim (meranti paya), *Shorea scabrida* Sym. (meranti lop) and *Shorea uliginosa* Foxw. (meranti buaya). It is sometimes also found in drier lowland forest and occurs up to 30 m altitude.

Propagation and planting In forest, natural regeneration is often fairly abundant. Swamp sepetir is considered to be fairly tolerant of shade, at least when still young. Experience with non-Malesian species of *Copaifera* suggests that propagation by seed will be successful.

Silviculture and management In mixed swamp forest in Sarawak an average of up to 3.5 large trees/ha can be found and locally 10% of the large trees are swamp sepetir. The mixed swamp forest is managed under a uniform silvicultural system with a single clear-felling planned at 45 years. Ten years after exploitation naturally regenerated trees should be selected. Young trees of swamp sepetir should remain under light shade, whereas most other species in the mixed swamp forest should be given full overhead light.

Harvesting The minimum diameter for felling swamp sepetir is 45 cm in Sarawak. The desired trees are selectively felled after which the undesired remaining trees over 13 cm diameter are poison-girdled and smaller trees are removed to favour the dominant trees of the desired species, including swamp sepetir, of 8 cm diameter and up.

Yield A tree with a diameter of 50 cm contains about 1.5 m^3 of timber, and a tree of 70 cm in diameter about 4.2 m^3.

Genetic resources The area of distribution of swamp sepetir is rather limited and it is only locally common in Sarawak. Large-scale clear-cutting or heavy logging in this region may easily endanger swamp sepetir as it does not regenerate as well in severely disturbed swamp forest as, for instance, the red merantis.

Prospects Swamp sepetir might be a promising timber for swamp forest managed under a selective logging system. However, very little information is available, even on the most basic aspects such as growth and development and propagation of swamp sepetir.

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Other selected sources 139, 228, 588, 595.

D. Hou (general part),
P.B. Laming (properties),
S.C. Lim (wood anatomy)

Cordia L.

Sp. pl. 1: 190 (1753); Gen. pl. (Ed. 5): 87 (1754).
BORAGINACEAE
$x = 7, 8$ or 9; *C. dichotoma*: $2n = 48$

Trade groups Cordia: lightweight hardwood, *Cordia dichotoma* J.G. Forster and *C. subcordata* Lamk.

Vernacular names Cordia. Indonesia: salimuli. Malaysia: kalamet. Papua New Guinea: kerosene wood, cordia, island walnut. Philippines: balu, anonang (general). Burma (Myanmar): sandawa. Thailand: mandong, kalamet.

Origin and geographic distribution *Cordia* is a large pantropical genus of about 250 species, most of which occur in tropical America. About 7 species are indigenous to the Malesian area; several others have been introduced.

Uses The wood is used for interior trim, light framing, posts, cabinets, furniture, musical instruments, turnery, tools and tool handles, mouldings, boats and wharves, carvings, fancy articles and rotary and sliced veneer. The attractively streaked heartwood is popular for carving and fancy articles, although it is only available in small dimensions. It is also used for fuel.

The bark and leaves are used medicinally against fever, and as a tonic. The fibres of the bark are sometimes used to make ropes. In upland rice fields the branches are used to repel termites and are also used as a green manure. The sticky juice of the fruit has been used as a glue and for gum. *Cordia* is also planted as a roadside tree.

Production and international trade *Cordia* timber generally has no importance as export timber, but is used locally. The logs do not usually reach a large diameter and length. If they do, they often show heart rot; this reduces the commercial value. However, the timber of *C. subcordata* is highly valued in Papua New Guinea (and the Solomon Islands) and its export as logs is banned.

Properties *Cordia* wood is lightweight and moderately soft to moderately hard. The heartwood is pale brown to dark brown, in *C. subcordata* with dark brown or nearly black streaks, indistinctly (*C. dichotoma*) or distinctly (*C. subcordata*) demarcated from the sapwood. The density is 425–650 kg/m^3 at 15% moisture content; *C. dichotoma* wood is lighter (425–520 kg/m^3) and *C. subcordata* wood heavier (470–650 kg/m^3). The grain is straight to slightly interlocked (especially in *C. dichotoma*) to interlocked (especially in *C. subcordata*), texture moderately coarse to coarse (finer in *C. subcordata*). Wood of *C. subcordata* is rather glossy.

At 12% moisture content, wood of *C. dichotoma* from Papua New Guinea showed the following mechanical properties: the modulus of rupture 64.5 N/mm^2, modulus of elasticity 8555 N/mm^2, compression parallel to grain 41.5 N/mm^2, shear 6–6.5 N/mm^2, cleavage 48 N/mm radial and 41.5 N/mm tangential, and Janka side hardness 2335–2485 N. Wood of *C. subcordata* is somewhat stronger and harder.

The rates of shrinkage are fairly low: for *C. dichotoma* wood from green to 12% moisture content 1.3–1.4% radial and 3.3–3.8% tangential, and from green to oven dry c. 2.5% radial and 6.2% tangential. The wood air dries easily without serious defects.

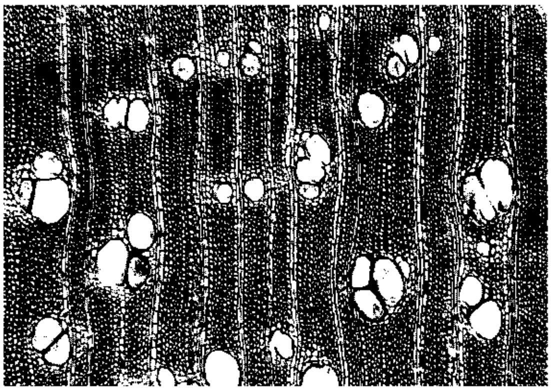
The wood is easy to saw and can be worked well with both hand and machine tools; it takes a good finish. It is non-durable in exposed situations and attacked by powder-post and longhorn beetles as well as decay fungi, but it is durable for interior work. The heartwood is resistant to preservative treatment, even when using a pressure treatment.

Description Shrubs or small to medium-sized trees, up to 30 m tall; bole usually crooked and short, up to 60(–100) cm in diameter, without buttresses; crown spreading; bark surface smooth or cracked, to fissured in older trees, grey or brown. Leaves alternate, simple, ovate to circular or cordate, distinctly stalked, glabrous, apex acute to acuminate, glossy dark green above, pale green beneath, without stipules. Inflorescence terminal, spike-like or dichotomously branched and paniculate. Flowers homomorphous or heterostylous or functionally more or less unisexual, in the latter case male and female flowers on separate trees, actinomorphic, pedicel articulate; calyx 5(–8)-lobed, usually persistent in fruit; corolla campanulate to funnelform, white or greenish to yellow, orange or red, 4–8-lobed; stamens alternating with corolla lobes, inserted on corolla tube, often hairy at base; ovary superior, 4-celled, with a single ovule in each cell, generally 3 cells abortive, style forked twice. Fruit a usually 1-seeded drupe, but practically a nut in *C. subcordata*, mesocarp watery or glutinous. Seed with a membranous coat; endosperm absent; cotyledons plicate. Seedling with epigeal germination; cotyledons leafy, palmately veined, toothed along the upper side; leaves arranged spirally.

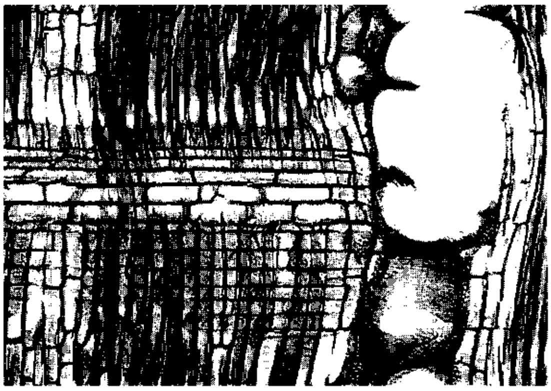
Wood anatomy

– Macroscopic characters:

Heartwood yellowish-brown to brown and indistinctly to fairly distinctly demarcated from the pale greyish sapwood (*C. dichotoma*), or dark brown to chocolate brown, often with darker streaks, and distinctly demarcated from the yellowish-brown sapwood (*C. subcordata*). Grain shallowly interlocked to interlocked. Texture moderately coarse to coarse. Growth rings fairly distinct because of more or less regularly spaced light-coloured bands (*C. dichotoma*) or loose tangential arcs of pores (*C. subcordata*).



transverse section (×25)



radial section (×75)

tangential section (×75)

Cordia subcordata

– Microscopic characters:
Growth rings fairly distinct, usually marked by differences in pore size and in width of parenchyma bands on either side of the ring boundary (*C. dichotoma*), or by loose tangential arcs of pores and shorter or longer confluent, marginal parenchyma bands (*C. subcordata*). Vessels diffuse (*C. dichotoma*) or diffuse with a slight tendency for a tangential arrangement (*C. subcordata*), 3–8/mm^2 (*C. dichotoma*) or 8–16/mm^2 (*C. subcordata*), solitary (60–80% in *C. dichotoma* and 20–60% in *C. subcordata*), in radial multiples of 2–3 or in clusters of 2–5, oval or slightly angular, 80–300 μm in tangential diameter; perforations simple; intervessel pits non-vestured, alternate, polygonal to round, 5–8 μm in diameter; vessel-ray and vessel-parenchyma pits almost similar to intervessel pits, but some enlarged up to 20 μm; tyloses abundant. Fibres 0.9–1.3 mm long, thin-walled to thick-walled, sometimes very thin-walled, with small, simple or minutely bordered pits mainly confined to the radial walls. Parenchyma paratracheal, vasicentric, sometimes confluent, with sporadic apotracheal (marginal) bands (*C. subcordata*) or in regularly spaced, wide or narrow bands at either side of the growth ring boundary, often wider than pores (*C. dichotoma*); vasicentric sheaths often associated with parenchyma bands (*C. dichotoma*); fusiform or in 2-celled strands. Rays 3–4/mm (*C. dichotoma*) or 5–7/mm (*C. subcordata*), (1–)3–5(–6)-seriate, 120–1400 μm high, uniseriate rays low and scarce, heterocellular with one or more marginal rows of square and upright cells (mostly Kribs type heterogeneous II–III); incomplete or complete sheath cells present along part or all the body ray cells. Crystals numerous in axial parenchyma cells and ray cells, prismatic or elongated, often more than one per cell and of various sizes and shapes; in *C. subcordata* also present as crystal sand.
Species studied: *C. dichotoma*, *C. subcordata*.

Growth and development Trees grow fast on moderately fertile and well-drained sites. It has been reported from Buru (Indonesia) that young plants of *C. subcordata* can reach a height of 1.1–1.5 m 10 months after planting on good sites. In East Java trees were 4–5 m tall in a 2-year-old plantation and on average 7 m tall after 4 years with an average diameter of 6.5 cm.
In *C. subcordata* heavy branches often develop low on the stem and form a wide spreading crown. The stem is often crooked, slanting or appears twisted.
C. subcordata plants of 3 years old may already

produce fruits. The fruits of this species are probably dispersed by ocean currents; they have a hard stone and corky tissue.

Other botanical information The genus *Cordia* together with the genus *Ehretia* is sometimes assigned to a separate family (*Ehretiaceae*); however, this is not widely accepted. *C. fragrantissima* Kurz occurs in Burma (Myanmar) and Thailand, and is used in Burma (Myanmar) for decorative veneer and furniture, where it is called 'sandawa' or 'kalamet'. *C. alliodora* Cham. is a promising agroforestry and plantation tree from tropical America; the wood is used similarly to that of the species indigenous in South-East Asia. It has been introduced e.g. in Sabah, the Solomon Islands, Vanuatu and Hawaii. In Vanuatu it grows very well. There have been reports of *C. myxa* L. from the Malesian area, but these have probably been of *C. dichotoma*, as *C. myxa* is confined to Africa and western Asia to India. However, it is still doubtful whether the two species are truly different.

Ecology The tree species of *Cordia* are usually found in primary and secondary forest in subhumid regions, or in thickets, or even savanna vegetation, especially right on the forest edge. They are most common in lowland vegetation, or even along the coast, but may occur up to 1500 m altitude, and are comparatively strong pioneer species.

C. subcordata is suited for planting on sandy soils and can grow well in subhumid climates with an annual precipitation of 1250 mm.

Propagation and planting There are 560–700 seeds of *C. subcordata* in one kg. In Malaysia, seeds of this species are reported to take 19–62 days to germinate, with about 25% of the seeds being viable. However, data from Indonesia show that viability may be as high as 90–100%, but seed collected from the ground showed 40–50% germination. Storage under ambient conditions reduces the viability from 60% initially to 40% after 7 months.

It is recommended to sow the seeds 1.5–2 cm deep, pointing downwards. Seedlings should be watered sparingly. In Indonesia, a spacing of 2.5 m × 1 m and 2.5 m × 3 m has been used. Young plants are not very shade tolerant but can develop reasonably well under light conditions above 30% relative light intensity.

Harvesting Very large trees often suffer from heart rot.

Genetic resources Both *C. dichotoma* and *C. subcordata* have a large area of distribution and are locally common. They are unlikely to be easily endangered.

Prospects *Cordia* is highly valued locally for its decorative wood. The trees reputedly grow fast and can also be planted in areas with a comparatively dry climate. This could stimulate more research to determine their value as local timber plantation trees, although the often small size and poor shape of the bole, and the occurrence of heart rot in large trees, reduce the value of the trees for this purpose.

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Selection of species

Cordia dichotoma J.G. Forster

Fl. ins. austr. prodr. 18: 110 (1786).

Synonyms *Cordia suaveolens* Blume (1826), *Cordia griffithii* C.B. Clarke (1885), *Cordia premnifolia* Ridley (1915).

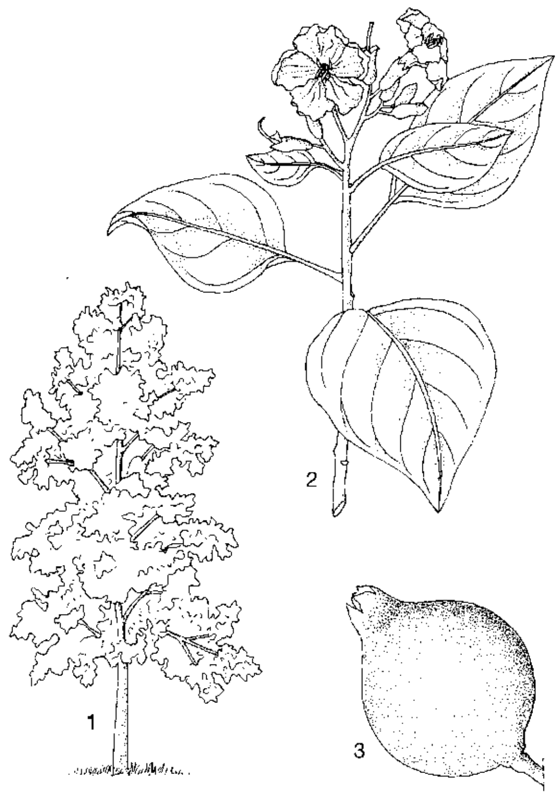
Vernacular names Indonesia: kendal (Java), nunang (Kalimantan), toleolo (Moluccas). Malaysia: sekendal, sekendai, petekat (Peninsular). Papua New Guinea: cordia (general). Philippines: anonang (general), anonang-bakir (Ilocos Sur), guma (Balabac). Burma (Myanmar): sebasten tree, thanat. Laos: 'man, 'man khôk. Thailand: mandong (Nakhon Ratchasima), phakmong (Shan, northern), manmu (Lampang).

Distribution From India, Indo-China and Thailand, throughout the Malesian area towards the Solomon Islands, north-eastern Australia and New Caledonia.

Uses The wood is used for temporary and light construction, small boats, tools and tool handles; sometimes also used for fuel. The bark and leaves are used medicinally against fever, and as a tonic. The fibres of the bark are used to make ropes. The juice of the fruit has been used for glue and gum. In the Philippines, branches are placed in upland rice to deter termites.

Observations A shrub or small to medium-sized tree up to 25 m tall, bole up to 60(–100) cm in diameter, bark surface smooth to vertically cracked, becoming fissured; corolla up to 1 cm long, white to greenish, with 4–6 lobes; fruit within an open calyx-cup. *C. dichotoma* is locally common in coastal hills, inland fringes of mangrove vegetation, but also in inland primary and secondary forest, thickets, teak forest, and even savanna, up to 700(–1500) m altitude. The density of the wood is 425–520 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 36, 60, 68, 77, 78, 99, 145, 203, 234, 273, 382, 450, 497, 527, 574, 676, 705.



Cordia subcordata Lamk – 1, habit of young tree; 2, flowering twig; 3, fruit.

Cordia subcordata Lamk

Tabl. encycl. 1: 421 (1891).

Synonyms *Cordia orientalis* R.Br. (1810), *Cordia moluccana* Roxb. (1824), *Cordia rumphii* Blume (1826).

Vernacular names Indonesia: salimuli (general), klimasada (Java), kanawa (Moluccas). Papua New Guinea: kerosene wood, island walnut, cordia (general). Philippines: balu, banago (general), koring-korong (Palawan). Thailand: rampon.

Distribution From eastern Africa towards India, Indo-China, Hainan and Thailand, and throughout the Malesian area to the Pacific.

Uses The wood is used for light construction, beams and posts, wharves, cabinets, furniture, musical instruments, scabbards, tools, carvings, and fancy articles; also for veneer. It is used for fuel in the Solomon Islands. In Polynesia, young leaves are sometimes chewed together with betel nut. The tree is also planted in gardens and is especially suitable for courts.

Observations A small to medium-sized tree up to 20 m tall, bole often crooked, branchless for up to 8 m, up to 70 cm in diameter, bark shallowly fissured and flaky, brown or grey; corolla 3–4.3 cm long, orange, with 6 or 7 lobes; fruit tightly enclosed in an enlarged calyx. *C. subcordata* is fairly common in secondary forest and thickets along the sea shore. The larger boles often develop heart rot. The wood is reported to burn fast and can easily be ignited by rubbing 2 pieces of wood together, hence the Papuan name kerosene wood. The density of the wood is 470–650 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 99, 115, 203, 218, 229, 234, 261, 273, 409, 463, 465, 526, 527, 654, 705.

W.C. Wong (general part, properties, selection of species),
S. Sudo (wood anatomy)

Cryptocarya R.Br.

Prodr.: 402 (1810).
LAURACEAE
$x = 12$; *C. amygdalina* Nees, *C. floribunda* (Wallich ex Nees) Nees: $n = 12$

Trade groups Medang: lightweight to medium-weight hardwood, e.g. *Cryptocarya alleniana* C.T. White, *C. ferrea* Blume, *C. nitens* (Blume) Koord. & Valeton.
Medang is used as the trade name for the timber of most *Lauraceae* genera, such as *Alseodaphne*, *Beilschmiedia*, *Cinnamomum*, *Dehaasia*, *Litsea*, *Persea* and *Phoebe*.

Vernacular names Medang. Papua New Guinea: cryptocarya. Philippines: dugkatan.

Origin and geographic distribution *Cryptocarya* is a large genus of about 250 species. Although pantropical it is absent in central Africa and its main centre of diversity is in Malesia, where about 125 species are found. Many species have a limited area of distribution.

Uses Medang timber is used for light construction, furniture, joinery, interior finishing, panelling, light framing, flooring, mouldings, boxes and cases, veneer, plywood, turnery and brushware. The medium-weight timber can be used for house posts.
The wood of one species (*C. impressa*) yields a yellow dye. A decoction of the aromatic bark of *C. massoy* (massoi bark) yields an essential oil, used in ointments for curing sore muscles and in a variety of other local medicines and tonics.

Production and international trade *Cryptocarya* timber is traded as medang, a timber trade group which comprises many *Lauraceae* species; the most important genera of this group are *Beilschmiedia*, *Cinnamomum* and *Litsea*.
The total export of medang from Peninsular Malaysia to Singapore in 1984 was 1500 m^3 with a value of US$ 62 000, the export from Sabah was 52 000 m^3 (about 10% as sawn timber) in 1992 with a total value of US$ 4.3 million. The minimum price for saw logs in Papua New Guinea in 1992 was US$ 43/m^3. Japan imports small amounts of *Cryptocarya* timber, mainly from Sarawak and Sabah, Papua New Guinea and the Solomon Islands.
Massoi bark is traded in western Malesia; exports have never been of any importance.

Properties *Cryptocarya* wood is a lightweight to medium-weight hardwood. The heartwood is pale brown to dark brown, often with a green or orange tinge and darkening upon exposure, generally not well defined from the straw-coloured to pale brown sapwood, but sometimes distinctly demarcated (e.g. in *C. bicolor*). The density is (350–)440–830(–870) kg/m^3 at 15% moisture content. The grain is usually straight but sometimes interlocked or wavy, texture moderately fine. The wood often has a fragrant odour which persists for years.
A test on wood of an unidentified *Cryptocarya* species from Papua New Guinea showed the following mechanical properties at 12% moisture content: the modulus of rupture 80.5 N/mm^2, modulus of elasticity 12 145 N/mm^2, compression parallel to grain 48 N/mm^2, shear 10 N/mm^2, cleavage 67 N/mm tangential and Janka radial hardness 3025 N.
The rates of shrinkage are moderate to fairly high: from green to 12% moisture content 1.5–4.1% radial and 4.3–8.4% tangential. The wood is usually easy to air dry, sometimes with slight surface checking and staining.
Generally, the wood saws well, but sometimes some silica is present and then saw teeth may be blunted. It planes well with little picking up of grain; the peeling properties are good. Heavier wood (e.g. of *C. bicolor*) may be rather hard to work. Sawdust may cause irritation to skin and eyes.
Most *Cryptocarya* wood is rated as non-durable when used outdoors and liable to termite and *Lyctus* attack, but sometimes it is durable when exposed to the weather and is resistant to termite attack (e.g. *C. bicolor*). The heartwood is very resistant to preservative treatment, the sapwood is permeable.
The active substances in the oil from massoi bark are lactones. These are powerful skin irritants.

Description Evergreen shrubs or small to fairly large, rarely large trees up to 40(–47) m tall; bole branchless for up to 16(–32) m, up to 60(–90) cm in diameter, usually without but sometimes with short buttresses, narrowly fluted or channelled; bark surface smooth, occasionally scaly or dippled, sometimes lenticellate, grey-brown to reddish-brown, inner bark granular, yellowish-brown to reddish-brown or brownish. Leaves arranged spirally or opposite, simple and entire, leathery, pinnately veined or less often triple-veined, with inconspicuous glandular dots and sometimes aromatic when crushed; stipules absent. Inflorescence an axillary or subterminal panicle or corymb. Flowers bisexual, regular, trimerous, small; perianth segments 6, equal or subequal, united in a turbinate, campanulate or ovoid tube below, constricted at the top after flowering; fertile stamens usually 9, sometimes 3 or 6, in whorls of 3 inserted on the perianth tube, the outer 2 whorls introrse, the third extrorse and the filaments flanked by glands, anthers 2-celled, opening by valves from the base upwards, staminodes conspicuous, stalked; ovary superior, sessile, 1-celled, with a single, pendulous, anatropous ovule, style short, stigma exserted, inconspicuous or small, sometimes capitate. Fruit a 1-seeded berry, entirely included in the enlarged flower tube, leaving only a small opening at the apex; exocarp and endocarp often bony and ribbed. Seedling with hypogeal germination.

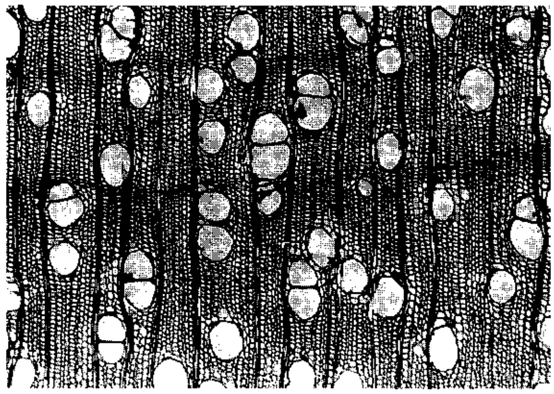
Wood anatomy

- Macroscopic characters:

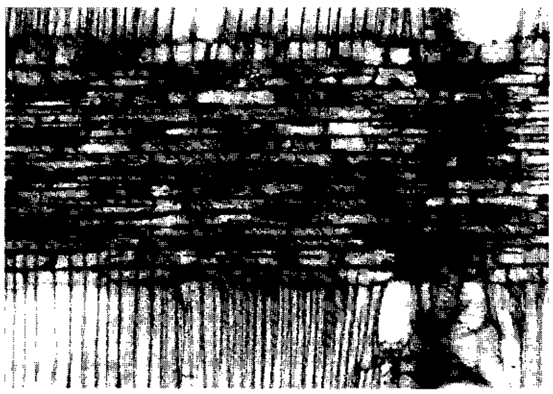
Heartwood pale to dark brown, often with a characteristic green tinge, darkening upon exposure, often not clearly demarcated from the sapwood. Grain straight or slightly to moderately interlocked. Texture moderately fine and even. Growth rings distinct, marked by terminal parenchyma; vessels moderately small to medium-sized, tyloses often abundant; parenchyma terminal, in few and narrow, irregularly spaced bands; rays very fine or moderately fine, sometimes visible to the naked eye on end surfaces but usually only visible with a lens, not conspicuous on radial surfaces; ripple marks absent.

- Microscopic characters:

Growth rings distinct, marked by irregularly spaced marginal parenchyma. Vessels diffuse, (5–)9–12/mm^2, solitary and in radial groups of 2–4 (rarely more), uniformly distributed, round to oval, average tangential diameter 90–170(–200) µm (mean 120 µm); perforation plates simple; intervessel pits alternate, 8–10(–11) µm in horizontal diameter; vessel-ray and vessel-parenchyma pits with reduced borders, horizontal to vertical, up to c. 20 µm in diameter; tyloses present. Fibres (0.7–)1.0–1.4(–1.6) mm long, non-septate, moderately thick-walled, sometimes very thick-walled, with simple pits mainly confined to the radial walls. Paratracheal parenchyma typically as irregular and often incomplete sheaths around the vessels, sometimes tending to aliform or conflu-



transverse section (×25)



radial section (×75)

tangential section (×75)

Cryptocarya kurzii

ent; apotracheal parenchyma as irregularly spaced marginal bands, in 2–4-celled strands. Rays (4–)5–7(–11)/mm, mostly multiseriate, (1–)2–3(–8) cells wide, up to 1 mm high, heterocellular with 1 marginal row of square cells (Kribs type heterogeneous III). Crystals often present; ray cells often with dark solid contents. Oil cells present in parenchyma and in the margins of the rays.

Species studied: *C. ferrea*, *C. griffithiana*, *C. kurzii*, *C. wrayi* Gamble.

Growth and development *Cryptocarya* trees seem to be rather slow growers. In a nursery in Central Kalimantan, *C. crassinervia* wildlings showed an average height growth of 39.3 cm and an average diameter growth of 3.6 mm 13 months after planting.

Other botanical information Like many other *Lauraceae* genera, *Cryptocarya* is in desperate need of a thorough taxonomic revision. At present, this situation results in an unreliable nomenclature, problematic identification (because there are no proper keys), and hence data e.g. on distribution, properties and ecology may be doubtful at species level.

Cryptocarya is probably closely related to *Eusideroxylon* and is characterized by the 2-celled anthers and the enlarged perianth tube enveloping the fruit. Three subgenera are distinguished: subgenus *Cryptocarya* with 9 fertile stamens, subgenus *Hexanthera* Kosterm. with 6 fertile stamens, and subgenus *Triandra* Kosterm. with 3 fertile stamens.

Ecology The timber-yielding species of *Cryptocarya* usually occur in primary rain forest, sometimes in secondary forest, at low to medium altitudes, including swamp forest and forest on limestone. Most species thrive in a perhumid climate with rainfall type A. In New Guinea, *Cryptocarya* is common in *Castanopsis-Quercus* lower montane rain forest and (together with *Macaranga tanarius* (L.) Muell. Arg.) has been found to be rather abundant in the pole and sapling layers of a seral stage of *Pometia pinnata* forest. It is a common component of lowland ridge forest and *Araucaria* forest at an altitude of 600–1800 m.

Propagation and planting *Cryptocarya* can be propagated by seed, although germination is poor and can take a long time. In a test with fresh seed of *C. ferrea* in Malaysia, 35% germinated in 1.5–5.5 months, whereas only 8% of an unidentified *Cryptocarya* species germinated in 6.5 months. Manually depulping the fruits significantly enhances germination. Seed that had passed through the guts of the dwarf cassowary, a cursorial frugivorous bird of New Guinea, was found to have 73% germination during the first 12 days after sowing.

Silviculture and management Medang is reported to be disregarded in silvicultural treatments in Peninsular Malaysia because the species which grow to timber size cannot be differentiated from the large number of species which reach small sizes only. In Papua New Guinea it has been observed that after the logging of *Cryptocarya* species, natural regeneration is influenced by dispersal by dwarf cassowaries. It is not known to what extent other birds or mammals disperse the seed and improve its germination by passing it through their guts. In a logged-over forest in Papua New Guinea, seedlings of an unidentified *Cryptocarya* species and a few other species belonging to other genera were dominant in the natural regeneration in gaps as well as in heavy shade after 1 year.

Harvesting Timbers of minor importance, such as medang, are increasingly being harvested as major commercial timbers become scarcer. The diameter limit of 50 cm, as applied in the selective cutting system, is also respected for medang.

When *C. massoy* trees have been felled for their bark, tranverse incisions are made in the bark about 1 m apart. After a short period of drying, the bark is removed and cut into strips approximately 1 m long and 5 cm wide. These pieces are set upright to allow the excess sap, which causes skin blisters, to drain away. The pieces are finally tied together in bundles of about 60 kg.

Yield The number of *Cryptocarya* trees with a diameter over 50 cm in a natural forest in Irian Jaya was found to be comparatively low, 1–3 trees and 2–4 m^3 of timber per ha.

One *C. massoy* tree can provide about 120 kg of fresh bark.

Genetic resources *Cryptocarya* is a large and poorly known genus. No information is available on genetic erosion of the individual species except for *C. massoy*. Although several species are undoubtedly rare, *Cryptocarya* does not seem to be particularly endangered by logging activities, as it is usually not among the trees which are selectively cut. *C. massoy* trees have become scarce, owing to uncontrolled felling to collect the bark.

Prospects Like most other *Lauraceae* genera, *Cryptocarya* is in need of a thorough taxonomical revision. This would enable the identity of the species used in experiments and tests to be established more reliably. Research is necessary on the regeneration, silviculture and wood properties of properly identified specimens, to establish the usefulness of *Cryptocarya* for its timber in the future.

Collection of *C. massoy* bark on a commercial scale from the natural forest should be prohibited, in order to prevent its extermination. Only if *C. massoy* trees can be cultivated might it be possible to guarantee a regular supply of bark.

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Selection of species

Cryptocarya alleniana C.T. White

Journ. Arn. Arb. 31: 82 (1950).

Vernacular names Allen's laurel (En). Papua New Guinea: cryptocarya (general).

Distribution New Guinea and the Solomon Islands.

Uses *C. alleniana* is an important source of medang in Papua New Guinea. The wood is used for e.g. light framing, domestic flooring, turnery and boxes.

Observations A medium-sized to fairly large tree up to 42 m tall, bole slightly flared at base, bark surface shed in stripes, leaving a surface that is pustular or with fine longitudinal fissures, pale grey to brown, sapwood white, heartwood very pale pinkish-yellow; leaves 8–13 cm × 4–7 cm, apex acute to acuminate, with 7–9 pairs of secondary veins, minutely tomentose below; inflorescence up to 10 cm long, the axis densely pubescent; perianth with 1.5 mm long lobes, pedicel 3 mm long; fruit ellipsoid, 2 cm across. *C. alleniana* is locally common in lowland rain forest, riverine or swamp forest, up to 750 m altitude. The density of the wood is about 420 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 145, 166, 297, 318, 696.

Cryptocarya ampla Merr.

Philipp. Journ. Sci., Bot. 4: 258 (1909).

Synonyms *Cryptocarya calelanensis* Elmer (1910), *Cryptocarya elliptifolia* Merr. (1919), *Cryptocarya pacifica* Elmer (1939).

Vernacular names Philippines: manayau (Tagalog).

Distribution The Philippines.

Uses The wood is used as medang for general construction purposes.

Observations A fairly large tree with terete, lenticellate branches; leaves arranged spirally, 15–25 cm × 5–9 cm, apex broadly to prominently acuminate, with 5–10 pairs of secondary veins, glabrous; inflorescence about as long as the leaves, somewhat pubescent; perianth 3.5–4 mm long, pubescent, the lobes about as long as or slightly longer than the tube, fertile stamens 9, pedicel 1–2 mm long; fruit globose to ellipsoid or obovoid, striate, c. 1.5 cm in diameter. *C. ampla* occurs at low and medium altitudes, often along small streams. The wood is hard and heavy.

Selected sources 316, 318, 414, 424, 527.

Cryptocarya aureosericea Kosterm.

Reinwardtia 7: 301 (1968).

Distribution New Guinea and the Solomon Islands.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, with steep buttresses up to 1.5 m high, bark surface smooth, rugulose with fine vertical lines of lenticels, sometimes hoop-marked, inner bark pink-fawn with dark brown fibres set in discrete radial lines; leaves arranged spirally, broadly elliptical to ovate-lanceolate, up to 17 cm × 9 cm, apex usually abruptly acuminate, with 7 pairs of secondary veins, densely golden sericeous below; inflorescence up to 12 cm long; perianth densely sericeous, pedicel very short; fruit globose but flattened at the top, c. 1.5 cm across, finely ribbed. *C. aureosericea* is found in ridge forest, up to 900 m altitude.

Selected sources 318.

Cryptocarya bicolor Merr.

Philipp. Journ. Sci., Bot. 4: 255 (1909).

Vernacular names Philippines: dugkatan (Tagalog), masagkunadug (Cotabato), nangka-nangka (Sibutu Island).

Distribution The Philippines (Mindanao).

Uses The wood is used as medang, e.g. for general construction, house posts and furniture.

Observations A small to medium-sized tree up to 25 m tall, bole straight and cylindrical, branchless for up to 12 m, up to 40 cm in diameter, buttresses absent, sapwood dull yellowish, heartwood dark chocolate-brown, branches terete; leaves arranged spirally, 10–20 cm × 4–7 cm, apex shortly acuminate, with about 10 pairs of secondary veins, midrib sometimes hairy above, lower surface pale glaucous and sparsely pubescent, the veins ferruginous; inflorescence up to 10 cm long, hairy; perianth c. 3 mm long, the lobes as long as the tube, pubescent, fertile stamens 9, pedicel short; fruit unknown. The density of the wood is about 870 kg/m^3 at 15% moisture content.

Selected sources 316, 338, 414, 527, 698.

Cryptocarya crassinervia Miq.

Fl. Ind. Bat. 1: 924 (1858).

Synonyms *Cryptocarya infectoria* Miq. var. *acuminulata* Meissner (1864), *Cryptocarya edanoii* Merr. (1922).

Vernacular names Indonesia: lebau fatuh (Simeuluë, Sumatra), medang talang (Palembang, Sumatra), madang sanggih (Minangkabau, Sumatra). Malaysia: medang kelarah, medang miang (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Borneo and the Philippines (Mindanao).

Uses The wood is used as medang.

Observations A medium-sized tree up to 33 m tall, bole up to 50 cm in diameter, bark surface scaly, brown, inner bark granular, reddish-brown; leaves arranged spirally, 12–32 cm × 7–15 cm, apex rounded to acute, rarely shortly acuminate or notched, with 5–8(–10) pairs of secondary veins, glaucous and densely velvety hairy below, midrib channelled below; flowers in reddish hairy panicles up to 15 cm long, with 9 fertile stamens; fruit oblong to ovate, c. 1.5 cm in diameter, faintly ridged. *C. crassinervia* occurs scattered in lowland and hill forest, up to 1000 m altitude. The density of the wood is 700–800 kg/m^3 at 15% moisture content.

Selected sources 77, 292, 316, 318, 425, 474, 705.

Cryptocarya erectinervia Kosterm.

Reinwardtia 7: 307 (1968).

Distribution Borneo and the Philippines (Luzon, Palawan).

Uses The wood is reputed to be used as medang.

Observations A small to medium-sized tree up to 20 m tall, bole branchless for up to 12 m, up to 60 cm in diameter, with small buttresses up to 0.5 m high, bark surface smooth, pale brown, inner bark pale brown; leaves arranged spirally, 11–20 cm × 3–6.5 cm, apex obtuse to shortly acuminate, with 6–8 pairs of secondary veins, dull and glabrous below; inflorescence up to 10 cm long, yellowish-brown pilose; fruit ellipsoid, smooth, up to 1.1 cm in diameter. *C. erectinervia* is found in lowland to montane forest, also along rivers and in freshwater swamp forest, up to 1600 m altitude.

Selected sources 318.

Cryptocarya ferrea Blume

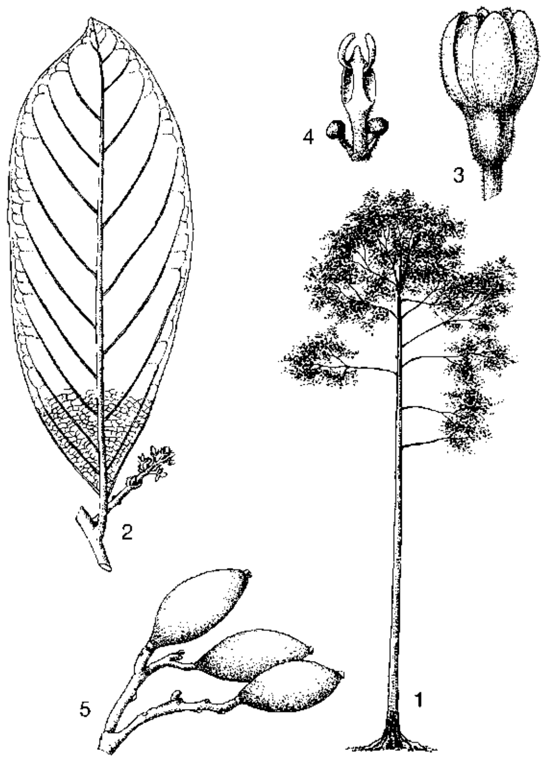
Bijdr. fl. Ned. Ind. 11: 557 (1826).

Synonyms *Cryptocarya oblongifolia* Blume (1826), *Cryptocarya mentek* Blume ex Nees (1836), *Cryptocarya obscura* Blume (1851).

Vernacular names Indonesia: huru mentek (Sundanese, Java), pecabian, ras-berasan (Madura). Malaysia: medang kuning, medang merah, medang tanah (Peninsular).

Distribution Peninsular Malaysia and Java; records from Indo-China are dubious.

Uses The wood is used as medang.



Cryptocarya ferrea Blume – 1, tree habit; 2, twig with leaf and inflorescence; 3, flower; 4, stamen with basal glands; 5, infructescence.

Observations A medium-sized tree up to 26 m tall, bole up to 50 cm in diameter, with short buttresses up to 1.4 m high, bark surface smooth, reddish-brown, inner bark yellowish-brown to reddish-brown; leaves 12–19 cm × 4–8 cm, with 8–16 pairs of secondary veins, faintly to distinctly glaucous and appressed hairy below; inflorescence up to 25 cm long; perianth 3.5–5 mm long, densely yellowish hairy, the lobes about as long as the tube, pedicel 0.3–1 mm long, fertile stamens hairy; fruit ovate to oblong, 1–1.5 cm in diameter. *C. ferrea* is fairly common in lowland forest, including swamp forest, to montane forest up to 1500 m altitude. The density of the wood is about 750 kg/m^3 at 15% moisture content.

Selected sources 36, 78, 140, 234, 303, 316, 465, 474, 705.

Cryptocarya griffithiana Wight

Icon. pl. Ind. orient. 5: 12, t. 1830 (1852).

Vernacular names Indonesia: medang buaya, piuta (Bangka). Malaysia: medang bulu merah, medang buaya, rambahan bukit (Peninsular).

Distribution Burma (Myanmar), Thailand, Peninsular Malaysia, Singapore, Borneo and the Philippines (Mindanao).

Uses The wood is used as medang for house building, interior finish, furniture, agricultural implements, and veneer and plywood.

Observations A medium-sized tree up to 33 m tall, bole up to 50 cm in diameter, bark surface closely set with lenticels, reddish-brown; leaves arranged spirally, 10–30 cm × 4–15 cm, apex long acuminate, with 5–9 pairs of secondary veins, glaucous and velvety hairy below; inflorescence axillary and up to 8 cm long or terminal and up to 22 cm long; perianth tube 1.5–2 mm long, tomentose, pedicel very short; fruit pear-shaped, c. 1.3 cm in diameter. *C. griffithiana* is uncommon in primary and secondary lowland forest. The density of the wood is 540–840 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 140, 474, 526, 529, 705.

Cryptocarya idenburgensis C.K. Allen

Journ. Arn. Arb. 23: 136 (1942).

Synonyms *Cryptocarya gonioclada* Kanehira & Hatusima (1943).

Distribution New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 10 m, up to 55 cm in diameter, with buttresses up to 1.3 m high, bark surface smooth or sparsely finely longitudinally cracked, with small lenticels in vertical rows, brownish, inner bark pale brown; leaves arranged spirally, 8–25 cm × 2.7–11 cm, apex usually long attenuate-acuminate, 3-veined at base and with few secondary veins above the middle, glaucous and densely golden sericeous below, eventually glabrous; inflorescence up to 6 cm long, fawn pubescent; perianth c. 4 mm long, pubescent; fruit unknown. *C. idenburgensis* is found in submontane and montane forest, up to 1900 m altitude. The density of the wood is about 670 kg/m^3 at 15% moisture content.

Selected sources 13, 316, 318, 474.

Cryptocarya impressa Miq.

Fl. Ind. Bat. 1: 923 (1858).

Synonyms *Cryptocarya infectoria* Miq. var. *opaca* Meissner (1864), *Cryptocarya venosa* Meissner ex Hook.f. (1886).

Vernacular names Indonesia: kayu kunyit (general). Malaysia: medang kunyit, munjuat, medang nau (Peninsular).

Distribution Indo-China, Peninsular Malaysia, Sumatra and Borneo (Kalimantan).

Uses The wood is used as medang. The wood also yields a yellow dye.

Observations A medium-sized tree up to 33 m tall, bole up to 50 cm in diameter, with short buttresses, bark surface smooth, reddish-brown; leaves arranged spirally, 7–19 cm × 3–7.5 cm, apex distinctly acuminate, with 5–9 pairs of secondary veins sunken above, midrib powdery hairy above, lower surface glaucous and reddish-brown powdery hairy; inflorescence hairy, up to 10 cm long; perianth turbinate, the tube 0.5–1 mm long, fertile stamens 9; fruit ovate to spherical, c. 1.5 cm long. *C. impressa* is uncommon in lowland forest, including swamps. The density of the wood is about 560 kg/m^3 at 15% moisture content.

Selected sources 78, 122, 140, 316, 318, 474, 529, 705.

Cryptocarya invasiorum Kosterm.

Reinwardtia 7: 312 (1968).

Vernacular names Indonesia: avies (Biak, Irian Jaya).

Distribution The Moluccas (Tanimbar and Aru Islands), New Guinea and the Solomon Islands.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 45 cm in diameter, with buttresses up to 2.5 m high, bark surface smooth or shallowly fissured, dark brown to blackish, inner bark pale brown to brown; leaves arranged spirally, 11–18 cm × 3–10.5 cm, apex long acuminate, with 5–6 pairs of secondary veins, lower surface dull, pale and glabrous; inflorescence umbel-like, up to 5 cm long; perianth 2–3 mm long, lobes longer than the tube, densely yellowish-brown sublanuginose; fruit ellipsoid, c. 12 mm in diameter. *C. invasiorum* is found in primary and secondary forest, up to 300 m altitude.

Selected sources 318.

Cryptocarya kurzii Hook.f.

Fl. Brit. India 5: 119 (1886).

Synonyms *Cryptocarya argentea* Gamble (1910).

Vernacular names Malaysia: medang ayer (Peninsular).

Distribution Peninsular Malaysia, Java and Borneo (Sarawak); the records from Burma (Myanmar) are dubious.

Uses The wood is used as medang.

Observations A small to medium-sized tree up to 21 m tall, bole up to 60 cm in diameter, bark surface smooth to slightly scaly, reddish-brown; leaves arranged spirally, 6.5–16 cm × 2.5–7 cm, apex acuminate, with 4–8 pairs of secondary veins, bluish glaucous and glabrous below; inflorescence about 5 cm long; perianth c. 2.5 mm long, puberulous, tube funnel-shaped; fruit ovoid to ellipsoid, c. 1.5 cm in diameter. *C. kurzii* occurs scattered in lowland forest. The density of the wood is about 725 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 140, 529, 705.

Cryptocarya longepetiolata Kosterm.

Reinwardtia 7: 315 (1968).

Distribution Papua New Guinea.

Uses The wood is reputed to be used as medang.

Observations A large tree up to 47 m tall, bole unbranched for up to 32 m, up to 90 cm in diameter, without buttresses but fluted or shallowly channelled at base, bark surface smooth to somewhat fissured, with vertical lines of lenticels, brownish, inner bark pale brown, indistinctly speckled; leaves arranged spirally, 8–11 cm × 3–5 cm, apex acuminate, with 6–8 pairs of secondary veins, glabrous except for the midrib above, below densely, minutely brown sublanuginose; inflorescence up to 11 cm long, densely minutely dark brown sublanuginose; perianth c. 2 mm long; fruit subovoid-ellipsoid, 1.5 cm in diameter. *C. longepetiolata* has been found in rather swampy locations, at low altitude as well as at 1200 m.

Selected sources 318.

Cryptocarya massoy (Oken) Kosterm.

New and critical Mal. pl. 3 (For. Serv. Indon., Bur. For. Planning): 21 (1955).

Synonyms *Cinnamomum massoy* Oken (1841), *Cryptocarya novoguineensis* Teschner (1923), *Cryptocarya aromatica* (Becc.) Kosterm. (1949).

Vernacular names Massoi, massoia (En). Indonesia: ai kor, ai kori (Irian Jaya). Malaysia: misoi, mesui, mersawir (Peninsular).

Distribution New Guinea and possibly north-eastern Australia.

Uses The wood is used as medang. More important is the use of the aromatic bark (massoi bark), a decoction of which is used externally to relieve sore muscles and headache. Internally it is used against fever, diarrhoea and for women after childbirth. Mixed with other substances massoi is used as a tonic, and also added to many local medicines.

Observations A medium-sized tree up to 25 m tall, bole rarely more than 30 cm in diameter; leaves arranged spirally, 9–12 cm × 4–5 cm, broadly acuminate; inflorescence up to 10 cm long; perianth 2.5–3 mm long, the lobes 1–1.5 times as long as the tube, pedicel 0.5–1 mm long, fertile stamens 9, hirsute; fruit globose, 1–2 cm in diameter, ribbed. *C. massoy* occurs in forest up to about 1000 m altitude. The density of the wood is 600–790 kg/m^3 at 15% moisture content.

Selected sources 12, 309, 316, 474, 635, 695.

Cryptocarya multipaniculata Teschner

Bot. Jahrb. Syst. 58: 405 (1923).

Synonyms *Cryptocarya cordata* C.K. Allen (1942).

Vernacular names Indonesia: watagi (Babo, Irian Jaya), menako (Manikiong, Vogelkop peninsula, Irian Jaya), kafu (Berik, Irian Jaya).

Distribution New Guinea and the Solomon Islands.

Uses The wood is reputed to be used as medang. In the Solomon Islands heated leaves have been applied medicinally to sore eyes. In New Britain the fruit has been used as a relish with certain foods.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 40 cm in diameter (probably more), with short buttresses up to 0.6 m high, bark surface smooth or peeling into papery plates, inner bark straw-coloured turning reddish-brown with red and black lines; leaves subopposite, 8–31 cm × 2.5–16 cm, apex acute to shortly acuminate, with 9–20 pairs of secondary veins, glabrous except for the midrib above, below densely tomentose; inflorescence up to 12 cm long, densely tomentose; perianth minutely puberulent, fertile stamens 9; fruit ellipsoid, c. 0.9 cm in diameter. *C. multipaniculata* occurs scattered in rain forest, up to 1200 m altitude, and has been reported to be inhabited by ants. The density of the wood is 410–570 kg/m^3 at 15% moisture content.

Selected sources 13, 316, 318, 474, 635.

Cryptocarya nitens (Blume) Koord. & Valeton

Meded. 's-Lands Plantentuin 68: 220 (1904).

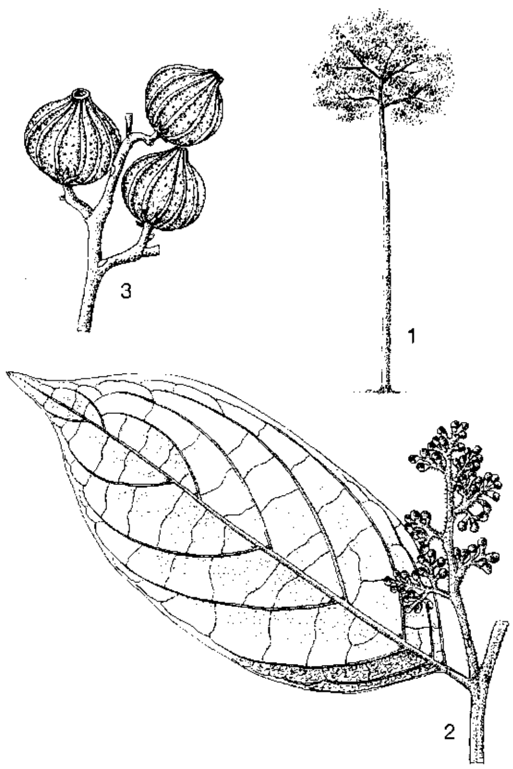
Synonyms *Cryptocarya areolata* Gamble (1910), *Cryptocarya bubongana* Gamble (1910), *Cryptocarya paucinervia* Gamble (1910).

Distribution Peninsular Malaysia, Sumatra and Java.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 28 m tall, bole up to 60 cm in diameter, bark surface smooth, lenticellate, grey-brown, inner bark granular, brownish, twigs angular; leaves arranged spirally, (6–)12–23 cm × (2.2–)4–10.5 cm, apex tapering to shortly acuminate, with (3–)4–10 pairs of secondary veins, sometimes glaucous below and densely barbate in the axils of secondary veins below; inflorescence 7–15 cm long, hairy; perianth 3–3.5 mm long, densely hairy outside, the lobes as long as the tube, filaments hairy, pedicel absent or very short; fruit globose, 1.1–1.5 cm in diameter. *C. nitens* occurs scattered in lowland forest (mixed forest, teak forest) along rivers and on limestone, up to 800 m altitude.

Selected sources 36, 181, 303, 316, 318, 705.



Cryptocarya nitens (Blume) Koord. & Valeton – 1, tree habit; 2, twig with leaf and inflorescence; 3, infructescence.

Cryptocarya palmerensis C.K. Allen

Journ. Arn. Arb. 23: 140 (1942).

Distribution New Guinea and the Solomon Islands.

Uses The wood is used as medang.

Observations A medium-sized tree up to 29 m tall, bole up to 60 cm in diameter, spurred at base, bark surface lenticellate, brown or grey; leaves arranged spirally, 7.5–12 cm × 3–5.5 cm, apex obtuse to obtusely acuminate, falcate, with 3–4 pairs of secondary veins, glaucous and with glabrescent veins below; inflorescence up to 12 cm long, hairy; perianth 2–3 mm long, pubescent, stamens pubescent; fruit ellipsoid, c. 1.5 cm in diameter. *C. palmerensis* has been found as a common tree in primary rain forest on flat terrain and in riverine forest, up to 850 m altitude.

Selected sources 13, 338.

Cryptocarya pulchrinervia Kosterm.

Reinwardtia 7: 325 (1968).

Distribution Borneo (Sabah and East Kalimantan).

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole branchless for up to 17 m, up to 45 cm in diameter, bark surface smooth or scaly, pale red-brown, inner bark pale yellow to pale reddish-brown, branches angular or slightly so; leaves arranged spirally, 21–30 cm × 5–13 cm, apex mucronate to obtuse or emarginate, with 11–17 pairs of secondary veins, dark rusty pilose and prominently reticulate below; inflorescence up to 22 cm long, pilose; perianth densely minutely grey appressed pilose, pedicel absent; fruit elongated-ovoid, up to 2.5 cm in diameter, with broad ribs. *C. pulchrinervia* is found in primary forest, along rivers, also on limestone, up to 300 m altitude.

Selected sources 318.

Cryptocarya rugulosa Hook.f.

Fl. Brit. India 5: 118 (1886).

Synonyms *Cryptocarya longepaniculata* Gamble (1910).

Vernacular names Malaysia: medang liang (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo (Sarawak).

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 45 cm in diameter, with short buttresses, bark surface smooth to dippled and scaly, lenticellate, reddish-brown, inner bark brown; leaves arranged spirally, 5–25 cm × 2–11 cm, apex acute to abruptly acuminate, with 4–9 pairs of secondary veins, lower surface slightly glaucous and hairy; inflorescence up to 30 cm long, hairy; perianth tube 2–3 mm long, the lobes as long as or shorter than the tube, pedicel absent, fertile stamens 9, hirsute; fruit ovoid to ellipsoid, c. 1.5 cm in diameter. *C. rugulosa* occurs frequently in lowland and hill forest, also in peat-swamp forest.

Selected sources 78, 181, 316, 318, 529, 705.

Cryptocarya scortechinii Gamble

Kew Bull.: 143 (1910).

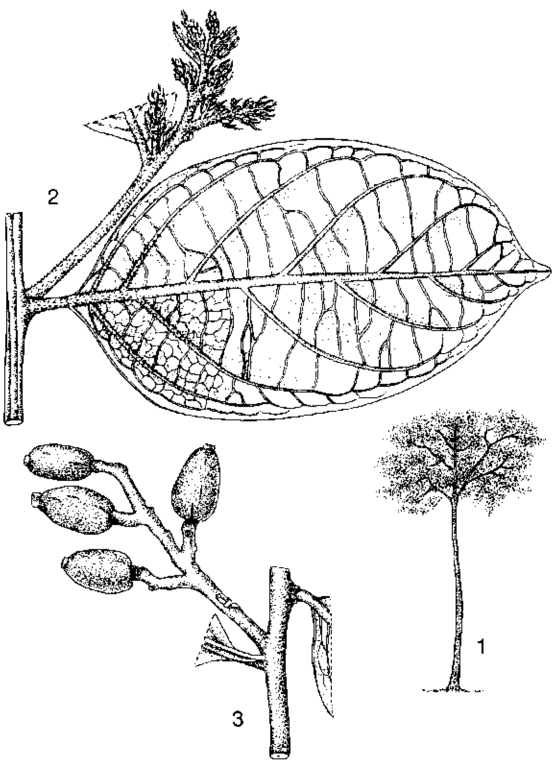
Vernacular names Malaysia: medang ayer, kayu rangan (Peninsular).

Distribution Peninsular Malaysia and Borneo (Sarawak).

Uses The wood is used as medang and is reported to be hard.

Observations A medium-sized tree up to 24 m tall, bole up to 50 cm in diameter, bark surface smooth, reddish-brown, inner bark brownish; leaves arranged spirally, 7–21 cm × 3–11 cm, apex broadly acuminate to blunt or emarginate, with 6–10 pairs of secondary veins, purplish-grey or purplish glaucous and with pubescent veins below; inflorescence 20–25 cm long, minutely bluish-grey pubescent; perianth 3 mm long, the lobes as long as the tube, pedicel 1 mm long, fertile stamens 9, villous; fruit oblong-ellipsoid, 10–15 mm in diameter, with a swollen pedicel. *C. scortechinii* is found in lowland and montane forest, up to 1500 m altitude.

Selected sources 181, 316, 318, 705.



Cryptocarya tomentosa Blume – 1, habit of young tree; 2, twig with leaf and young inflorescence; 3, twig with infructescence.

Cryptocarya tomentosa Blume
Mus. bot. Lugd.-Bat. 1: 335 (1851).

Synonyms *Cryptocarya fuliginosa* Elmer (1939).

Vernacular names Indonesia: huru kunyit, huru mentek, huru tengek (Sundanese).

Distribution Peninsular Malaysia, Java, Borneo, Sulawesi and the Philippines.

Uses The wood is used as medang.

Observations A medium-sized tree up to 20 m tall, bole up to 40 cm in diameter, with short buttresses, bark surface finely scaly, reddish, inner bark pale yellowish-brown to deep yellow turning brown on exposure; leaves arranged spirally, 9–20 cm × 3–9 cm, apex usually shortly acuminate, with 6–10 pairs of secondary veins, lower surface glaucous and finely reddish-brown or grey hairy; inflorescence up to 10 cm long, hairy; perianth tube funnel-shaped, 2–2.5 mm long, grey puberulous, the lobes as long as the tube, pedicel 1 mm long; fruit ovoid to ellipsoid, 10–15 mm in diameter, ribbed. *C. tomentosa* is found in lowland and montane forest, sometimes along rivers, up to 1500 m altitude. The density of the wood is 440–830 kg/m^3 at 15% moisture content.

Selected sources 36, 78, 234, 303, 316, 318, 474, 529, 705.

Cryptocarya verrucosa Teschner
Bot. Jahrb. Syst. 58: 406 (1923).

Vernacular names Indonesia: menako (Manikiong, Irian Jaya), orofon (Tehid, Irian Jaya), kalaso (Mooi, Irian Jaya).

Distribution New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole branchless for up to 20 m, up to 60 cm in diameter, with short buttresses up to 1.5 m high, bark surface smooth to shallowly fissured or peeling off in large flakes, pale brown to grey-brown or greenish-brown, inner bark pink, branches and basal part of inflorescences with pale lenticels; leaves arranged spirally, 7–14 cm × 3–6 cm, apex acuminate, with 3–5 pairs of secondary veins, lower surface glaucous and minutely lanuginose; inflorescence up to 5 cm long; perianth minutely puberulous, fertile stamens 9, filaments pilose; fruit bluish-green. *C. verrucosa* is locally common in forest up to 800 m altitude. The density of the wood is 350–420 kg/m^3 at 15% moisture content.

Selected sources 316, 318, 635.

B. Sunarno (general part, selection of species),
W.C. Wong (properties),
S.C. Lim (wood anatomy),
M.S.M. Sosef (selection of species)

Dacrycarpus (Endl.) de Laubenf.

Journ. Arn. Arb. 50: 315 (1969).
PODOCARPACEAE
$x = 10, 20$; *D. imbricatus*: $2n = 20$

Trade groups Podocarp: lightweight to medium-weight softwood, e.g. *Dacrycarpus cinctus* (Pilger) de Laubenf., *D. cumingii* (Parl.) de Laubenf., *D. imbricatus* (Blume) de Laubenf.
The timber is traded as podocarp together with that of the genera *Nageia*, *Podocarpus* and *Prumnopitys*. In Indonesia, all *Podocarpaceae* timber is traded as 'melur'.

Vernacular names Podocarp (En, Fr), kajoerapat (En, Am, Fr). Indonesia: jamuju. Malaysia: rempayan (Sabah), landin (Sarawak). Papua New Guinea: high mountain podocarp. Philippines: igem. Burma (Myanmar): thitmin. Thailand: paya, makhampom. Vietnam: thong nang.

Origin and geographic distribution *Dacrycarpus* consists of 7 species and occurs from northern Burma (Myanmar), Indo-China and southernmost China throughout Thailand and Malesia towards Fiji and New Zealand. The greatest diversity is found in New Guinea where 5 species occur. Fossil records from the Eocene are known in New Zealand, Victoria (Australia) and Tasmania.

Uses The wood of *Dacrycarpus* is used for furniture, panelling, cabinet work, carving, masts, beams, tea chests, face material for blockboard, veneer, utensils and light construction work; it has good qualities for paper manufacture. It is also used for the manufacture of fine engineering instruments (e.g. rulers, T-squares, drawing boards, pencil slats) because of the light and fine grained wood. It is highly valued locally for construction wood.
Copal has been collected by tapping the trees. *Dacrycarpus* is planted as ornamental; its beautiful needles make it an attractive tree in parks and gardens.

Production and international trade Podocarp timber is generally consumed by the local industry. Export of sawn timber of *D. imbricatus* from North Sumatra to Singapore in 1978/1979 was only 162 m^3 with a value of US$ 16 000. Export of sawn timber of *D. imbricatus*, mixed with *Dacrydium* and some other softwoods from Indonesia was 661 m^3 in 1981 with a value of US$ 147 000. In Papua New Guinea, podocarp timber commands high prices and the export of logs is banned to encourage domestic processing.

Properties Podocarp is a lightweight to medium-weight softwood. The heartwood is pale yellow with a greenish tinge or pale golden brown and not clearly demarcated from the sapwood. The density is 380–770 kg/m^3 at 15% moisture content. The grain is straight, texture fine and even; wood without figure, lustrous.

A test on the mechanical properties of *D. imbricatus* var. *patulus* from Fiji at 12% moisture content showed the following results: the modulus of rupture 77.5 N/mm^2, modulus of elasticity 9175 N/mm^2, compression parallel to grain 47 N/mm^2, shear 10.5–12.0 N/mm^2, cleavage 38 N/mm radial and 54 N/mm tangential, Janka side hardness 3295–3825 N and Janka end hardness 5585 N.

The rates of shrinkage are moderate: from green to oven dry 3.4% radial and 7.1% tangential for *D. imbricatus* wood. The wood seasons well with little degrade, but is susceptible to brown-stain caused by the leaching out of a soluble manganese compound.

Podocarp wood is easy to work with machines and hand tools and is easy to saw, but softer boards show a tendency to crumble on end grain. The wood can be planed, shaped, turned, mortised and sanded with good results and to a smooth finish, but the results of boring are sometimes rated as moderate. Generally, the wood holds nails well, but large nails may cause some splitting. The gluing, staining, varnishing and painting properties are satisfactory. The peeling and slicing properties are rated as good with a negligible degrade upon drying; pretreatment is not needed. The wood is suitable for the production of sulphate pulp for paper making.

Podocarp wood is classified as non-durable when used in contact with the ground or exposed to the weather in the lowland tropics. At higher elevations or in a temperate climate, however, it is considered fairly durable. It is susceptible to termite, pinhole borer, longhorn beetle and marine borer attack, but not to *Lyctus* beetle attack. The sapwood is permeable for preservatives, but the heartwood is moderately resistant to impregnation. Hot soaking of the wood for 1, 2 and 3 hours results in retentions of BFCA active substances of 8.9 kg/m^3, 9.4 kg/m^3 and 9.5 kg/m^3, respectively. Retention of copper-chrome-arsenic preservative is 12.7 kg/m^3.

Wood of *D. imbricatus* contains 52.5% cellulose, 29% lignin, 10% pentosan, 1% ash and 0.3% silica. The solubility is 4.3% in alcohol-benzene, 1.9% in cold water, 2.7% in hot water and 12.3% in a 1% NaOH solution. The energy value of *D. imbricatus* wood is 20 400 kJ/kg. The wood is resistant to burning.

Description Dioecious shrubs or small to large trees up to 50 m tall; bole cylindrical; bark on older trees breaking off into small, thick plates or sometimes short strips, bark surface rough with occasional lenticels, dark brown or blackish but becoming grey, inner bark pink to reddish-brown. Leaves arranged spirally, lanceolate or sometimes triangular, flattened, broadly decurrent, apiculate, with stomata on both surfaces; juvenile leaves spreading at about 60° and giving the shoot a feather-like appearance, falcate but with the apex curved and pointing parallel to the shoot, flattened and usually keeled on both surfaces; adult leaves not distichous, shorter and more robust than the juvenile leaves. Fertile structure terminal on short, mostly lateral shoots, the seed-bearing structure usually on a considerably longer shoot than the pollen cone. Pollen cone elongated, mostly 6–10 mm × 2–3 mm; apex of microsporophyll triangular, acute to apiculate. Seed-bearing structure solitary, with an involucre of sharply elongated leaves at the base, composed of a small warty receptacle which enlarges when mature, fleshy, orange at first becoming red or purple and later brown, bearing 1 or 2 protruding sterile leaf-like bracts and 1 or 2 fertile bracts; inverted ovules fused as a rib along 1 side with the fertile bract. Mature seed spherical to ovate, remaining covered by the leathery epimatium and scale, forming an erect or somewhat oblique dark structure of about 5–6 mm × 4.5–5.5 mm. Seedling with epigeal germination.

Wood anatomy

– Macroscopic characters:

Heartwood straw-coloured, yellow-brown to pale brown, rarely with darker streaks (usually near the pith and resulting from compression wood), often not clearly demarcated from the paler sapwood. Grain straight. Texture fine and even; wood without figure except in samples with tendency to growth rings, lustrous. Growth rings indistinct; diffuse parenchyma rarely evident to the naked eye; rays very fine, not visible to the naked eye.

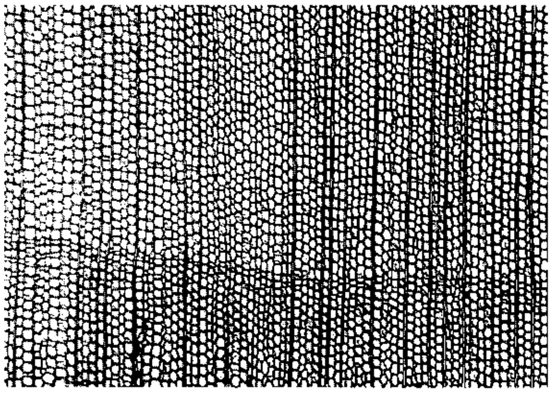
– Microscopic characters:

Growth rings not clearly marked, tracheid wall thickness in latewood barely different from that in earlywood. Tracheids square, rounded, polygonal to irregular in cross-section, radially aligned, tan-

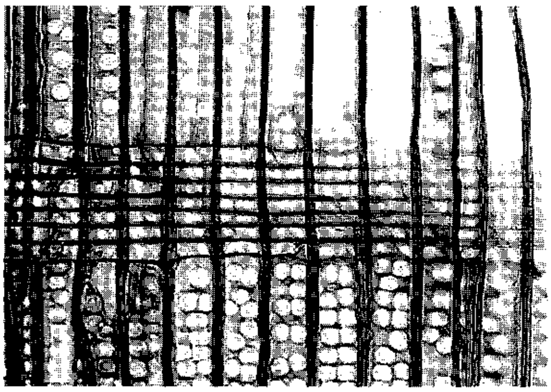
gential diameter approximately 45–55 μm, 2–6 mm long; intertracheid pits in 1 row, sometimes opposite and paired near the tips, moderately large (14–18 μm in diameter), rounded, rarely flattened due to compression on radial section; smaller pits on tangential walls in latewood tracheids sometimes present, c. 14 μm in diameter. Parenchyma diffuse, moderately abundant to abundant, end walls thin and smooth. Rays 4–8/mm, predominantly uniseriate, biseriate rays rare, (1–)2–35(–40) cells high, end walls smooth; ray-tracheid pits half-bordered, mainly cupressoid to piceoid, medium-sized, 8–10 μm in diameter, 1–2 per crossfield. Ray tracheids absent, resin ducts absent. Reddish-brown extraneous material abundant in parenchyma cells, less in ray cells.
Species studied: *D. cinctus*, *D. imbricatus*.
Wood of *Agathis*, *Falcatifolium*, *Nageia*, *Phyllocladus*, *Podocarpus* and *Prumnopitys* may resemble *Dacrycarpus*. *Agathis* differs from the other genera by having alternate intertracheid pits. In *Phyllocladus* and *Prumnopitys* parenchyma is absent. *Falcatifolium*, *Nageia* and *Podocarpus* are very similar to *Dacrycarpus*, though the wood of *Dacrycarpus* tends to have a pinkish tinge.

Growth and development The annual diameter increment of *D. imbricatus* in natural forest in the Philippines is 0.7 mm and 2.1 mm for diameter class 0–10 cm and 50–60 cm, respectively. The mean annual height increment of *D. imbricatus* in a 28-year-old plantation in Java dominated by *Schima wallichii* (DC.) Korth. ssp. *noronhae* (Reinw. ex Blume) Bloembergen var. *noronhae* and a second layer of *Altingia excelsa* Noroña is 0.3–0.7 m. The mean annual increment in a 7.5-year-old open plantation was 0.9–1.0 m in height and 1.0 cm in diameter.
Dacrycarpus is pollinated by wind. In Thailand *D. imbricatus* flowers from January to May and the seeds ripen from March to September. Root nodules have been observed, but it is unknown whether nitrogen fixation occurs.

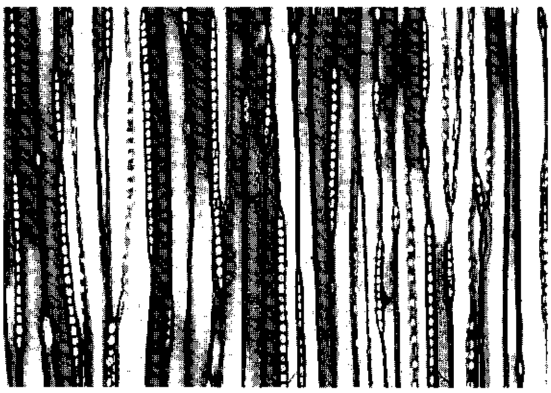
Other botanical information The genus *Dacrycarpus* was formerly treated as a section within *Podocarpus* (section *Dacrycarpus* Endl.). Sterile specimens closely resemble *Dacrydium* but they can be distinguished by the distinctive dimorphic foliage. *Dacrycarpus* is thought to be most closely related to *Acmopyle* (New Caledonia and Fiji) and *Falcatifolium* (Peninsular Malaysia to New Caledonia) on the basis of resemblance of female reproductive structures and morphology of the leaves.
Chromosomal evolution within the *Podocarpaceae*



transverse section (×25)



radial section (×150)



tangential section (×75)

Dacrycarpus imbricatus

seems to have involved fusion and splitting of chromosomes, leading to a wide range of chromosome numbers with a basic number of 10 or 20.

Ecology *Dacrycarpus* generally occurs scattered but sometimes it is common and even dominant, or rarely occurs in pure stands in primary rain forest. It often grows in very humid locations such as poorly drained or boggy sites, sometimes on river banks or well-drained mountain slopes. Most species occur in submontane or montane habitats at 800–2500 m altitude but may descend almost to sea-level or ascend to 3600 m although at the higher altitudes the trees do not reach exploitable timber sizes.

Propagation and planting *Dacrycarpus* can be propagated by seed or cuttings. *D. imbricatus* has about 16 000 dry seeds/kg. In this species, 59% of the seeds germinated in 16–63 days in Peninsular Malaysia; a germination rate of 88–98% has been reported for the Philippines. Exposure to the sun for 6–18 hours prior to sowing enhanced germination significantly.

The moisture retention capacity of the medium used in the nursery should be very high. Early development of *Dacrycarpus* is slow. Although natural regeneration is generally scarce, seedlings can be used to make stumps. The rooting success of short stem cuttings of *D. imbricatus* with one node, a leaf and an axillary bud from juvenile material was found to be 50%. Wildlings planted at 3 m × 2 m in North Sumatra showed a survival of 90%.

Silviculture and management In 1890, *D. imbricatus* was already reported to be in cultivation. Natural regeneration is very difficult, but *D. imbricatus* is planted in the same way as *Altingia excelsa* and underplanted in *Acacia mearnsii* De Wild. in protection forest in Java.

Canopy closure of *D. imbricatus* in pure plantations takes a long time. *Dacrycarpus* is one of the most fire-resistant trees in the natural forest of Java.

Diseases and pests The mistletoe *Korthalsella dacrydii* (Ridley) Dans. has been observed on *Dacrycarpus*, but its importance is probably insignificant.

Harvesting Felling with strips of 20 m wide left untouched to diminish erosion and to favour establishment of natural regeneration is recommended for *D. imbricatus* forest in Java on erodible sandy soils; the conventional selective cutting system has been abandoned. Forest containing *D. imbricatus* is difficult to exploit as the rugged topography poses problems when conventional machinery is used. Wire skidding is used for log extraction.

Yield The exploitable timber volume of a montane forest in West Java dominated by *D. imbricatus* is estimated at 300 m^3/ha. Individual trees with a diameter of 41 cm at breast height and a clear bole height of 12 m have an estimated timber volume of 1.2 m^3, and trees with a diameter of 102 cm and a clear bole height of 18 m have 9.9 m^3.

Handling after harvest As the timber is non-durable, it should be converted as soon as possible after felling.

Genetic resources Large-scale exploitation of *Dacrycarpus* is not possible because it occurs in not easily accessible forest. Species are locally common, but may have a restricted area of distribution. Therefore, it is expected that genetic resources are generally satisfactorily conserved. In-situ and ex-situ conservation of *D. imbricatus* in the South-East Asian region is found in national parks and in botanical gardens.

Prospects The quality of the wood is valued locally, and mature trees can no longer be found close to human settlements. Research into small-scale silvicultural management of forest containing *Dacrycarpus* may increase its utilization beyond the local level.

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Selection of species

Dacrycarpus cinctus (Pilger) de Laubenf.

Journ. Arn. Arb. 50: 332 (1969).

Synonyms *Podocarpus cinctus* Pilger (1938), *Podocarpus dacrydiifolia* Wasscher (1941), *Dacrycarpus dacrydiifolia* (Wasscher) Gaussen (1974).

Vernacular names Indonesia: sareh (Sulawesi).

Distribution Central Sulawesi, the southern Moluccas and New Guinea.

Uses The wood is probably used as podocarp.

Observations An often flat-crowned tree up to 33 m tall, bole up to 90 cm in diameter; adult leaves curved in the upper half, bifacially flattened, 2–5 mm × 0.4–0.6 mm, involucral leaves curved throughout, completely surrounding the developing seed, 6–10 mm long; receptacle bright red when ripe; seed 7 mm × 6–7 mm. In New Guinea, *D. cinctus* is extremely common and often dominant or co-dominant with *Nothofagus*, *Libocedrus*, *Elaeocarpus* and *Podocarpus*. It occurs in mountain forest and mossy forest at (900–)1300–3000(–3600) m altitude. The density of the wood is 490–630 kg/m^3 at 15% moisture content.

Selected sources 117, 127, 145, 162, 189, 474, 685.

Dacrycarpus cumingii (Parl.) de Laubenf.

Journ. Arn. Arb. 50: 329 (1969).

Synonyms *Podocarpus cumingii* Parl. (1868), *Podocarpus imbricatus* Blume var. *cumingii* (Parl.) Pilger (1903).

Vernacular names Indonesia: sangu (Gayo, northern Sumatra). Philippines: igem (Davao, Mindanao).

Distribution Northern Sumatra and Sarawak (rare), and throughout the Philippines.

Uses *D. cumingii* is a fairly important source of podocarp timber in the Philippines; the wood is especially used for face veneer.

Observations A medium-sized tree up to 25 m tall, bole up to 75 cm in diameter; adult leaves straight, bilaterally flattened and slightly keeled on the lateral faces, 3–6 mm × 0.6–0.8 mm, involucral leaves curved, completely surrounding the developing seed, 7–13 mm long; receptacle reddish when ripe. *D. cumingii* is locally common in mossy primary forest at (1000–)1850–2650(–3300) m altitude.

Selected sources 77, 117, 127, 129, 162, 189, 685.

Dacrycarpus expansus de Laubenf.

Journ. Arn. Arb. 50: 334 (1969).

Distribution The central highlands of Papua New Guinea.

Uses The wood is probably used as podocarp.

Observations A medium-sized tree up to 25(–30) m tall, bole up to 58 cm in diameter; adult leaves with the upper half curved forward, bifacially flattened, distinctly keeled on the upper and lower surface, 1.5–3 mm × 0.4–0.8 mm, involucral leaves curved, covering only the receptacle of the mature seed; seed c. 3–3.5 mm long. *D. expansus* is locally common or occurs even in pure stands in often disturbed habitats, e.g. on edges of tree-fern grassland, at 1300–2750 m altitude.

Selected sources 127, 162.

Dacrycarpus imbricatus (Blume) de Laubenf.

Journ. Arn. Arb. 50: 320 (1969).

Synonyms *Podocarpus imbricatus* Blume (1827), *Podocarpus cupressina* R.Br. ex Mirbel (1925), *Podocarpus javanicus* auct. non (Burm.f.) Merr.

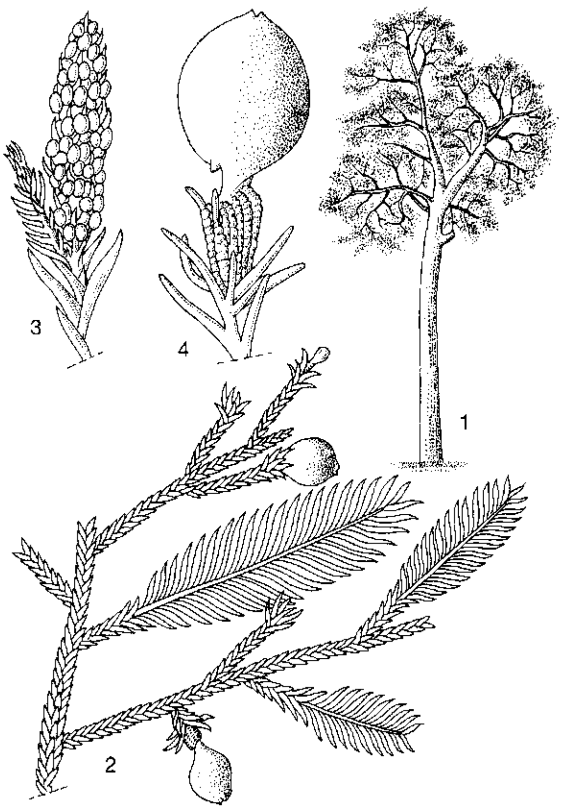
Vernacular names Indonesia: jamuju (general), kayu embun (Sumatra, Sulawesi), cemba-cemba (Sulawesi). Philippines: igem. Burma (Myanmar): sha-mo-pin. Malaysia: podo chucher atap

(Peninsular). Laos: hing[2] 'khièo, pêk dêng, lông leng. Thailand: phaya-makhampom dong (eastern), phayamai, sarun (south-eastern). Vietnam: thong nang.

Distribution From southern China, Indo-China, Burma (Myanmar) and Thailand throughout the Malesian archipelago towards Vanuatu and Fiji.

Uses *D. imbricatus* is the most important source of podocarp timber; the wood is used especially in the Philippines, e.g. for utensils, masts, tea chests and carving. In Thailand, it is used for furniture and cabinet work.

Observations A large, majestic tree up to 50 m tall, bole up to 200 cm in diameter; adult leaves imbricate or spreading, straight, scale-like, keeled on 1 to 4 sides, 1.0–1.8 mm × 0.4–1.0 mm, involucral leaves spreading and exposing the receptacle already when this is immature, 2.5–5.0 mm long; receptacle red when ripe; seed about 6 mm long. *D. imbricatus* is divided into 4 varieties: var. *imbricatus*, var. *patulus* de Laubenf. (synonyms: *Podocarpus kawaii* Hayata, *Dacrycarpus kawaii* (Hayata) Gaussen), var. *robustus* de Laubenf. (synonyms *Podocarpus papuanus* Ridley, *Dacrycarpus papuanus* (Ridley) Gaussen) and var. *curvulus* (Miq.) de Laubenf. (synonyms: *Podocarpus cupressina* R.Br. ex Mirbel var. *curvula* Miq., *Podocarpus imbricatus* Blume var. *curvula* (Miq.) Wasscher). They are distinguished on the basis of the leaves being slender or robust and imbricate or spreading. *D. imbricatus* occurs scattered but is locally common and sometimes co-dominant or dominant as a canopy or emergent tree in primary forest at (0–)700–2500(–3400) m altitude. The density of the wood is 380–770 kg/m^3 at 15% moisture content. See also the table on wood properties.



Dacrycarpus imbricatus (Blume) de Laubenf. – 1, tree habit; 2, twig with seed cones; 3, pollen cone; 4, seed cone.

Selected sources 21, 41, 46, 55, 61, 67, 73, 77, 78, 117, 127, 129, 135, 145, 160, 161, 162, 189, 213, 226, 234, 268, 282, 289, 332, 401, 404, 444, 459, 465, 474, 548, 571, 572, 575, 587, 589, 636, 652, 676, 685, 705, 716.

Dacrycarpus steupii (Wasscher) de Laubenf.

Journ. Arn. Arb. 50: 328 (1969).

Synonyms *Podocarpus steupii* Wasscher (1941).

Distribution East Kalimantan, central Sulawesi and throughout New Guinea.

Uses The wood is probably used as podocarp.

Observations A medium-sized to fairly large tree, up to 36 m tall, bole up to 100 cm in diameter; adult leaves spread widely, becoming nearly quadrangular in cross section, 2–3 mm × 0.4–0.6 mm, involucral leaves becoming spreading and exposing the receptacle already when this is immature, 3–4 mm long; seed 5–6 mm in diameter. *D. steupii* is locally common, particularly in disturbed forest, or in poorly drained locations where it may form nearly pure stands, at (850–)1500–2000(–3400) m altitude. The density of the wood is about 620 kg/m^3 at 15% moisture content.

Selected sources 127, 162, 189, 474, 685.

B. Sunarno (general part),
E. Boer (properties),
J. Ilic (wood anatomy),
M.S.M. Sosef (selection of species)

Dacrydium Sol. ex J.G. Forster

De pl. escul. insul. oceani austr. comm. bot.: 80 (1786).

PODOCARPACEAE

$x = 10, 15$; *D. elatum*: $2n = 20$

Trade groups Sempilor: lightweight to medium-weight softwood, e.g. *Dacrydium beccarii* Parl., *D. elatum* (Roxb.) Wallich ex Hook., *D. nidulum* de Laubenf.

The timber is traded as sempilor together with that of *Falcatifolium* and *Phyllocladus*. In Indonesia, all *Podocarpaceae* timber is traded as 'melur'.

Vernacular names Sempilor: meloor (Am, En, Fr). Indonesia: melur (general), kayu alau (Kalimantan). Malaysia: ekor (Peninsular), melor (Sarawak, Sabah). Papua New Guinea: dacrydium. Philippines: lokinai (general). Cambodia: srol-kraham. Thailand: samphanpi (north-eastern), sonhangkarok (central), phayamakhampom (south-eastern). Vietnam: hoang dan. Burma (Myanmar): taw-kyet-gale-pan.

Origin and geographic distribution *Dacrydium* consists of about 25 species and is distributed from mainland South-East Asia through Malesia (but not on Java and the Lesser Sunda Islands except for Sumba), towards New Caledonia, Fiji, Tasmania, New Zealand and southern Chile. The greatest numbers of species are found in Borneo (7), New Guinea (6), Peninsular Malaysia (5), the Moluccas (5), and outside the Malesian area in New Caledonia (4) and New Zealand (4).

Dacrydium has a long fossil record dating back to the Middle Jurassic and Upper Cretaceous floras of western Antarctica. The centre of origin is believed to have been located in the Australian-New Zealand region, where the most primitive species are distributed.

Uses *Dacrydium* timber is resinous and relatively hard and used for light construction, furniture, joinery, mouldings, light traffic flooring, door and window frames, masts, interior finish, novelties, veneer and plywood, and packing-cases. It is suitable for pulp and paper.

A volatile oil resembling commercial cedar oil can be distilled from the wood.

D. elatum is planted as an ornamental tree.

Production and international trade No statistics are available on the trade of *Dacrydium* timber. In Papua New Guinea, timber of *Dacrydium* commands high prices, just like other conifer woods, and the export of logs is banned to encourage local processing and obtain added value.

Properties *Dacrydium* yields a lightweight to medium-weight softwood. The heartwood is yellow-brown, pinkish-yellow, golden, pale brown to brown or red-brown, not clearly demarcated from the paler sapwood. The density is 425–720 kg/m^3 at 15% moisture content. The grain is straight, rarely wavy, texture fine and even. The wood generally lacks figure, occasionally with fine dark streaks giving an attractive appearance and without taste or odour.

A test on the mechanical properties of *D. nidulum* wood in Fiji at 12% moisture content showed the following figures: the modulus of rupture 106 N/mm^2, modulus of elasticity 11 590 N/mm^2, compression parallel to grain 61.5 N/mm^2, shear 14 N/mm^2, cleavage 38 N/mm radial and 54.5 N/mm tangential, Janka side hardness 5430 N and Janka end hardness 8635 N.

The rates of shrinkage are fairly low to moderate: from green to 12% moisture content 2.0% radial and 4.5% tangential. The wood seasons well with very little collapse, but thicker boards must be dried slowly to avoid surface checking. Warping in the form of slight to moderate twist may occasionally occur, while backsawn boards may cup to a slight extent. The recommended kiln schedule is at a dry bulb temperature of 65–80°C. Kiln-drying 25 mm thick boards of *D. nidulum* wood from green to 12% moisture content takes 3–4 days and 50 mm thick boards take about 2 weeks; the timber can also easily be air dried under cover. A high humidity treatment should be given, to relieve stresses, but when considerable twist occurs, a saturated steaming treatment for 2–4 hours should be given instead. The wood is stable in service.

Dacrydium timber is easy to saw and works well with hand and machine tools. The wood planes and turns well to a smooth surface and takes a high polish. Gluing, nailing and peeling properties of *D. elatum* are satisfactory. *D. nidulum* is not suitable for face veneer, as it may buckle during drying. Sawdust of *D. nidulum* may cause irritation to nose and throat.

Sempilor is classified as non-durable when used in contact with the ground or exposed to the weather in the lowland tropics. At higher elevations or in a temperate climate, however, it is considered fairly durable. It is susceptible to termite and marine borer attack. *D. nidulum* is resistant to decay and termites, but susceptible to pinhole borer attack. Sempilor is not susceptible to *Lyctus* attack. The sapwood is probably moderately resistant to impregnation but the heartwood is resistant.

D. beccarii wood contains 53% cellulose, 29.2%

lignin, 18.1% pentosan, 0.6% ash and 0.4% silica. The solubility is 5.6% in alcohol-benzene, 3.3% in cold water, 6.8% in hot water and 15.2% in a 1% NaOH solution. The energy value of *D. beccarii* wood is 17 320 kJ/kg.

The volatile oil that can be distilled from the wood consists largely of cedrene and cedrol.

Description Usually dioecious, evergreen, small to fairly large trees up to 40 m tall, or less often shrubs; bole cylindrical, up to 70(–100) cm in diameter; bark surface hard and smooth with fissures, breaking off in plates, with many small lenticels, dark or reddish-brown and weathering to grey; branches often ramified, often curving upwards and the ultimate branches aggregated into dense tufts. Leaves arranged spirally, variable, from small appressed scales to linear or needle-like, straight to strongly incurved at the tip, tetragonal in cross section or keeled on the dorsal side and flat or concave on the upper surface, blunt to narrowly acute; juvenile leaves spreading at about 75° and bent forward in a gradual curve, lanceolate or linear-lanceolate, strongly keeled on the dorsal side, generally longer and more slender than the mature leaves. Fertile structure terminal or lateral or on short lateral branches. Pollen cone solitary or clustered, cylindrical, with sterile vestigial leaves at the base; microsporophyll with a triangular or marked lanceolate apex. Seed-bearing structure usually solitary, with slightly enlarged scale-like bracts or with leaf-like bracts at the base, the entire structure often becoming enlarged, fleshy and red when mature; ovule solitary, with a slightly to distinctly inverted apex gradually turning up as the seed develops. Seed ovoid, laterally keeled, dark brown.

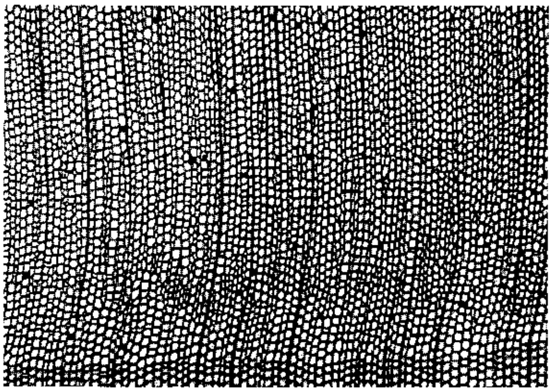
Wood anatomy

– Macroscopic characters:

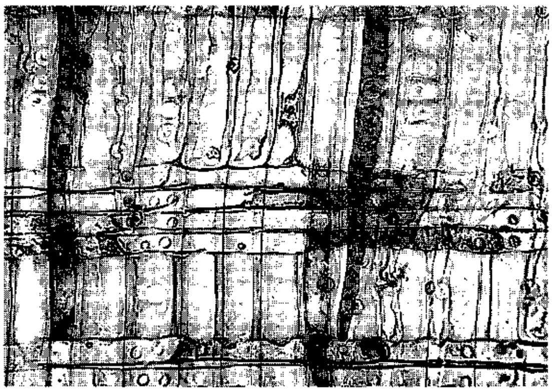
Heartwood yellow-brown, pinkish-yellow, golden, pale brown to brown or red-brown, not always clearly demarcated from the paler sapwood. Grain straight, texture fine and even; wood with little or no figure, occasionally with fine darker streaks, with little or no lustre. Growth rings generally indistinct; diffuse parenchyma rarely evident to the naked eye; rays very fine, not visible to the naked eye.

– Microscopic characters:

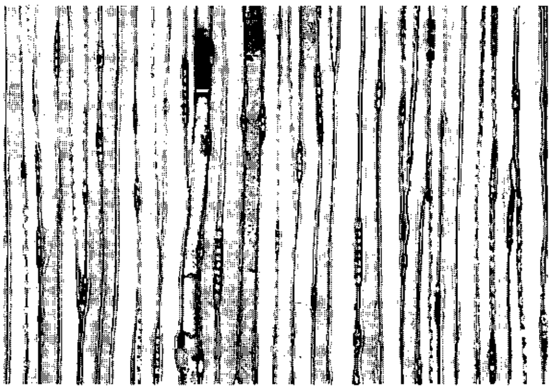
Growth rings barely marked, tracheid wall thickness in latewood little different from that in earlywood. Tracheids square, rounded, polygonal to irregular in cross-section, radially aligned, tangential diameter approximately 40–55 μm, 3–5 mm long; intertracheid pits mainly in radial walls,



transverse section (×25)



radial section (×150)



tangential section (×75)

Dacrydium elatum

usually in 1 row, sometimes opposite and paired, loosely scattered, moderately large (16–20 μm in diameter), rounded, sometimes flattened axially; smaller pits on tangential walls in latewood, tracheids loosely scattered. Parenchyma diffuse, scattered uniformly singly or in small groups, moderately abundant to abundant, end walls thin and smooth. Rays 4–8/mm, predominantly uniseriate, biseriate rays rare, (1–)6–15(–20) cells high, end walls smooth; ray-tracheid pits half-bordered, taxodioid to cupressoid, medium-sized, 12–15 μm in diameter, 1–2 per crossfield, crossfields of marginal cells sometimes containing somewhat larger pits, often with a markedly reduced border. Ray tracheids absent, resin ducts absent. Reddish-brown extraneous material abundant in parenchyma cells, less in ray cells.
Species studied: *D. beccarii*, *D. elatum*, *D. nidulum*.
Wood of *Agathis*, *Dacrycarpus*, *Falcatifolium*, *Nageia*, *Phyllocladus*, *Podocarpus* and *Prumnopitys* can resemble *Dacrydium*. *Agathis* differs from the other genera by having alternate intertracheid pits. In *Phyllocladus* and *Prumnopitys*, parenchyma is absent. *Dacrycarpus*, *Falcatifolium*, *Nageia* and *Podocarpus* are very similar to *Dacrydium*, although in *Dacrycarpus* the rays are somewhat higher.

Growth and development Root nodules have been observed in *Dacrydium*, but it is unknown whether these fix nitrogen.

Other botanical information *Dacrydium* is thought to be closely related to *Falcatifolium* because of the similarity in their seed-bearing structure but the latter is easily distinguished by its bilaterally flattened leaves. Some species of *Dacrydium* show similarities with those of *Halocarpus*. The small genera *Lagarostrobus* and *Lepidothamnus*, incorporating some Tasmanian, New Zealand and Chilean species, are sometimes separated from *Dacrydium*.
D. cupressinum Sol. ex J.G. Forster is a fairly well-known and valuable timber tree in New Zealand.

Ecology *Dacrydium* generally occurs in primary rain forest. It is a canopy tree and usually occurs scattered but is sometimes common and dominant or might even be present in pure stands. It has a preference for boggy or peaty locations. Some of the species occur in the lowland down to sea-level, but the majority are found on hills and mountains at 600–2500(–2700) m altitude.

Propagation and planting *Dacrydium* can be propagated by seed, wildlings or cuttings. Fruits are macerated carefully to remove the fleshy receptacles. Seed should be graded by flotation, discarding empty ones, and sown in nursery beds immediately after collection. In *D. comosum* Corner, a shrub of montane forest in Peninsular Malaysia, 8% of the seed germinate in 16–52 weeks. The nursery beds must be shaded, as seedlings do not thrive in full light. In Peninsular Malaysia planted wildlings of *D. elatum* succeed under favourable weather conditions.

Silviculture and management *D. elatum* is a light-demander. Natural regeneration is abundant in gaps, but is sparse elsewhere. It responds very well to liberation thinning, when not too intensive. Regeneration of pure stands of *D. pectinatum* in Sabah and Sarawak after exploitation proved very difficult, due to the nearly complete removal of all mother trees.

Diseases and pests The mistletoe *Korthalsella dacrydii* (Ridley) Dans. has been observed on *Dacrydium*, but is probably insignificant.

Harvesting Logs of *D. elatum* as small as 25 cm in diameter are exploited in Sarawak. Exploitation of timber for construction purposes in remote, mountainous areas is common.

Yield A high timber volume of *Dacrydium* and *Falcatifolium falciforme* (Parl.) de Laubenf. trees over 50 cm in diameter was found in Riau (14.4 m^3/ha) and in East Kalimantan (5.6 m^3/ha). The volume of these species with a diameter of 10 cm or more is estimated at 17.1 m^3/ha in Central Kalimantan and is a resource for pulp and paper manufacture.

Genetic resources Species such as *D. beccarii* and *D. elatum* occur gregariously and widespread and are not liable to genetic erosion. Pure stands of *D. pectinatum*, a species only locally common in Sabah and Sarawak on isolated patches of sandy podzol in peat swamp, have been almost completely logged; this species is vulnerable to genetic erosion.

Prospects Supply of *Dacrydium* timber to the market is decreasing due to over exploitation and inherent poor regeneration. The excellent quality of the timber, however, justifies increased efforts to achieve proper forest management and plantation establishment.

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Selection of species

Dacrydium beccarii Parl.

DC., Prodr. 16(2): 494 (1868).

Vernacular names Indonesia: kayu embun (Kalimantan), sampinur tali (Sumatra). Malaysia: ekor kuda, ekor tupai (Peninsular), sempilor (Sarawak). Papua New Guinea: netukuria (New Britain), mejoop (Kebar), kawau (Taliabu). Philippines: lokinai (Subanon).

Distribution Peninsular Malaysia, Sumatra, Borneo, central Sulawesi, the southern Moluccas, the Philippines (but not in Luzon), New Guinea and the Solomon Islands.

Uses The wood is used as sempilor. A volatile oil can be distilled from the wood.

Observations A shrub or small to medium-sized tree up to 20(–40) m tall, bole up to 70 cm in diameter, branches curved upward, forming an umbrella-like crown; adult leaves spreading, linear-lanceolate, triangular in cross section, 5–10 mm × 0.3–0.4 mm, 0.2 mm thick; apex of microsporophyll a lanceolate spur c. 1 mm long; seed not completely covered by subtending bracts, c. 4 mm long. *D. beccarii* is common on mossy ridges where it is often dominant. It occurs on a variety of soils at 600–2500 m altitude. The density of the wood is 470–710 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 104, 115, 117, 129, 140, 162, 189, 230, 231, 268, 404, 474, 589, 705.

Dacrydium cornwalliana de Laubenf.

Fl. Malesiana, ser. I, 10: 366 (1988).

Synonyms *Dacrydium nidulum* de Laubenf. var. *araucarioides* de Laubenf. (1969).

Distribution Western and central New Guinea.

Uses The wood is probably used as sempilor.

Observations A medium-sized tree up to 30 m tall, crown elongated; adult leaves spreading but incurved towards the tip, linear-lanceolate, strongly keeled on the back and slightly concave and slightly keeled on the ventral side, 2–5 mm × 0.6–0.8 mm, 0.3–0.4 mm thick; apex of microsporophyll triangular; apex of mature seed extending beyond cone bracts, seed c. 5 mm long. *D. cornwalliana* is locally dominant or occurs in pure stand in swamp forest at 1450–2300 m altitude.

Selected sources 127, 162.

Dacrydium elatum (Roxb.) Wallich ex Hook.

Journ. Bot., Lond. 2: 144, t. 2 (1843).

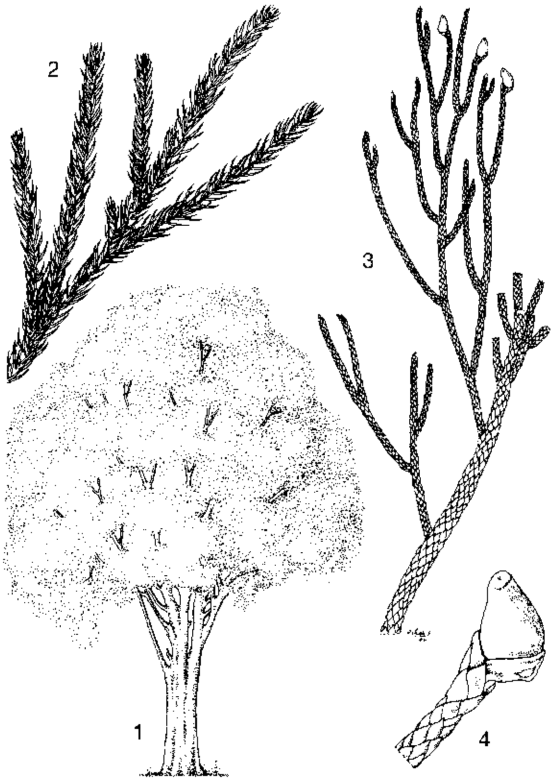
Synonyms *Dacrydium junghuhnii* Miq. (1851), *Dacrydium pierrii* Hickel (1930), *Dacrydium beccarii* Parl. var. *subelatum* Corner (1939).

Vernacular names Indonesia: cemara gunung, sampinur tali, sangur (Sumatra). Malaysia: ekor kuda, ru bukit (Peninsular), melor (Sarawak). Philippines: lokinai. Burma (Myanmar): taw-kyet-gale-pan. Thailand: samphanpi (north-eastern), son-hangkarok (central), phayamakhampom (south-eastern). Vietnam: hoang dan.

Distribution Burma (Myanmar), Cambodia, Laos, Vietnam, Thailand, Peninsular Malaysia, Sumatra and western Borneo.

Uses *D. elatum* is probably the main source of sempilor timber in South-East Asia. A volatile oil can be distilled from the wood.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 100 cm in diameter, crown a large billowy dome with tufts of more or



Dacrydium elatum (Roxb.) Wallich ex Hook. – 1, tree habit; 2, young twig; 3, mature twig with seeds; 4, top of twig with seed.

less erect branchlets; adult leaves imbricate, triangular and scale-like, sharply keeled outside, 1–1.5 mm × 0.4–0.6 mm; apex of microsporophyll triangular; mature seed completely exposed above the short cone bract, 4–4.5 mm long. *D. elatum* generally occurs scattered in moist rain forest at (0–)300–1700 m altitude. It is often associated with *Podocarpus* spp. and *Agathis* spp. The density of the wood is 425–720 kg/m^3 at 15% moisture content.

Selected sources 47, 69, 71, 77, 78, 104, 115, 117, 127, 135, 140, 162, 166, 189, 213, 222, 234, 289, 404, 474, 527, 575, 676, 705, 744.

Dacrydium nidulum de Laubenf.

Journ. Arn. Arb. 50: 292, fig. 3a (1969).

Vernacular names Indonesia: kwennum (Maibrat, Arfak Mountains), samiampi (Roberbai, Yapen Island), uier (Itik, Hollandia).

Distribution Central and south-eastern Sulawesi, Sumba, Halmahera, throughout New Guinea and Fiji.

Uses The wood is probably used as sempilor.

Observations A medium-sized tree up to 30 m tall, bole up to 50 cm in diameter, crown dense, with numerous branchlets; adult leaves spreading, not crowded, nearly straight to distinctly curved, linear-lanceolate, triangular in cross section and strongly keeled on the back, 1–5 mm × 0.3–0.7 mm, 0.2–0.3 mm thick; apex of microsporophyll triangular; mature seed just overtopping the cone bracts, 3.5–4 mm long. *D. nidulum* occurs as a canopy tree in primary or sometimes secondary rain forest from sea level up to 600(–1200) m altitude. The density of the wood is 600–620 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 61, 115, 127, 145, 162, 189, 268, 289.

Dacrydium pectinatum de Laubenf.

Journ. Arn. Arb. 50: 289, fig. 1b–2 (1969).

Synonyms *Dacrydium pectinatum* de Laubenf. var. *robustum* de Laubenf. (1969).

Vernacular names Indonesia: melo (Natuna Islands), malur, cemantan (Kalimantan). Malaysia: sempilor (Sabah, Sarawak). Philippines: malasuklai (Tagalog).

Distribution Hainan, Borneo and surrounding islands, and the Philippines.

Uses The wood is probably used as sempilor.

Observations A medium-sized to fairly large tree up to 40 m tall, crown rounded, dense, with numerous branchlets; adult leaves spreading, slightly curved, linear-lanceolate, keeled on 4 sides, 2–5 mm × 0.4–0.8 mm, 0.4–0.8 mm thick; apex of microsporophyll triangular; mature seed exposed above short cone bracts, 4–4.5 mm long. *D. pectinatum* is fairly common in Borneo and occurs scattered in primary non-dipterocarp forest or in dense stands on boggy or sandy places, usually on poor soils, sometimes in heath forest or on ultrabasic soils from sea level up to 600(–1500) m altitude.

Selected sources 127, 129, 162, 189, 479.

Dacrydium xanthandrum Pilger

Bot. Jahrb. Syst. 69: 252 (1938).

Vernacular names Indonesia: arun gunung (Aceh, Sumatra). Malaysia: kerapui (Dusun, Sabah). Philippines: lokianai dilau (Luzon).

Distribution Peninsular Malaysia, northern Sumatra, Borneo, central Sulawesi, the Philippines, New Guinea, New Britain and Bougainville.

Uses The wood is probably used as sempilor.

Observations A shrub to medium-sized or fairly large tree up to 36 m tall, bole up to 70 cm in diameter; adult leaves spread widely, straight or slightly curved, lanceolate to linear-lanceolate, 6–10 mm × 0.5–0.8 mm, 0.2 mm thick; apex of microsporophyll a lanceolate spur of 0.6–1.2 mm long; mature seed exposed above short cone bracts, c. 4 mm long. Larger individuals of *D. xanthandrum* occur scattered in primary forest on mossy ridges or peaty soils overlying clay, sand, sandstone or granite at (500–)1000–2700 m altitude.

Selected sources 117, 127, 129, 162, 189, 705.

H.C. Ong (general part),
E. Boer (properties),
J. Ilic (wood anatomy),
M.S.M. Sosef (selection of species)

Dillenia L.

Sp. pl. 1: 535 (1753); Gen. pl. (Ed. 5): 239 (1754).
DILLENIACEAE

x = unknown; *D. indica*: n = 28, $2n$ = 24, 54, *D. ovata*: $2n$ = 32, 48, *D. pentagyna*: n = 13, *D. suffruticosa*: $2n$ = 26

Trade groups Simpoh: medium-weight to heavy hardwood, e.g. *Dillenia excelsa* (Jack) Gilg, *D. grandifolia* Wallich ex Hook.f. & Thomson, *D. papuana* Martelli, *D. pentagyna* Roxb., *D. pulchella* (Jack) Gilg, *D. reticulata* King.

Vernacular names Simpoh. Brunei: simpor. Indonesia: simpur, sempur. Malaysia: simpor (Sabah). Philippines: katmon (general). Burma (Myanmar): zinbyum, mai-masan. Cambodia: 'san. Thailand: san, masan. Vietnam: s[oof].

Origin and geographic distribution *Dillenia* consists of about 60 species and is distributed from Madagascar and the Seychelles, north to the Himalayas and southern China, throughout South-East Asia and east to the Fiji Islands and Australia. The Philippines is richest in species (12, 10 endemic), followed by Peninsular Malaysia and New Guinea (each 10, 6 endemic in New Guinea and 1 endemic in Peninsular Malaysia), Borneo, Sumatra and Thailand (each 9, 2 endemic in Borneo), Burma (Myanmar) and Indo-China (each 8, 2 endemic in Burma (Myanmar) and 1 endemic in Indo-China). *D. indica* and *D. pentagyna* have the largest areas of distribution (from India and southern China to Borneo for *D. indica*, and from India and southern China to Thailand and in eastern Java, the Lesser Sunda Islands and southern Sulawesi for *D. pentagyna*).

Uses Simpoh timber is suitable for general construction, posts, beams, joists, rafters, doors, window frames and sills, stairs, flooring, ceilings, decorative wall panelling, furniture, mouldings, frames and bottom boards of boats, vans, fancy boxes, package, pallets, structural grade plywood and sliced veneers. Quarter-sawn boards usually show a beautiful grain and may be used for decorative items. Although the wood is not durable under tropical conditions, it is easy to treat with preservatives and then suitable for all medium-heavy construction and also for sleepers and pilings. It used to be used for dunnage as a substitute for keruing (*Dipterocarpus* spp.). Several species yield a good quality charcoal.

The indehiscent fruits of some species are eaten either cooked or uncooked in jellies and curries; the taste is usually slightly acid.

Trees of *D. indica*, *D. obovata*, *D. ovata* and *D. suffruticosa* (Griffith) Martelli are widely planted as ornamental, the last species especially because of its attractive flowers and fruits produced throughout the year.

The bark yields an extract which has astringent properties and a red dye. The bark has also been used medicinally against boils.

Production and international trade Simpoh has some importance as export timber in Sabah and Papua New Guinea. In 1992, the export from Sabah was 15 000 m^3 (24% as sawn timber) with a total value of US$ 1.4 million. In Papua New Guinea, *Dillenia* wood is traded in MEP (Minimum Export Price) group 4; in 1992 it fetched a minimum price of US$ 43/m^3 for logs. Japan imports simpoh timber mainly from Papua New Guinea and the Solomon Islands. In 1987, simpoh accounted for about 5% of the total timber import in Japan from Papua New Guinea, and for about 10% of that from the Solomon Islands.

Properties Simpoh is a medium-weight to heavy hardwood. The heartwood is red-brown to dark reddish-brown, sometimes with a purplish tinge, and usually indistinctly demarcated from the slightly paler sapwood. Quarter-sawn wood may have an attractive silver grain figure. The density is 560–930 kg/m^3 at 15% moisture content. The grain is straight or, more usually, interlocked, texture moderately coarse and even.

At 12% moisture content, the modulus of rupture is 86–102 N/mm^2, modulus of elasticity 11 100–17 440 N/mm^2, compression parallel to grain 38–49 N/mm^2, compression perpendicular to grain 10.5–12 N/mm^2, shear 9–14 N/mm^2, Janka side hardness 4050–6530 N and Janka end hardness 8035–8830 N.

The rates of shrinkage of simpoh are fairly high to high: in Malaysia from green to 15% moisture content c. 2.2% radial and 3.9% tangential and from green to oven dry 4.1–5.2% radial and 8.8–9.6% tangential; for simpoh wood from Papua New Guinea, shrinkage values of 3.0% radial and 12.0% tangential from green to oven dry are reported. Experiments in Malaysia showed that radial boards of *D. grandifolia* air dry without difficulty, but tangential board cupped fairly badly and some showed slight twisting, bowing and end and surface checking; end splitting may be severe, and sawn material tends to spring immediately after sawing. It takes about 4 months to air dry boards 15 mm thick; 40 mm thick boards dry in about 5 months. For kiln drying, a temperature of 40.5–65.5°C is recommended with corresponding relative humidity of 85% to 40% (kiln schedule C in Malaysia). Wood from *D. papuana* is difficult to kiln dry as it easily deforms; a mild kiln schedule is recommended, drying the wood in about 7 days from green to 1% moisture content.

Wood of *D. grandifolia* is comparatively easy to saw, although the very fine sawdust tends to clog the saw. It is easy to plane, bore and turn, and finishes to a smooth surface, although slightly rough after boring. The nail-holding properties are often poor. Timber of *D. reticulata* was found to be suitable for the production of veneer and plywood in a test in Malaysia, but tests with *D. grandifolia* in Indonesia showed that the peeled veneers of 1.5 mm thick (without pretreatment at a 91° peeling angle) become wavy after drying, although gluing with urea-formaldehyde produces plywood complying with the Japanese standard. Tests in Malaysia showed that wood of *D. grandifolia* is suitable for the production of concrete shuttering and it meets the Japanese standard for structural plywood with regard to bending strength and stiffness value. Tests in Korea on pulping characteristics of simpoh wood from Kalimantan and Papua New Guinea showed that the wood is not suitable for this purpose, and in India it has been found that wood of *D. pentagyna* showed considerable variation in fibre length and wood density both within and between trees, which makes it less suitable for pulping. *D. papuana* wood is suitable for making cement board.

Simpoh is classified as non-durable to moderately durable. Test sticks of *D. grandifolia* in Malaysia were destroyed within one year when partly buried in the ground. The wood is susceptible to dry-wood termites, blue stain and wood-rotting fungi, but *D. reticulata* wood is moderately resistant to fungi. Wood of *D. grandifolia* is fairly easy to treat with preservatives; it absorbs 105–130 kg/m^3 of an equal mixture of creosote and diesel fuel when using the open tank method.

Wood of *D. grandifolia* contains 50% cellulose, 31% lignin, 14% pentosan and 1.0% ash. The solubility is 0.6% in alcohol-benzene, 2.3% in cold water, 4.6% in hot water and 17.0% in a 1% NaOH solution. *D. papuana* wood contains 78% holocellulose, 29% lignin, 8% pentosan and 2.0% ash. The solubility is 1.5% in alcohol-benzene. The wood of some species (e.g. *D. pentagyna*) contains saponins. The wood is often suitable for charcoal manufacture, with high energy value, e.g. 32 200 kJ/kg for *D. papuana*.

Description Evergreen or deciduous shrubs or small to fairly large trees up to 40(–50) m tall; bole up to 125(–200) cm in diameter, often with steep buttresses, sometimes buttresses absent, stilt roots often present; bark surface smooth becoming slightly fissured, flaky or papery scaly, often reddish-brown, sometimes greyish-brown, inner bark fairly thick and fibrous, usually hissing when cut and with copious watery exudate, pinkish-red to brownish-red, with fine radial lines; branching often sympodial but sometimes monopodial, twigs stout, with prominent horseshoe-shaped leaf scars. Leaves arranged spirally, simple, entire, toothed or undulate at margin, usually prominently pinnately veined, petiole often with wings, either caducous and amplexicaul or persistent and not completely amplexicaul; stipules absent. Flowers in axillary or terminal racemose inflorescences or solitary, often large and showy, pedicellate, (4–)5(–6)-merous; sepals free, generally fleshy and concave, persistent in fruit; petals free but sometimes not spreading and falling as a whole, caducous, white or yellow, sometimes absent; stamens numerous, usually free, anthers opening by pores or longitudinal slits, sometimes staminodes also present; carpels 4–20, joined at base and arranged in a whorl around a more or less distinct protruding part of the receptacle, each carpel with 4–numerous ovules. Fruit consisting of several follicles and enclosed by the enlarged fleshy sepals (a pseudocarp), remaining closed or splitting open as a star. Seeds arillate (in species with dehiscent fruits), or not arillate (in most species with indehiscent fruits), with dark brown to black, leathery or bony seed-coat, thick endosperm and very small embryo. Seedling with epigeal germination, taproot weak and its function is soon taken over by vigorous adventitious roots; leafy cotyledons, leaves arranged spirally.

Wood anatomy

– Macroscopic characters:

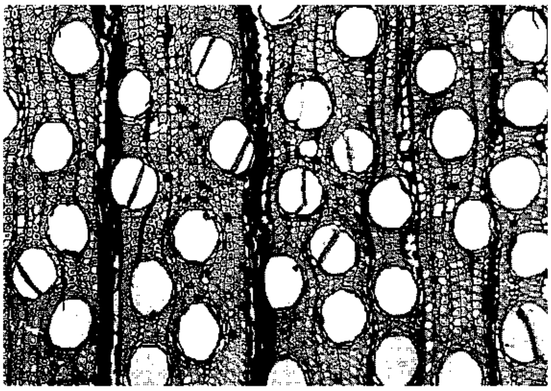
Heartwood red-brown to dark red-brown, sometimes with a definite purplish tinge; sapwood yellowish on the outside and gradually becoming pinkish or orange near the heartwood and usually not sharply defined. Grain interlocked, sometimes straight. Texture moderately coarse to coarse and even; figure prominent particularly on quartersawn surfaces due to darker wide rays. Growth rings not evident; vessels moderately large and distinct to the naked eye, evenly distributed, with scattered presence of white chalky deposits; parenchyma sparse to moderately abundant; rays of two sizes, the larger rays easily visible to the naked eye, conspicuous on radial surface; ripple marks absent.

– Microscopic characters:

Growth rings inconspicuous, but clear annual rings reported for *D. indica*. Vessels diffuse, 3–9/mm², predominantly solitary (c. 95%), rarely in radial pairs, round to occasionally oval, often angular, (110–)130–240 μm in tangential diameter; perforations scalariform with 5–40 bars; intervessel pits sparse, opposite and scalariform, rarely alternate, mainly found in overlapping ends of vessel tips, 12–20 μm in diameter, non-vestured; vessel-ray pits large, half-bordered, with elongated apertures, oblique to horizontal; helical thickenings absent; scattered chalky deposits present; tyloses scarce. Fibres 1.7–3.7 mm long, non-septate, thick-walled, with distinctly bordered pits mainly in the radial walls. Parenchyma sparse to moderately abundant, mainly apotracheal, diffuse to diffuse-in-aggregates, in 4–8-celled strands. Rays c. 2–3/mm, of 2 distinct sizes, uniseriate and (2–)3–15(–20)-seriate, 4–10 mm (up to 100 cells) high, heterocellular with 3–6 rows of upright cells (Kribs type heterogeneous II), central portion of multiseriate rays made up of procumbent to square cells, uniseriate rays made up of upright cells. Raphides infrequent and scattered in enlarged cells (idioblasts) in ray and parenchyma cells. Silica absent. Extraneous reddish-brown deposits sparse to abundant in ray and parenchyma cells.

Species studied: *D. excelsa*, *D. grandifolia*, *D. indica*, *D. philippinensis*, *D. pulchella*, *D. salomonensis* (C.T. White) Hoogl., *D. schlechteri*.

Keruing (*Dipterocarpus*) wood, particularly heartwood with a purplish cast, can sometimes exhibit a superficial appearance to simpoh. However, sim-



transverse section (×25)

radial section (×75)

tangential section (×75)

Dillenia grandifolia

poh can easily be identified by having rays of two sizes and conspicuous radial divisions in the pores along with the distinctive chalky white deposits.

Growth and development The seedling has a weak taproot and its function is soon taken over by adventitious roots from the hypocotyl and stem which may later develop into prominent stilt roots in mature trees. Saplings do not branch for a long time and have larger leaves than mature trees. The apical bud is protected by the base of an unexpanded leaf. *D. pentagyna* and *D. indica* trees have Scarrone's model of tree architecture, with an indeterminate trunk bearing tiers of branches, each branch complex is orthotropic and sympodially branched as a result of terminal flowering.

Mean annual diameter increments of over 0.8 cm have been reported for *D. grandifolia*, but other species grow slower, e.g. about 0.3 cm/year in diameter for *D. obovata* and *D. ovata*. Trees of *D. grandifolia* planted in an arboretum in Malaysia reached a diameter of 62 cm in 45 years and a height of 28 m. In India, it was calculated that trees of *D. pentagyna* take over 200 years to reach a diameter of 60 cm with fastest annual diameter increment of 0.3–0.4 cm/year for diameter classes ranging from 51–90 cm.

Several species are deciduous, e.g. *D. grandifolia*, *D. obovata*, *D. pentagyna* and *D. reticulata*. The flowers are borne before or after the new leaves develop. However, most species in Malesia are evergreen. *D. indica* is known to flush once a year; new leaves start to flush at about the same time that most old leaves abscise (a 'leaf-exchanging' species).

The arillate seeds of simpoh species with dehiscent fruits are eaten and dispersed by birds. Indehiscent fruits are eaten mainly by mammals such as elephants, monkeys, pigs and squirrels. Fruits are sometimes dispersed by water (e.g. *D. indica*).

Other botanical information Species with dehiscent fruits and arillate seeds were formerly considered as belonging to the separate genus *Wormia*. However, some species with indehiscent fruits also have arillate (although rudimentary) seeds (e.g. *D. reticulata*), a condition which is regarded as derived.

D. salomonensis (C.T. White) Hoogl. is a large tree from the Solomon Islands the wood of which is exported.

Ecology Simpoh is found in lowland and hill dipterocarp forest, swamp to semi-swamp forest and old secondary forest, generally below 1000 m altitude, but some species occur up to 2000 m (e.g. *D. montana* Diels in Papua New Guinea). *D. pentagyna* is confined to regions with a distinct dry period.

Propagation and planting The seed weight is only reported for *D. pentagyna*: 1 kg contains about 58 500 dry seeds. The heavy, fleshy and indehiscent fruits of some species such as *D. philippinensis* can be collected from the ground, but in general fruits containing many small seeds need to be collected from the tree. After extraction by maceration, seed should not be allowed to dry out before sowing. The duration of the period before germination varies with the species. Generally, germination is poor. Seed of *D. excelsa* germinates after only 5–9 days, there is 35% germination of *D. sumatrana* seed in 1.5–4 months, and of *D. grandifolia* after 2.5–11 months; there is 1–25% germination of *D. ovata* in 3–9.5 months, 60% germination of *D. reticulata* in 2–12 months and only 6% of the seeds of *D. obovata* germinate in 7.5–14.5 months. Whole fruits may also be planted, as was shown in experiments with *D. ovata* in Malaysia in which germination was 70%, but the period of germination is very long and ranges from 1.5–10 months. Planting stock can also be produced from wildlings.

Silviculture and management Most *Dillenia* species are referred to as long-lived pioneer or late secondary species. *D. suffruticosa*, however, is a real pioneer species and can be found in clearings and forest fringes. Both *D. indica* and *D. salomonensis* can stand shade very well; vigorous saplings have been found in dense shade. However, *D. pentagyna* is a light-demanding species in the conditions prevailing in India. Natural regeneration is generally sufficient in natural forest and simpoh can compete successfully with fast-growing secondary forest species. Rather abundant natural regeneration of *D. grandifolia* was observed in 18-month-old industrial plantations of *Acacia mangium* Willd. and *Eucalyptus deglupta* Blume in East Kalimantan. It was considered appropriate to combine the natural regeneration with that of other long-lived pioneers to fill gaps in industrial plantations. Small species of simpoh may be regarded as a weed in silvicultural operations, because of their heavy crowns. Some species coppice freely.

Harvesting Trees are usually sound, but logs may split very badly soon after felling. Simpoh species from peat-swamp forest are among those producing more durable wood and are used for bearers in logging railways.

Yield Simpoh usually occurs not abundantly and scattered. In Peninsular Malaysia, on average about 1 tree of commercial size per 3 ha is found, although locally in secondary bamboo forest more than 1 tree per ha may be found.

Genetic resources Many *Dillenia* species are local endemics, especially in the Philippines and New Guinea, and seem to be at risk of genetic erosion or even extinction. An example is *D. celebica*, the wood of which is locally used in Sulawesi without additional planting.

Prospects Simpoh may have good prospects for commercial timber exploitation from plantations. The wood is decorative and can be used for many purposes; it is generally non-durable but easy to treat with preservatives. At least a few species (e.g. *D. grandifolia*) are fast growing. However, more research is needed, especially on methods of propagation and preservative treatment of the wood.

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Selection of species

Dillenia alata (R.Br. ex DC.) Martelli

Becc., Malesia 3: 157 (1886).

Synonyms *Wormia alata* R.Br. ex DC. (1817).

Distribution Waigeo Island, southern New Guinea and Queensland (Australia).

Uses The timber is used as simpoh, e.g. for furniture.

Observations A medium-sized evergreen tree up to 20 m tall, with bole up to 60 cm in diameter, bark surface peeling off in thin papery flakes, reddish-brown, branches crooked; leaves ovate to elliptical, (5–)8–25(–35) cm × (3.5–)5–15(–20) cm, margin entire, slightly recurved, petiole up to 4 cm long, with 2–6 mm broad wings amplexicaul at base and partly caducous; flowers c. 7.5 cm in diameter, sepals 5, petals yellow, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by pores; fruit dehiscent; seed enclosed by whitish aril. In New Guinea *D. alata* is found in savanna forest. The wood is dark red and easy to work.

Selected sources 162, 243, 289.

Dillenia auriculata Martelli

Becc., Malesia 3: 159 (1886).

Synonyms *Wormia auriculata* Gilg & Werderm. (1925).

Distribution New Guinea.

Uses The timber is reputed to be used as simpoh.

Observations A slender medium-sized evergreen tree up to 30 m tall, bark surface flaky, reddish-brown; leaves oblong, (4–)7–16(–21) cm × (2–)3–7(–9) cm, margin entire to slightly undulate, petiole up to 5 cm long, with up to 7 mm broad wings amplexicaul at base and caducous except for 2 small auricles below the blade; flowers 8–10 cm in diameter, sepals 5, petals yellow, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by pores; fruit unknown. *D. auriculata* occurs in lowland forest along rivers, in flood plains and on ridges.

Selected sources 145, 162, 243.

Dillenia bolsteri Merr.

Philipp. Journ. Sci., Bot. 7: 305 (1912).

Synonyms *Dillenia cauliflora* Merr. (1915).

Vernacular names Philippines: Bolster katmon (general).

Distribution The Philippines (Samar, Leyte, Mindanao).

Uses The timber is reputed to be used as simpoh.

Observations A medium-sized evergreen tree up to 20 m tall; leaves elliptical-oblong to ovate, (8–)10–25(–30) cm × 4–11(–12.5) cm, margin slightly dentate, petiole up to 4.5 cm long, with 4–6 mm broad wings amplexicaul at base and completely caducous; flowers in cauline inflorescences, c. 6 cm in diameter, sepals 5, petals whitish, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by pores; fruit indehiscent; seed without aril. *D. bolsteri* occurs in primary forest at low altitude.

Selected sources 162, 243, 426.

Dillenia borneensis Hoogl.

Blumea 7: 80, fig. 9 e–h (1952).

Vernacular names Indonesia, Malaysia: simpur (general), geriga, riga, rogung (Dayak). Malaysia: simpoh bulu (Sarawak), simpoh gajah, rakau (Sabah).

Distribution Borneo.

Uses The timber is reputed to be used as simpoh.

Observations A medium-sized to fairly large deciduous tree up to 40 m tall, with bole up to 70 cm in diameter having stilt roots; leaves elliptical, elliptical-oblong or obovate, (12–)25–40 cm × (7.5–)12–20 cm, margin minutely undulate-dentate, petiole up to 9 cm long, densely hirsute above, with 1–3 mm broad non-amplexicaul wings; flowers c. 6 cm in diameter, sepals 5, petals yellow, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by longitudinal slits; fruit unknown. *D. borneensis* occurs in primary and secondary forest at low altitude.

Selected sources 69, 77, 99, 162, 243.

Dillenia castaneifolia (Miq.) Diels

Bot. Jahrb. Syst. 57: 438 (1922).

Synonyms *Wormia castaneifolia* Miq. (1868).

Vernacular names Indonesia: usang, wesang (Irian Jaya).

Distribution New Guinea, Yapen, Korido.

Uses The timber is reputed to be used as simpoh.

Observations A medium-sized evergreen tree up to 20 m tall, with bole up to 50 cm in diameter; leaves oblong to elliptical-oblong, (8–)13–20(–30) cm × (3–)6.5–12(–18) cm, margin entire to slightly dentate, petiole up to 6 cm long, with 4–7 mm broad wings amplexicaul at base and completely caducous; flowers 6.5–9 cm in diameter, sepals 5, petals deep lemon-yellow, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by pores; fruit dehiscent; seed enclosed by aril. *D. castaneifolia* occurs in lowland forest (up to 200 m altitude), often along rivers, sometimes in swamps. The heartwood is pale brown.

Selected sources 12, 162, 243.

Dillenia celebica Hoogl.

Blumea 7: 24, fig. 3 c–e (1952).

Vernacular names Indonesia: njeher, rerer (Sulawesi).

Distribution Sulawesi.

Uses The timber is used in house building.

Observations A medium-sized evergreen tree up to 30 m tall, with bole up to 50 cm in diameter having small buttresses, bark slightly flaky, greyish-brown; leaves elliptical-oblong, (9–)13–18(–21) cm × (4.5–)6–10(–12) cm, margin undulate to dentate, petiole up to 7(–8) cm long, with 2–5(–10) mm broad wings amplexicaul at base, slightly auriculate at apex and completely caducous; flowers c. 4.5 cm in diameter, sepals 5, petals absent, stamens all subequal, anthers without acumen, opening by longitudinal slits; fruit unknown. *D. celebica* occurs only very locally up to 300 m altitude. The heartwood is greyish-red.

Selected sources 162, 243.

Dillenia diantha Hoogl.

Blumea 7: 57, fig. 7 (1952).

Vernacular names Philippines: katmon-kambal (general), magatali (Ibanag).

Distribution The Philippines (Luzon).

Uses The timber is used in house building, e.g. for beams and flooring.

Observations A medium-sized evergreen tree up to 25 m tall, with bole up to 60 cm in diameter; leaves ovate to oblong, (3.5–)6–12(–16) cm × (2–)4.5–7.5(–11) cm, margin slightly undulate to dentate, petiole up to 4 cm long, with 1–2 mm broad wings amplexicaul at base, rounded or auriculate at apex and completely caducous; flowers c. 9 cm in diameter, sepals 5, petals yellow, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by pores; fruit dehiscent. *D. diantha* has often been confused with *D. luzoniensis* Merr. (rare in Luzon), but it differs from the latter in the amplexicaul petiolar wings and, later, scars. It occurs in lowland forest up to 400 m altitude.

Selected sources 162, 243.

Dillenia excelsa (Jack) Gilg

Engl. & Prantl, Nat. Pflanzenfam. 3, 6: 123 (1893).

Synonyms *Wormia excelsa* Jack (1822), *Wormia oblonga* Wallich ex Hook.f. & Thomson (1855), *Wormia tomentella* Martelli (1900).

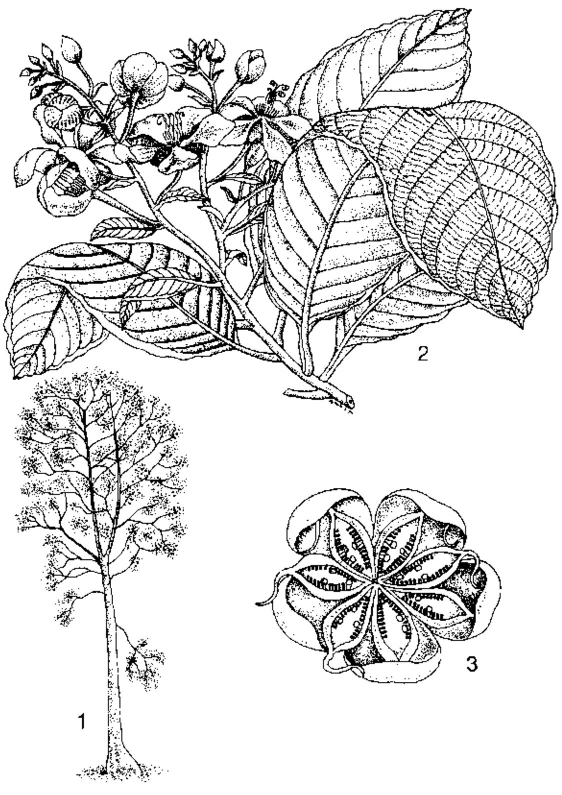
Vernacular names Indonesia: sempur segel (Sundanese, Java), simpur talang (Sumatra), kendikara (Kalimantan). Malaysia: simpoh ungu (Peninsular), simpoh laki (Sabah), simpur bukit, simpoh wangi (Sarawak). Philippines: katmon-layugan. Thailand: san-dam (Nakhon Si Thammarat), saen (Songkhla).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra, Bangka, western Java, Borneo and the Philippines (Balabac Island).

Uses The timber is used as simpoh, e.g. for house building. The tree is sometimes used as an ornamental or hedge plant, e.g. in Java. The leaves are used in local medicine.

Observations A medium-sized to fairly large evergreen tree up to 40 m tall, with bole branchless for up to 20 m and up to 75 cm in diameter, buttresses absent or small, bark surface fissured to papery scaly, greyish-brown; leaves elliptical to oblong, 15–30 cm × 7–10 cm, margin slightly undulate to dentate or entire, petiole up to 5 cm long; flowers 7–10 cm in diameter, sepals 5, petals bright yellow, stamens in 2 distinct groups, the inner ones larger, anthers purplish, without acumen, opening by pores; fruit dehiscent; seed enclosed at base by red aril. *D. excelsa* is variable in hairiness and subdivided into three varieties. It occurs commonly in lowland forest, in swampy areas and on hillsides. The dark reddish wood is comparatively heavy with a density of 650–1080 kg/m^3 at 15% moisture content and more durable than in other species.

Selected sources 12, 36, 69, 77, 99, 162, 234, 243, 404, 426, 463, 465, 498, 575, 705.



Dillenia excelsa (Jack) Gilg – 1, tree habit; 2, flowering twig; 3, dehisced fruit.

Dillenia grandifolia Wallich ex Hook.f. & Thomson

Fl. Ind. 1: 71 (1855).

Synonyms *Dillenia eximia* Miq. (1861), *Dillenia scortechinii* (King) Ridley (1910).

Vernacular names Indonesia: ampalu, mempelu, simpur kijang (Sumatra). Malaysia: simpoh daun merah, simpoh jangkong (Peninsular), simpoh lichin (Sarawak).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo.

Uses *D. grandifolia* is one of the most important simpoh timber-producing species, especially in Peninsular Malaysia and Sumatra.

Observations A fairly large deciduous tree up to 40 m tall, with straight bole branchless for up to 30 m and up to 75 cm in diameter having large buttresses up to 3 m high merging into stilt roots, bark surface smooth and finely lenticellate, greyish-brown or reddish-brown; leaves elliptical to obovate, (10–)15–25(–35) cm × (6–)9–15(–18) cm, margin undulate or serrate, petiole up to 7 cm long; flowers c. 2.5 cm in diameter, sepals 5, petals absent, stamens all of comparable length, anthers obtuse at apex, opening by pores; fruit indehiscent; seed with rudimentary aril. *D. grandifolia* is locally common in primary and old secondary lowland forest up to 300 m altitude. The density of the wood is 680–930 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 12, 69, 77, 140, 162, 243, 298, 377, 404, 458, 463, 466, 565, 575, 705.

Dillenia indica L.

Sp. pl. 1: 535 (1753).

Synonyms *Dillenia speciosa* Thunb. (1791).

Vernacular names Indonesia: simpur air (Sumatra, Java), sempur cai (Sundanese, Java), sempu (Javanese, Java). Malaysia: simpoh (Peninsular), simpoh kuning (Sarawak). Philippines: India katmon (general), handapara (Singhalese). Burma (Myanmar): thabyu. Cambodia: 'san. Thailand: matat (central), sompru (Surat Thani), sanpao (Chiang Mai). Vietnam: s[oof] b[af].

Distribution India, Sri Lanka, Burma (Myanmar), Indo-China, southern China, Thailand, Peninsular Malaysia, Sumatra, Java and Borneo; often cultivated as ornamental, sometimes outside the area of natural distribution, e.g. in the Philippines.

Uses The timber is used as simpoh, especially for interior construction. The wood is also used as firewood. The fruits are eaten in curries or jellies; mixed with sugar, they are used against coughs and rubbed in water as soap. The tree is often planted as an ornamental.

Observations A medium-sized to large evergreen tree up to 40 m tall, with often rather crooked bole branchless for up to 15 m and up to 120 cm in diameter (but often much less), buttresses absent or small, bark surface smooth but peeling off in small scales, orange-brown to dark orange; leaves oblong, (8–)15–30(–40) cm × (4–)6–12(–15) cm, margin slightly to distinctly dentate, petiole up to 10(–15) cm long; flowers 15–20 cm in diameter, sepals 5, petals white with green veins, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by pores; fruit indehiscent; seed without aril. *D. indica* occurs in evergreen forest or tropical rain forest, often along rivers, in Java especially in teak forest, up to 1100 m altitude. The density of the reddish wood is 560–650 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 36, 68, 69, 77, 78, 162, 216, 234, 243, 386, 575, 648, 705.

Dillenia megalantha Merr.

Philipp. Journ. Sci., Bot. 9: 519 (1914).

Synonyms *Dillenia mindanaensis* Elmer (1915).

Vernacular names Philippines: katmon-bayani (general).

Distribution The Philippines.

Uses The timber is reputed to be used as simpoh. The fruits are edible; they taste acid and are suitable for preserves.

Observations A medium-sized evergreen tree up to 20 m tall (rarely more), with bole up to 40 cm in diameter, bark surface peeling off in small and thin plates, brown and grey mottled; leaves oblong to oblanceolate, (20–)25–70(–100) cm × (6–)8–25(–35) cm, margin manifestly dentate, petiole up to 5(–7.5) cm long, with 1.5–3(–6) cm broad wings amplexicaul at base, completely caducous; flowers c. 20 cm in diameter, sepals 5(–6), petals yellow, stamens in 2 distinct groups, the inner ones larger, anthers rounded (rarely with acumen) at apex, opening by pores; fruit indehiscent; seed enclosed by thin aril. *D. megalantha* occurs in primary lowland forest, often along rivers, up to 1000 m altitude.

Selected sources 68, 162, 243, 414, 426, 527, 673.

Dillenia nalagi Hoogl.

Blumea 9: 581 (1959).

Distribution Papua New Guinea.

Uses The timber is reputed to be used as simpoh.

Observations A medium-sized evergreen tree up to 30 m tall, with short rather straight, often fluted bole up to 60 cm in diameter, bark surface papery flaky, dull red-brown; leaves ovate or obovate to elliptical-oblong, (18–)30–65(–80) cm × (10–)18–30 cm, margin undulate to shallowly dentate (in upper part of leaf), petiole up to 18(–25) cm long, with up to 18 mm broad wings obtuse at apex and completely caducous; flowers not expanding, sepals 5, petals yellow and falling off collectively without spreading, stamens gradually increasing in length towards the centre of the flower, anthers without acumen, opening by pores; fruit dehiscent; seed enclosed by fleshy white aril. *D. nalagi* occurs in lowland rain forest and regrowths up to 100 m altitude and is very locally common. The heartwood is reddish.

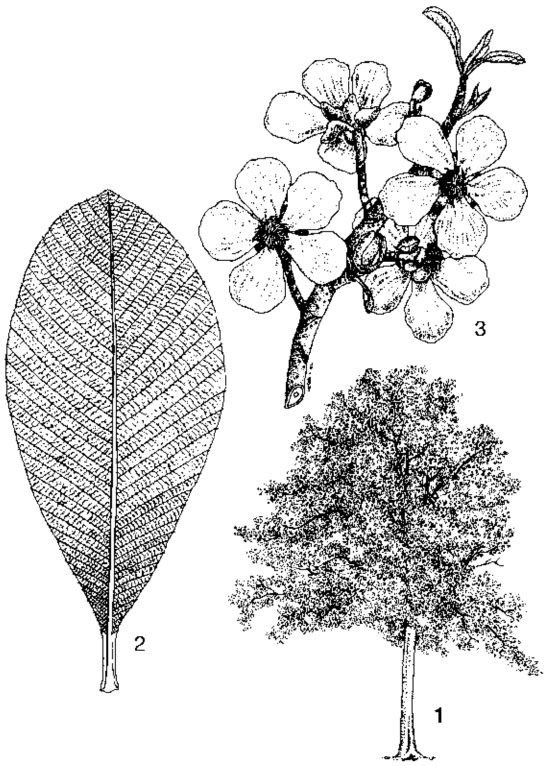
Selected sources 244.

Dillenia obovata (Blume) Hoogl.

Fl. Malesiana, ser. I, 4: 173, fig. 13 (1951).

Synonyms *Dillenia aurea* auct. non J.E. Smith.

Vernacular names Indonesia: simpur rimba, simpur talang (Sumatra), sempur batu (Sundanese, Java). Malaysia: simpoh padang, simpoh ayer (Peninsular). Burma (Myanmar): zinbyun, mai-san. Thailand: masan (south-eastern), sanyai, san-tong (peninsular).



Dillenia obovata (Blume) Hoogl. – 1, tree habit; 2, leaf; 3, flowering twig.

Distribution Southern Burma (Myanmar), Indo-China, eastern and southern Thailand, northern Peninsular Malaysia, southern Sumatra and western Java.

Uses The timber is sometimes used in house building. The fruits are eaten in curries. In Java, the bark and fruits are used in local medicine. The branches are locally used for fence posts, where they often root and sprout.

Observations A medium-sized to fairly large deciduous tree up to 35 m tall, with often rather crooked bole branchless for up to 14 m (but usually much less) and up to 70 cm in diameter, buttresses absent or small, bark surface rather smooth and flaky, yellowish-grey to reddish-grey; leaves obovate, (16–)20–40(–60) cm × (10–)12–20 (–26) cm, margin slightly dentate to nearly entire, petiole up to 4 cm long; flowers 14–16 cm in diameter, sepals 5, petals bright yellow, stamens in 2 distinct groups, the inner ones larger, anthers sharply emarginate at apex, opening by pores; fruit indehiscent; seed without aril. *D. obovata* is closely related to *D. aurea* J.E. Smith; the latter differs in having elliptical-oblong leaves and occurs in north-western India, Burma (Myanmar) and northern Thailand. *D. obovata* occurs in lowland deciduous or evergreen secondary forest, also in regrowths, bamboo forest, teak forest and even regularly burned grasslands, up to 500 m altitude but in Indo-China up to 1800 m. The density of the wood is about 720 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 36, 78, 140, 162, 197, 234, 243, 463, 465, 498, 575, 705.

Dillenia ovalifolia Hoogl.

Blumea 7: 33, fig. 3 a–b (1952).

Vernacular names Indonesia: karu ai, wadajouw (Yapen Island).

Distribution The Moluccas (Halmahera, Morotai) and Irian Jaya (Waigeo, Sorong, Yapen Island).

Uses The timber is reputed to be used as simpoh.

Observations A medium-sized evergreen tree up to 30 m tall, with bole up to 60 cm in diameter; leaves ovate to nearly orbicular, 7–27 cm × 6–22 cm, margin slightly undulate, petiole up to 10 cm long, with 5–10 mm broad wings amplexicaul at base and with rounded auriculate apex, partly caducous; flowers c. 6 cm in diameter, sepals 5, petals white to reddish, stamens all of about the same length, anthers with long acumen at apex, opening by pores; fruit dehiscent; seed enclosed by thin aril. *D. ovalifolia* occurs in primary forest up to 1000 m altitude.

Selected sources 162, 243, 244.

Dillenia ovata Wallich ex Hook.f. & Thomson

Fl. Ind. 1: 70 (1855).

Vernacular names Indonesia: simpur minyak, pisang maru (Sumatra), simpur darut (Bangka). Malaysia: simpoh beludu (Peninsular). Cambodia: 'san 'nhai[1]. Thailand: tanokkot (north-eastern), san-khwang, san-bailek (peninsular). Vietnam: s[oof] xoan.

Distribution Indo-China, Thailand, Peninsular Malaysia, Sumatra and Bangka.

Uses The timber is used as simpoh, e.g. for beams, planks and furniture. The fruits are eaten in jellies. The tree is sometimes planted as an ornamental. In Indo-China the bark is used against diarrhoea.

Observations A medium-sized evergreen tree up to 20(–30) m tall, bole often rather knotted and branchless for up to 5 m and up to 40(–100) cm in diameter, bark surface flaky, reddish-brown;

leaves ovate to elliptical, (7–)10–20(–30) cm × (5–)7–12(–15) cm, margin entire to obscurely dentate, petiole up to 4.5 cm long; flowers c. 16 cm in diameter, sepals 5, petals lemon-yellow, stamens in 2 distinct groups, the inner ones slightly larger, anthers emarginate to mucronate at apex, opening by pores; fruit indehiscent; seed without aril. *D. ovata* occurs in open or secondary forest and on savannas, usually in the lowland but in Indo-China up to 1500 m altitude.

Selected sources 78, 162, 243, 458, 463, 465, 575, 705.

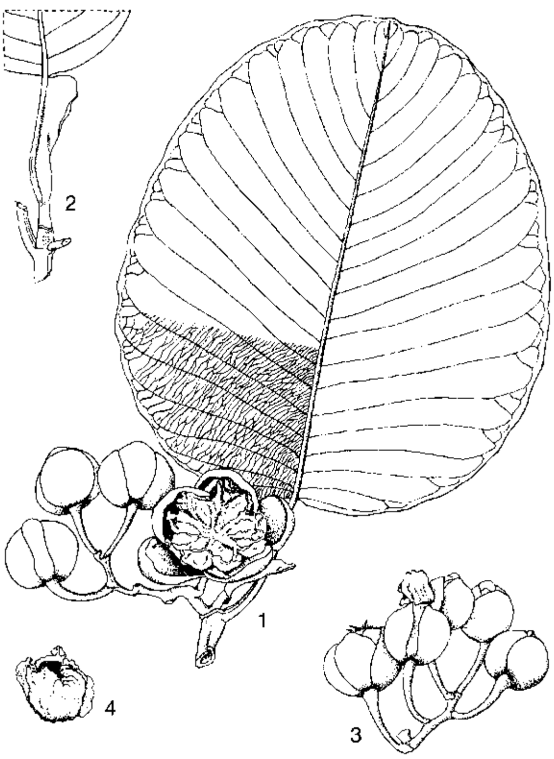
Dillenia papuana Martelli

Becc., Malesia 3: 156 (1886).

Synonyms *Dillenia calothyrsa* Diels (1922), *Wormia calothyrsa* (Diels) Gilg & Werderm. (1925), *Wormia papuana* (Martelli) Gilg & Werderm. (1925).

Vernacular names Indonesia: kamyemeye, kaigabar (Moluccas), mayonga (Irian Jaya).

Distribution The Moluccas (Tanimbar Islands, Aru Islands) and New Guinea.



Dillenia papuana Martelli – 1, fruiting twig; 2, winged petiole of young leaf; 3, inflorescence; 4, seed with aril.

Uses *D. papuana* is an important source of timber in New Guinea.

The timber is used for general construction, moulding, decorative wall panelling, interior trim, veneer and structural grade plywood.

Observations A medium-sized to large evergreen tree up to 40 m tall, with bole branchless for up to 20(–25) m and up to 100 cm in diameter, with or without buttresses, bark surface peeling off in very thin papery flakes; leaves elliptical to ovate (rarely almost circular), (12–)25–40 cm × (7.5–)15–35 cm, margin undulate to slightly dentate, petiole up to 8 cm long, with 5–35 mm broad wings, often broadest near apex and amplexicaul at base, completely caducous; flowers not expanding, very variable in size, sepals 5, petals shed without spreading, stamens all of about the same length, anthers with acumen at apex, opening by pores; fruit dehiscent; seed enclosed by rather thick aril. *D. papuana* occurs in primary forest at low altitude (rarely up to 2000 m), often in temporarily flooded forest but also in permanently dry places. The heartwood is reddish-brown with a purplish cast; the density is 540–620 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 145, 162, 243, 612.

Dillenia papyracea Merr.

Philipp. Journ. Sci., Bot. 9: 520 (1915).

Synonyms *Dillenia megalophylla* Merr. (1919), *Wormia papyracea* (Merr.) Gilg & Werderm. (1925).

Vernacular names Philippines: kambug (general), malaigang (Sulu).

Distribution The Philippines (Luzon, Mindanao, Basilan).

Uses The timber is reputed to be used as simpoh.

Observations A medium-sized to fairly large evergreen tree up to 40 m tall, with bole branchless for up to 27 m and up to 125 cm in diameter, bark surface peeling off in plates, orange-red; leaves elliptical, (23–)30–60(–100) cm × (11–)16–35 (–60) cm, margin entire to slightly undulate-dentate, petiole up to 10 cm long, with 7–25 mm broad wings amplexicaul at base and usually caducous; flowers 10–12 cm in diameter, sepals 5, petals white, stamens all of about the same length, anthers without acumen, opening by pores; fruit dehiscent; seed enclosed by aril. *D. papyracea* occurs in primary forest at low altitudes. *D. pteropoda* (Miq.) Hoogl. from the Moluccas and western Irian Jaya is very similar to *D. papyracea* in leaf characteristics but differs in its larger, red flowers not fully expanding.

Selected sources 162, 243, 244, 426.

Dillenia pentagyna Roxb.

Pl. Coromandel 1: 21, t. 20 (1795).

Synonyms *Dillenia baillonii* Pierre ex Lanessan (1886).

Vernacular names Indonesia: janti (Sundanese, Java), sempu (Javanese, Java), tawro (Sulawesi). Burma (Myanmar): zinbyun. Cambodia: phêng. Thailand: san-na (general), san-nokplao (northern), san-chang (south-western). Vietnam: s[oof] ng[ux] th[uw].

Distribution India, Burma (Myanmar), Indo-China, southern China, Thailand, the Andaman Islands, central and eastern Java, the Lesser Sunda Islands and southern Sulawesi.

Uses The timber is used extensively in India for construction under cover and decorative work, but more rarely in the Malesian region, probably because the trees are comparatively small and the bole is often crooked. The wood is also used for making a good quality charcoal. The fruits are eaten in curries and jellies and used in local medicine against coughs.

Observations A medium-sized deciduous tree up to 20(–25) m tall, with often rather crooked bole branchless for up to 12 m and up to 100 cm in diameter, bark surface smooth, peeling off in thin scales, greyish; leaves obovate to lanceolate-obovate, (20–)30–50 cm × (10–)15–30 cm, margin nearly entire to manifestly dentate, petiole up to 6(–8) cm long, with small, 1–3 mm broad wings non-amplexicaul at base; flowers 2.5–3 cm in diameter, sepals 5, petals yellow, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by longitudinal slits; fruit indehiscent; seed without aril. *D. pentagyna* occurs in open forest and savanna, in Java especially in teak forest up to 850 m altitude. The heartwood is brownish; the density ranges from 560–820 kg/m^3 at 15% moisture content.

Selected sources 36, 162, 218, 243, 474, 575.

Dillenia philippinensis Rolfe

Journ. Linn. Soc. Bot. 21: 307 (1884).

Synonyms *Dillenia catmon* Elmer (1915).

Vernacular names Philippines: katmon (general), katmon-buhukan (general, for var. *pubifolia*).

Distribution Throughout the Philippines.

Uses The timber is used in house building, e.g. for light construction, framing and flooring and for furniture and cabinet making. The fruits are edible and eaten fresh or in sauces or jellies; they are also used medicinally against coughs and for cleansing the hair. A red dye can be obtained from the bark.

Observations A small to medium-sized evergreen tree up to 17 m tall, usually with short bole up to 60 cm in diameter, bark surface peeling off in thin irregular plates, reddish-brown to dark brown; leaves ovate, elliptical, oblong to lanceolate, (6.5–)10–16(–27) cm × (5–)7–12(–17) cm, margin undulate to dentate, petiole up to 5 cm long, with 3–12 mm broad wings completely caducous; flowers 10–15 cm in diameter, sepals 5, petals white, stamens in 2 distinct groups, the inner ones larger, anthers obtusely acuminate at apex, opening by pores; fruit indehiscent; seed at base enclosed by aril. Var. *pubifolia* Merr. is more hairy than var. *philippinensis* and occurs in Luzon and Mindanao. *D. philippinensis* occurs in primary and secondary forest at low and medium altitudes, rarely up to 2000 m. The heartwood is reddish-brown with a purplish cast, in the centre sometimes almost black; the density is about 750 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 68, 125, 162, 243, 414, 426, 526, 527, 626, 690.

Dillenia pulchella (Jack) Gilg

Engl. & Prantl, Nat. Pflanzenfam. 3, 6: 123 (1893).

Synonyms *Wormia pulchella* Jack (1822).

Vernacular names Indonesia: jaha keling, simpur paya (Sumatra), debah lulus (Dayak, Kalimantan). Malaysia: simpoh paya, simpoh ayer (Peninsular), simpoh pipit (Sarawak).

Distribution Peninsular Malaysia, Sumatra, the Riau Archipelago, Bangka and Borneo.

Uses The timber is of good quality and sometimes used for house building.

Observations A medium-sized to fairly large evergreen tree up to 40 m tall, with bole branchless for up to 25 m and up to 90 cm in diameter, without buttresses but bole sometimes slightly fluted at base, bark surface smooth to slightly scaly or with long cracks, greyish-brown to reddish; leaves ovate to obovate, (4–)5–10(–15) cm × (2.5–)3.5–5.5(–9) cm, margin entire, petiole up to 1.5 cm long; flowers c. 3.5 cm in diameter, sepals 5, petals yellow, stamens in 2 distinct groups, the inner ones larger, anthers without acumen, opening by longitudinal slits; fruit dehiscent; seed enclosed by red aril. *D. pulchella* occurs in primary and secondary forest at low altitudes, usually on wet, often peaty soil, rarely on hillsides. The heartwood is reddish; the density is comparatively high being 750–970 kg/m^3 at 15% moisture content.

Selected sources 69, 77, 140, 162, 234, 243, 705.

Dillenia quercifolia (C.T. White & Francis ex Lane Poole) Hoogl.

Fl. Malesiana, ser. I, 4: 161 (1951).

Synonyms *Wormia quercifolia* C.T. White & Francis ex Lane Poole (1925).

Distribution Papua New Guinea.

Uses The timber is reputed to be used as simpoh.

Observations A medium-sized to fairly large evergreen tree up to 40 m tall, with bole branchless for up to 28 m and up to 120 cm in diameter, bark surface peeling off in papery flakes, reddish-brown; leaves ovate, 8–15 cm × 4.5–12 cm, margin more or less undulate, petiole up to 4 cm long, with 3–7 mm broad wings amplexicaul at base and completely caducous; flowers c. 5 cm in diameter, sepals 5, stamens all of about the same length, anthers obtuse at apex, opening by pores; fruit unknown. *D. quercifolia* is rather unknown.

Selected sources 162, 243, 244.

Dillenia reifferscheidia Villar

Nov. App.: 3 (1880).

Vernacular names Philippines: katmon-kalabau (general), katmon-kadlagan, balali (Bikol).

Distribution The Philippines.

Uses The timber is suitable for construction work. The fruits are edible, with the flavour of a sour apple; they make excellent jam.

Observations A small evergreen tree up to 12 m tall, with bole up to 60 cm in diameter, with widely spreading, crooked branches; leaves elliptical to obovate, (12–)20–30(–50) cm × (8–)13–20 (–35) cm, margin dentate to nearly entire, petiole up to 4 cm long, with large obovate wings amplexicaul at base and completely caducous; flowers c. 17.5 cm in diameter, sepals 11-17, increasing in size towards centre of flower, petals white, rarely rose-red, stamens in 2 distinct groups, the inner ones larger, anthers shortly acuminate at apex, opening by pores; fruit indehiscent; seed enclosed by membranous aril. *D. reifferscheidia* occurs in primary and secondary forest up to 1000 m altitude, particularly in humid regions.

Selected sources 68, 162, 243, 414, 426, 673.

Dillenia reticulata King

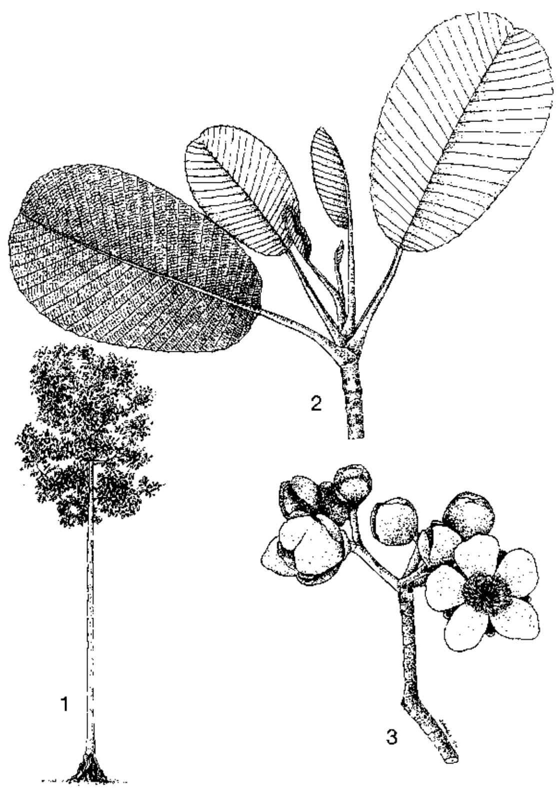
Journ. As. Soc. Beng. 58(2): 367 (1889).

Vernacular names Malaysia: simpoh gajah, simpoh jangkang, simpoh paya (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The timber is reputed to be used as simpoh. It is suitable for the production of veneer and plywood.

Observations A fairly large deciduous tree up to 40 m tall, with straight bole branchless for up to 30 m and up to 70 cm in diameter, conspicuous stilt roots up to 2 m high present, bark surface smooth, very finely cracked or fissured, grey-brown or red-brown with brown lenticels; leaves elliptical, elliptical-oblong or obovate, (10–)15–30 (–45) cm × (6–)10–20(–28) cm, margin entire to slightly undulate-dentate, petiole up to 10 cm long, with narrow, up to 2 mm broad wings non-amplexicaul at base; flowers c. 8 cm in diameter, sepals 5, petals yellow, stamens gradually increasing in size towards the centre of flower, anthers without acumen, opening by pores; fruit



Dillenia reticulata King – 1, tree habit; 2, twig with leaves; 3, flowering branchlet.

indehiscent; seed with rudimentary aril. Two varieties are distinguished: var. *reticulata* with carpels densely hirsute in apical part and only known from Peninsular Malaysia, and var. *psilocarpella* Hoogl. with glabrous carpels and occurring throughout the area of distribution. *D. reticulata* is locally common, especially in Peninsular Malaysia, in forest at low altitude, up to 200 m, at swampy localities or on dry land. The density of the wood is 670–810 kg/m^3 at 15% moisture content.

Selected sources 12, 77, 78, 140, 162, 243, 377, 404, 463, 465, 474, 705.

Dillenia schlechteri Diels

Bot. Jahrb. Syst. 57: 438 (1922).

Synonyms *Dillenia macrophylla* (Laut.) Diels (1922), *Wormia macrophylla* (Laut.) Gilg & Werderm. (1925), *Wormia schlechteri* (Diels) Gilg & Werderm. (1925).

Distribution Papua New Guinea including the Bismarck Archipelago.

Uses The timber is used for house building; it is reported to be durable.

Observations A large evergreen tree up to 50 m tall, with bole up to 200 cm in diameter having buttresses up to 2 m high, bark surface flaky, reddish-brown; leaves ovate to broadly ovate, 11–30 cm × 7.5–21 cm, margin slightly undulate, petiole up to 9 cm long, with 4–8 mm broad wings amplexicaul at base and completely caducous; flowers probably never quite expanding, sepals 5, petals shed without spreading, bright yellow, stamens all of about the same length, anthers obtuse at apex, opening by pores; fruit dehiscent; seed enclosed by membranous aril. *D. schlechteri* occurs in montane forest at 1300–1700 m altitude, in New Ireland in primary lowland forest. The wood is reddish-brown, hard and heavy.

Selected sources 162, 243.

Dillenia serrata Thunb.

Trans. Linn. Soc. 1: 201 (1791).

Synonyms *Dillenia elliptica* Thunb. (1791).

Vernacular names Indonesia: dengen, dongi bolusu, songi (Sulawesi).

Distribution Sulawesi.

Uses The timber is used for house building, e.g. for planks and posts, but is reportedly not durable; it is also used for boats. The fruits are edible, acidic, and sometimes used as a substitute for lemon.

Observations A medium-sized evergreen tree up to 30 m tall, with bole branchless for up to 16 m and up to 70 cm in diameter, bark surface smooth, scaling off with thin flakes, reddish-grey; leaves oblong to lanceolate, (20–)25–35(–45) cm × (8–)10–14(–19) cm, margin dentate to nearly entire, petiole up to 6.5 cm long, with 5–30 mm broad wings, broadest near apex, amplexicaul at base and completely caducous; flowers c. 7.5 cm in diameter, sepals 5, yellow, petals absent, stamens all of about the same length, anthers emarginate at apex, opening by apical pores; fruit indehiscent; seed without aril. *D. serrata* is closely related to *D. celebica* but differs in its larger flowers, more numerous carpels and petiolar wings broader at apex. It occurs in primary and secondary forest up to 100 m altitude. The heartwood is reddish-brown.

Selected sources 162, 234, 243, 673.

Dillenia sumatrana Miq.

Fl. Ind. Bat., Suppl. 1(3): 620 (1861).

Synonyms *Dillenia meliosmifolia* Hook.f & Thomson (1872).

Vernacular names Indonesia: surumak delok, sipang-sipang, wahom bouho (Sumatra). Malaysia: simpoh bukit, simpoh hutan (Peninsular), simpoh gunung, simpoh merah (Sarawak).

Distribution Peninsular Malaysia, Sumatra and adjacent islands, and northern Borneo (Sarawak, Sabah).

Uses The timber is sometimes used in house building. The fruits are edible.

Observations A medium-sized, slender evergreen tree up to 20 m tall, with bole branchless for up to 6 m and up to 35 cm in diameter, bark surface cracking and lenticellate, reddish-brown; leaves oblong, (13–)16–30(–45) cm × (5–)7–16(–20) cm, margin dentate to nearly entire, petiole up to 5 cm long; flowers c. 6 cm in diameter, sepals 5, petals yellow, stamens in 2 distinct groups, the inner ones larger, anthers rounded to slightly mucronate at apex; fruit indehiscent; seed without aril. *D. sumatrana* occurs in lowland forest up to 500 m altitude.

Selected sources 69, 78, 162, 234, 243, 458, 463, 465, 705.

Rugayah (general part, selection of species),
A. Martawijaya (properties),
J. Ilic (wood anatomy),
R.H.M.J. Lemmens (selection of species)

Diospyros L.

Sp. pl. 2: 1057 (1753); Gen. pl. (Ed. 5): 478 (1754).

EBENACEAE

$x = 15$; $2n = 30$ for most of the species, *D. ebenum*: $2n = 90$, *D. kaki*: $2n =$ c. 54–56, 90

Trade groups

- Black ebony: heavy hardwood, e.g. *Diospyros ebenum* Koenig, *D. ferrea* (Willd.) Bakh.
- Streaked ebony: heavy hardwood, e.g. *D. blancoi* A.DC., *D. celebica* Bakh., *D. pilosanthera* Blanco.
- White *Diospyros* wood: medium-weight hardwood, e.g. *D. discocalyx* Merr., *D. rigida* Hiern.

Black and streaked ebony is the corewood of the species involved. In species producing white *Diospyros* wood, this corewood has developed only slightly or is absent, and the remainder of the wood is pale.

Vernacular names

- Black ebony: East Indian ebony, Ceylon ebony (En). Ebène noir (Fr). Indonesia: kayu arang, kayu eboni. Philippines: kamagong, camagon. Burma (Myanmar): mepyaung. Cambodia: trayung. Thailand: maklua, lambit.
- Streaked ebony: Macassar ebony, Andaman marblewood, zebrawood (En). Ebène de Macassar, coromandel (Fr). Indonesia: kayu hitam, kayu eboni. Malaysia: buey (general), merpinang (Iban, Sarawak). Philippines: kamagong, camagon. Thailand: kaling.
- White *Diospyros* wood: persimmon (Am). Malaysia: kayu arang, kayu malam. Philippines: ata-ata, malatinta, bolong-eta. Thailand: tako-na.

Origin and geographic distribution *Diospyros* consists of over 300 species and occurs throughout the tropics. Some 170 species have been recognized within the Malesian region; 70 species occur within Peninsular Malaysia and about 100 in Indonesia.

Uses In South-East Asia, the fancy wood of black and streaked ebonies is in great demand for high quality sculptures and carving. It is also valued for furniture, cabinet work, interior fittings, fans, decorative articles, turnery, brushware, household utensils, tool handles, machete handles and sheaths, decorative veneer, musical instruments (e.g. pianoforte keys, stringholders in violins), toys, chisels, bowling alleys and pins, canes, inlaying, but also for boxes, construction (posts, poles) and bridges. The light-coloured wood is used for furniture, pallets and other utility purposes. The sapwood of several species is reported to be strong and tough and is used for tool handles and shoe trees.

The fruits of many *Diospyros* species are edible; the most important fruit trees are *D. blancoi*, *D. digyna* Jacq. and *D. kaki* L.f. The unripe fruits of a few species (*D. malabarica* (Desr.) Kostel. var. *malabarica* and var. *siamensis* (Hochr.) Phengklai, and *D. mollis* Griffith) are used to dye cloth black and for tanning nets and sometimes hides. The tannin in young fruits has medicinal uses, as does an extract of the bark. Fruits are also used as a source of fish poison. *D. malabarica* is sometimes planted as an ornamental tree.

Production and international trade The timber of *D. celebica* was already being exported from Sulawesi in the 18th century. It is reported to be the most valuable timber species in Indonesia. Around 1920 exports were about 2300 m^3/year, increasing to 8200 m^3 in 1928, and from then on were 6000 m^3/year on average. In 1973 exports peaked at 26 000 m^3, and in 1978 were still 23 000 m^3. By then, stands had been heavily depleted and exports decreased considerably.

The export of white *Diospyros* wood ('kayu malam') from Sabah was about 1060 m^3 in 1992 (86% as sawn timber, 14% as logs) with a total value of US$ 500 000 (US$ 540/m^3 for sawn timber and US$ 70/m^3 for logs). In Papua New Guinea, ebony also fetches high prices and is classified as very high quality wood; the export of logs is banned. Most of the ebony timber is exported to Japan, but smaller amounts are sold to Europe and the United States.

Properties Black and streaked ebony are heavy, hard and strong woods. The heartwood is dark brown or black and may have reddish stripes, sometimes with pale green, distinctly demarcated from the usually wide sapwood which is yellowish-white to pale reddish-brown. The density is 640–1270 kg/m^3 at 15% moisture content. The grain is straight to shallowly interlocked, texture fine to very fine and even. The wood is lustrous and has no distinct odour or taste.

At 15% moisture content, the modulus of rupture is c. 110 N/mm^2, modulus of elasticity 14 700 N/mm^2, compression parallel to grain 60 N/mm^2, shear 6 N/mm^2, cleavage 49 N/mm radial and 67.5 N/mm tangential, Janka side hardness 6420 N and Janka end hardness 7205 N.

The rates of shrinkage are moderate to high: from green to 15% moisture content up to 5.5% radial and 8.7% tangential, and from green to oven dry 6.2–8.7% radial and 7.8–13.3% tangential. Black and streaked ebony is difficult to dry; it may develop deep checks and has a tendency to warp and cup. It is recommended to convert the logs in green condition to small sizes and dry slowly. For kiln drying, a temperature of 30–50°C and corresponding relative humidity of 88% to 31% are recommended.

The heartwood is generally difficult to work with hand and machine tools because of its high density, especially when air dry. It dulls tool edges and the wood requires considerable pressure bar loading and power in sawing; stellite-tipped saws are necessary for good results. The wood is somewhat brittle but saws to a good finish. It turns and planes well, taking a high polish; to plane wood with a slightly interlocked grain the cutting angle must be reduced to prevent the grain picking up. Pre-boring is necessary for nailing and screwing, but the wood holds nails and screws fairly well. It is reputed to be difficult to glue. Very beautiful veneer can be made by slicing, but pretreatment is required; the veneer is usually used as face veneer.

The heartwood of black and streaked ebony is very durable. The service life in contact with the ground under tropical conditions is over 25 years. Sapwood is not durable when exposed or in contact with the ground but is durable when used indoors. The wood may be moderately susceptible to dry-wood termites and *Lyctus* beetles. The heartwood is extremely resistant to preservative treatment and the sapwood is moderately resistant.

Wood of *D. celebica* contains 46.5% cellulose, 28.5% lignin, 18.5% pentosan, 1.7% ash and no silica. The solubility is 7.1% in alcohol-benzene, 2.0% in cold water, 4.1% in hot water, and 11.1% in a 1% NaOH solution. The energy value is about 19 500 kJ/kg. The wood dust sometimes causes dermatitis.

White *Diospyros* wood is a medium-weight hardwood. The heartwood is greyish or yellowish-white to buff-coloured but often with a streaky or black core up to 10 cm in diameter; it is not distinctly demarcated from the sapwood. The density is (440–)540–945(–1065) kg/m^3 at 15% moisture content. Most properties of the wood are comparable with black and streaked ebony, but the wood usually seasons more easily (although slowly), works more easily, is less durable and more easy to treat with preservatives.

Description Evergreen, usually dioecious or sometimes monoecious or polygamous shrubs or small to large trees up to 40(–50) m tall; bole branchless for up to 24 m, up to 70(–85) cm in diameter, usually without buttresses, though if present these are short, up to 2(–4) m high; crown monopodial, with branches in pseudowhorls; bark surface smooth, fissured, or cracked, black, hard and brittle. Leaves alternate, distichous, simple, pinnately veined, without stipules. Inflorescence axillary or cauliflorous on older branches or rarely on the trunk, cymose, 1–many-flowered, multibracteate. Flowers usually unisexual, actinomorphic, 3–5(–8)-merous; pedicel articulate; sepals united at base, sometimes free, the lobes valvate or imbricate, persistent in fruit; petals basally united into a tube, with patent lobes; stamens (3–)12–20(–100), often inserted at the base of the corolla tube, sometimes on the receptacle, rarely higher up on the corolla tube, often in 2 whorls, anthers basifixed, 2-locular, longitudinally dehiscent, staminodes usually present in female flowers; ovary rudimentary in male flowers, in female ones superior, multilocular, 2–8-carpellate, each carpel corresponding to a 2-ovulate locule or more commonly to a pair of uni-ovulate locules, resulting from the presence of false septae, ovules pendulous, styles 2–8. Fruit a berry, with fibrous to fleshy pericarp. Seeds 1–16, with a thin leathery testa, and thick, horny, smooth or ruminate endosperm; cotyledons leafy, flat. Seedling usually with epigeal germination, sometimes hypogeal (cotyledons remaining within the seed-coat and hypocotyl not elongated) or with the durian type of germination (cotyledons remaining within the seed-coat and hypocotyl elongated); first 2 leaves opposite or alternate, subsequent leaves alternate.

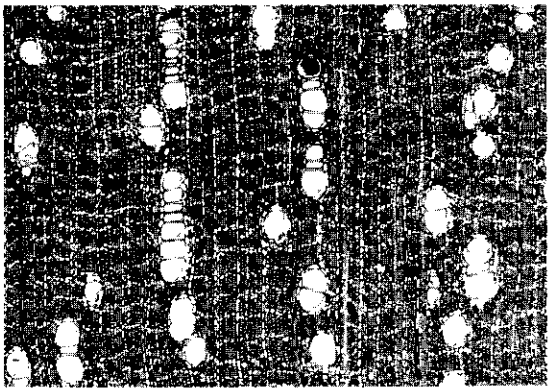
Wood anatomy

– Macroscopic characters:

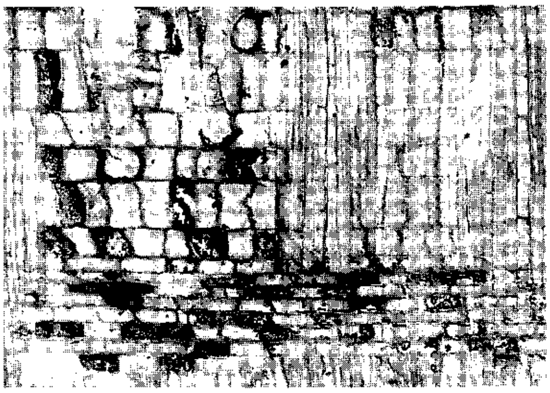
Heartwood black (e.g. *D. ebenum*) or black with pale yellow streaks (*D. ferrea*) or black with pinkish streaks (*D. blancoi*), or practically without dark-coloured heartwood and grey to almost white (e.g. *D. papuana*), usually distinctly demarcated from the yellowish-white or pinkish sapwood. Grain straight or shallowly interlocked. Texture fine; wood lustrous. Growth rings usually indistinct; vessels in the sapwood often dark stained; parenchyma reticulate, visible with a hand lens; ripple marks uncommon but present in some species.

– Microscopic characters:

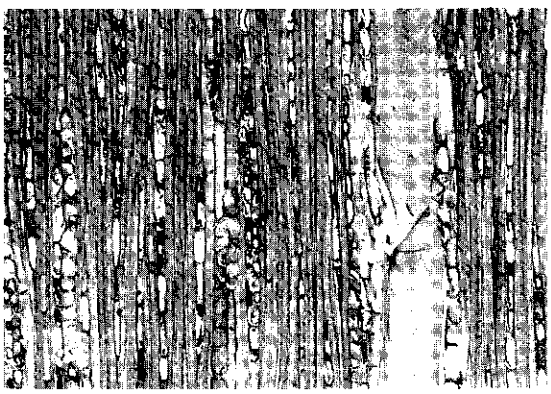
Growth rings usually indistinct but, if present, marked by flattened fibres. Vessels diffuse, the number varying with species, solitary (percentage varying with species) and in radial multiples of 2–5(–7), 80–190 μm in tangential diameter; perforations simple; intervessel pits non-vestured, alternate, fine, 3–5 μm in diameter, often with coalescent apertures; vessel-ray and vessel-paren-



transverse section (×25)



radial section (×75)



tangential section (×75)

Diospyros ferrea

chyma pits almost similar to intervessel pits; vessels filled or coated with dark-coloured substances; tyloses often present. Fibres 650–1350 μm long (*D. ferrea*), mostly thick-walled, with numerous, small slit-like pits. Parenchyma scanty paratracheal and abundant apotracheal, reticulate, in bands 1–2 cells wide, often seemingly in long concentric bands; in 4–8-celled strands. Rays 11–16/mm, uniseriate (*D. blancoi*, *D. ebenum*), 1–2-seriate (*D. ferrea*) or 1–3(–5)-seriate (*D. papuana*), 260–1500 μm high, heterocellular with low or high marginal rows of upright cells (Kribs type heterogeneous II, rarely I). Prismatic crystals present, scarce in ray cells and scarce to fairly numerous in chambered axial parenchyma cells, in chains of 4–5, sometimes up to 20. Silica bodies absent.

Species studied: *D. blancoi*, *D. ebenum*, *D. ferrea*, *D. papuana*.

Growth and development Most *Diospyros* species have epigeal germination, but in *D. maingayi* germination is of the 'durian type', whereas *D. pendula* shows hypogeal germination. In the latter food reserves are transferred to the taproot (which becomes swollen) during the first weeks of growth. In some species from Peninsular Malaysia, the cotyledons are shed almost immediately after emergence without ever turning green, thus not exploiting the photosynthetic advantage of epigeal germination; this phenomenon is only known for *Diospyros*. However, the first two leaves develop precociously as if to compensate for the early loss of the cotyledons.

The growth of young plants is slow and in a plantation trial of *D. celebica* under teak in Java the young trees were 30–100 cm tall after 2 years, 40–190 cm at the age of 4 years, 60–300 cm at the age of 6 years, and 70–450 cm when 8 years old. The mean annual height increment was 90 cm during the first 10 years, then it decreased, whereas the mean annual diameter increment was 1.5 cm during the first 20 years then decreasing to 0.5 cm. Diameters recorded for *D. ebenum* at different ages are: 46 cm when 25 years old, 91 cm when 75 years old, 137 cm when 135 years old and 183 cm when 200 years old.

All *Diospyros* species are characterized by the architectural growth model of Massart, i.e. an orthotropic, monopodial trunk with rhythmic growth producing regular tiers of branches.

Trees of *D. celebica* may already start to flower and fruit at the age of 5–7 years. The period from anthesis to fruit ripening takes 6 months in *D. celebica*, 9–11 months in *D. maingayi* and 5 months in *D. pendula*. The seeds are dispersed by birds, bats and monkeys.

Other botanical information The large genus *Diospyros* has been subdivided into 5 subgenera: *Eudiospyros* (which should actually be called *Diospyros*), *Maba*, *Hierniodendron*, *Cargillia*, and *Mabacea*. The first two are subdivided further into many sections. The distinction between the subgenera and sections is not always clear. Several cultivars of species producing edible fruits are known, including cultivars with seedless fruits.

Ecology Most ebony species occur in primary or rarely secondary lowland to hill evergreen rain forest up to 900 m altitude. Some species occur in lower montane or montane forest up to 1700 m, in peat-swamp forests, in kerangas forest or on limestone hills and ultrabasic soils. The important ebony-producing species, however, are mainly confined to lowland and hill rain forest. Exceptions are *D. pilosanthera*, which is often found in peat-swamp forest, and the important *D. celebica*, which grows naturally in humid as well as in markedly seasonal climates, where it occurs as a constituent of the rain and monsoon forest. *D. celebica* grows on a variety of soils, e.g. latosols, calcareous soils, and podzolic soils.

Propagation and planting Propagation is from seed or stumps. Species producing edible fruits may also be propagated by air layering, budding, grafting or separation of root suckers. Ebony is reported to coppice well.

Seed should be extracted from fruits harvested from the tree when mature and dark brown, or collected from the ground. Pulp and seed can be separated by maceration. One kg contains about 9000 seeds of *D. ebenum*, about 800 of *D. celebica* from South Sulawesi and about 1150 of *D. celebica* from Central Sulawesi. Seed is recalcitrant and looses its viability very rapidly, although when kept in the ripe fruits it can be stored for longer. Seed sun-dried for three days does not germinate. Soaking in water for 24 hours slightly improves the germination rate and slightly shortens the germination period. Seed should be sown in shaded beds. When seed of *D. celebica* was sown one day after being collected, germination was 85% in 17–65 days; when stored in wet charcoal powder during 12 days 70% germination was achieved, whereas after storage for 20 days the germination rate dropped to 28%. For *D. maingayi* in Malaysia 55% of the seed germinate in 1-5 months, but for most *Diospyros* species 45–95% of the seed germinate in 2–8 weeks. Seed sown with the pulp still attached takes somewhat longer to complete germination. Freshly germinated seed requires a high humidity so that the testa remains soft and can be shed. Otherwise, young seedlings may have their cotyledons and epicotyl trapped in the testa; this often occurs in seedlings of *D. pendula* and *D. sumatrana*, even when watered twice a day. When planted or transplanted, care should be taken not to harm the taproot. Stumps of 1–3 cm diameter showed 85% survival after being planted out. In Sulawesi, seedlings of 6–7 months old and 20–30 cm tall and wildlings of 15–20 cm tall were successfully used for planting. Seedlings or stumps should be planted under light shade (e.g. under *Pinus merkusii* Junghuhn & de Vriese or *Paraserianthes falcataria* (L.) Nielsen). *D. celebica* can be planted at 1 m × 2 m under shade of *Leucaena leucocephala* (Lamk) de Wit planted 2–3 years earlier, or by planting between rows of *Leucaena leucocephala*. Seedlings at least one year old may be planted in the open. In Sulawesi, enrichment planting of secondary forest by line or strip planting has been successfully conducted with a spacing of about 7.5 m × 4 m.

Silviculture and management In Indonesia, natural forest with *Diospyros* spp. is selectively cut under the Indonesian selective felling and replanting system (TPTI). Natural regeneration is enhanced by clearing the undergrowth and by opening up the canopy after logging. *Diospyros* spp. are generally shade tolerant and very persistant growers. Seed germinates readily if sufficient light is available. In forest where commercial tree species grow slowly and where it is difficult to find trees with a diameter at breast height of over 50 cm, the diameter limit for selective felling may be lowered to 35 cm, leaving 25 healthy smaller trees per ha with a diameter of 15–34 cm. This is the case in mixed *D. celebica* forest. Enrichment planting is required if logged-over stands are poorly stocked by natural regeneration. The cutting cycle is extended to 45 years instead of the 35 years generally adopted in Indonesia.

Diseases and pests No serious diseases or pests attack *D. celebica* plantations. Seed from fallen fruits is frequently infested by the fungus *Penicilliopsis clavariaeformis*, which is specific to ebony seeds.

Harvesting Before 1972 the diameter limit for *D. celebica* in Indonesia was 55–60 cm. This regulation was followed consistently, because smaller logs, weighing less than 700 kg could not be exported. The diameter limit has now been lowered to 35 cm, although small logs may have insufficient streaked ebony heartwood. People felling the trees prefer to use an axe instead of a saw, as the wood dust irritates the skin, eyes and respiratory organs. After felling the sapwood is removed, because only the heartwood is marketed. Large-diameter *D. celebica* and *D. rumphii* trees are reported to be hollow for a large part.

Yield So far, *D. celebica* has not been planted on a large scale, but in trial plantations in West Java the estimated mean annual increment is 6 m^3/ha. In natural forest *D. celebica* trees are very scattered and irregular, but locally in Central Sulawesi the estimated timber volume of ebony is 60 m^3/ha. Reputedly, the more stony and rough the site, the more heartwood is present. The heartwood in *D. celebica* trees measures 10–25 cm in diameter in logs of 60 cm diameter.

Genetic resources The logging of black or streaked ebony-producing *Diospyros* species should be carefully controlled and monitored. The resources have been depleted for centuries, because the wood has long been in great demand. *D. celebica* was once widespread in Sulawesi, but has now become comparatively rare, especially in South Sulawesi, and has been proposed for inclusion in Appendix II of the CITES convention (which means controlling the timber trade). Small trial plantations have been established in Indonesia, e.g. in West Java. *D. philippinensis* is a protected species in the Philippines.

Prospects The establishment of large-scale plantations of ebony seems promising as the timber is so highly valued. This should be coupled with conservation of the existing resources. Tree improvement programmes may result in superior stock for planting. However, the trees grow comparatively slowly and it takes a long time to produce sufficient amounts of heartwood. This makes the economic feasibility dubious, as very long cutting cycles are needed and the timber production will be comparatively low.

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Selection of species

Diospyros andamanica (Kurz) Bakh.

Bull. Jard. Bot. Buitenzorg, sér. 3, 15: 74 (1937).

Synonyms *Maba racemosa* Ridley (1925), *Diospyros carpinifolia* (Ridley) Bakh. (1933), *Diospyros malayana* Bakh. (1933).

Vernacular names Indonesia: awa buluan, siawang etem (Sumatra), jangis (Kalimantan). Malaysia: poko assam kumbang (Peninsular).

Distribution The Andaman Islands, Peninsular Malaysia, Sumatra and Borneo.

Uses The wood has been used as dark-coloured ebony in house construction.

Observations A small to medium-sized tree up to 20 m tall, bole up to 75 cm in diameter, bark surface smooth to scaly, black, grey or brown; leaves usually elliptical or oblong-elliptical, rarely ovate or obovate, 5–30 cm × 1.5–12 cm, base cordate to rounded, apex acuminate, hairy on veins below, tertiary venation scalariform, slightly prominent below; male flowers in 8–15-flowered cymes, 3-merous, stamens 4–12; female flowers in 3–12-flowered cymes, 3-merous, calyx lobes valvate, densely hirsute outside, corolla divided to about halfway, staminodes 3, ovary with 3 styles and 6 uni-ovulate locules; fruit globose, ovoid, or ellipsoid, 1.5–2.5 cm × 1.3–2.0 cm, papillose to finely warty. *D. andamanica* is uncommon, occurring scattered in primary lowland forest, occasionally on limestone, up to 600 m altitude.

Selected sources 42, 457, 463, 705.

Diospyros areolata King & Gamble

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 74 (extra numb.): 228 (1905).

Synonyms *Diospyros pseudomalabarica* Bakh. (1933).

Vernacular names Malaysia: kayu arang. Thailand: phlap, maphlap (general).

Distribution Peninsular Thailand and Peninsular Malaysia.

Uses The wood is reputed to be used as ebony. The fruits are used to dye nets and clothes in Thailand.

Observations A large tree up to 50 m tall, bole up to 70 cm in diameter, bark surface smooth to scaly-dippled, grey, brown, or black; leaves oblong, elliptical-oblong or ovate-oblong, 6.5–21 cm × 2.5–7 cm, base acute to rounded, apex acute to slightly acuminate, glabrous or pilose only on the midrib below, tertiary veins closely reticulate, prominent on both surfaces; male flowers in 3-flowered cymes, 4-merous, stamens about 21; female flowers solitary, 4–5-merous, calyx lobes valvate, hairy on both sides, corolla divided almost to the base, staminodes 8–12, ovary with 1 style with 4 or 5 stigmas and 8 or 10 uni-ovulate locules; fruit globose to ovoid, 3–5 cm × 2.5–3.5 cm, glabrous. *D. areolata* is uncommon, occurring scattered in primary lowland and hill forest, often along the periphery of mangrove vegetation, up to 700 m altitude.

Selected sources 42, 457, 495, 575, 705.

Diospyros blancoi A.DC.

Prodr. 8: 237 (1844).

Synonyms *Diospyros discolor* Willd. (1806), nom. illeg., *Diospyros philippensis* (Desr.) Guerke (1891).

Vernacular names Mabolo, velvet apple, butter fruit (En). Pommier velours (Fr). Indonesia: buah mentega (Malay, Sumatra), bisbul, mabolo (Sundanese). Malaysia: buah lemah, buah sagalat, kayu mantega (Peninsular). Philippines: mabolo, kamagong (general), talang (Tagalog).

Distribution The Philippines and Taiwan; cultivated in Peninsular Malaysia, Sumatra and Java, and in other tropical countries.

Uses The wood is used as streaked ebony, especially for carvings and special furniture. The tree is often planted for its rather sweet but dry edible fruits, and also as a roadside tree.

Observations A small to medium-sized tree up to 15(–32) m tall, bole branchless for up to 10 m, generally straight and fluted, up to 100 cm in diameter; leaves oblong to elliptical-oblong, 8–30 cm × 2.5–12 cm, base usually rounded or slightly cordate, apex pointed, silvery hairy below, tertiary venation reticulate, distinct; male flowers in 3–7-flowered cymes, 4-merous, stamens 24–30; female flowers solitary, 4–5-merous, calyx lobes overlapping, appressed sericeous outside, corolla divided to halfway, staminodes 4–5 or 8–10, ovary with 4–5 styles and 8 or 10 uni-ovulate locules; fruit globose or depressed globose, 7–10 cm in diameter (sometimes larger in fruit trees), velvety. *D. blancoi* is very common and widespread in the Philippines and is found in both primary and secondary forest, up to 800 m altitude. The density of the wood is about 1090 kg/m^3 at 15% moisture content.

Selected sources 42, 78, 125, 216, 234, 248, 374, 527, 595, 673, 690, 705.

Diospyros buxifolia (Blume) Hiern

Trans. Cambr. Phil. Soc. 12: 218 (1873).

Synonyms *Diospyros microphylla* Bedd. (1871), *Diospyros munda* Hiern (1911), *Diospyros sphenophylla* Hiern (1925).

Vernacular names Indonesia: ki merak (Sundanese), rangkemi (Malay, Sumatra), meribu (Malay, Kalimantan). Malaysia: meribut, delai putih, mempunai (Peninsular). Thailand: riphao, sangtham (peninsular). Vietnam: c[aa]y v[aa]y oc.

Distribution From India and Indo-China, throughout the Malesian area towards New Guinea.

Uses The wood is used as black ebony, e.g. for posts and poles.

Observations A medium-sized to fairly large tree up to 37 m tall, bole up to 70 cm in diameter, bark surface finely fissured, greenish-grey to black; leaves almost sessile, ovate, subrhomboid to elliptical, 1.2–5(–7) cm × 0.5–2.5(–3) cm, base acute to rounded, apex bluntly pointed to slightly acuminate, sparsely appressed hairy below, tertiary venation invisible; male flowers in 1–5-flowered cymes, 4-merous, stamens 8–20; female flowers solitary, 4–5-merous, calyx lobes overlapping, densely pubescent outside, corolla divided from halfway to three-fifths, staminodes absent, ovary with 2 styles and 4 uni-ovulate locules; fruit oblong-ellipsoid, 1–2.5 cm × 0.4–1.1 cm, hairy at the tip. *D. buxifolia* is widespread but scattered in wet to dry evergreen forest, up to 700(–1000) m altitude. The density of the wood is 780–1070 kg/m^3 at 15% moisture content. The wood is non-durable.

Selected sources 42, 77, 78, 140, 234, 495, 575, 595, 705.

Diospyros celebica Bakh.

Gard. Bull. Str. Settl. 7: 166 (1933).

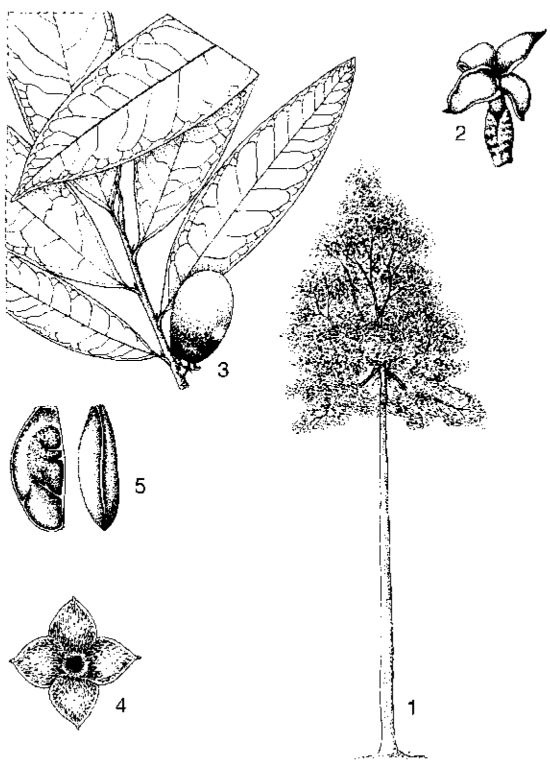
Vernacular names Black ebony (En). Indonesia: kayu maitong, sora, toetandu (Sulawesi), kayu lotong (South Sulawesi).

Distribution Sulawesi.

Uses *D. celebica* is probably the most important source of streaked ebony.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for 10–26 m, up to 150 cm in diameter, with buttresses up to 4 m high, bark surface scaly, black; leaves linear-elliptical, 12–35 cm × 2.5–7 cm, base obtuse to slightly cordate, apex acute to obtusely acuminate, tertiary venation reticulate, slightly prominent on both surfaces; male flowers in 3–7-flowered cymes, 4-merous, stamens 16; female flowers in 1–3-flowered cymes, 4-merous, calyx lobes valvate, densely sericeous outside, corolla divided to about halfway, ovary with 4–8 uni-ovulate locules; fruit ovoid, 3.5–5 cm × 3–3.5 cm, appressed sericeous, glabrescent at base and apically. *D. celebica* is found in lowland forest, up to 540 m altitude. Its stands have been heavily depleted and it is now considered a comparatively rare species. The density of the wood is 1010–1270 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 15, 42, 212, 376, 403, 526, 537, 586, 595, 601, 602.



Diospyros celebica Bakh. – 1, tree habit; 2, flower; 3, fruiting twig; 4, fruiting calyx; 5, lateral and dorsal view of seed.

Diospyros clavigera C.B. Clarke

Hook.f., Fl. Brit. India 3: 558 (1882).

Synonyms *Diospyros malaccensis* Bakh. (1933).

Vernacular names Indonesia: kayu arang (Bangka, Lingga). Malaysia: kayu arang, komoi, kumoi (Peninsular).

Distribution Peninsular Malaysia, Singapore, Bangka and the Lingga Archipelago.

Uses *D. clavigera* is an important source of black ebony.

Observations A large tree up to 46 m tall, bole up to 75 cm in diameter, bark surface closely fissured, black; leaves ovate to obovate, 3.5–15 cm × 2.5–8 cm, base attenuate or rarely rounded, apex rounded to acuminate, glabrous, tertiary venation laxly reticulate, faint; male flowers in 4–20-flowered cymes, 4-merous, stamens 12–16; female flowers unknown; fruit globose, 4-locular, 1–1.5 cm across. *D. clavigera* is fairly common but scattered in primary lowland forest, up to 500 m altitude. The density of the wood is 935–1010 kg/m^3 at 15% moisture content.

Selected sources 42, 78, 140, 457, 705.

Diospyros confertiflora (Hiern) Bakh.

Gard. Bull. Str. Settl. 7: 162 (1933).

Synonyms *Maba confertiflora* Hiern (1873), *Maba perakensis* King & Gamble (1906).

Vernacular names Indonesia: nyangit toan (Dayak, Kalimantan), malam (Kutai, Kalimantan). Malaysia: kayu arang (general), delik (Pahang), melemau (Selangor). Thailand: lukhuanok (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Bangka and Borneo.

Uses The wood is reputed to be used as ebony.

Observations A medium-sized tree up to 27 m tall, bole up to 40 cm in diameter, bark surface fissured or scaly, black, grey, or brown; leaves elliptical-oblong, 2.5–14 cm × 1.5–5 cm, base acute to rounded, apex acuminate, glabrous except for the often finely hairy midrib, tertiary venation reticulate, indistinct; male flowers in 5–many-flowered clusters, 3-merous, stamens 9–12; female flowers in 1–3-flowered cymes, 3-merous, calyx lobes overlapping, short appressed and pilose outside, corolla divided to about halfway, staminodes 3 or 6, ovary with 3 styles and 6 uni-ovulate locules; fruit ovoid and curved, beaked, 2.5–3.5 cm long, sparsely hairy to glabrous. *D. confertiflora* is fairly common and occurs scattered in primary forest, up to 1250 m altitude. The density of the wood is about 820 kg/m^3 at 15% moisture content.

Selected sources 42, 77, 457, 458, 463, 575, 705.

Diospyros curranii Merr.

Philipp. Journ. Sci., Bot. 4: 306 (1909).

Synonyms *Diospyros sibuyanensis* Elmer (1912), *Diospyros viridifolia* Elmer (1915).

Vernacular names Philippines: malagaitmon (Tagalog). Thailand: nangchoi (eastern).

Distribution Burma (Myanmar), Laos, Cambodia, Thailand, Sumatra, Borneo and the Philippines.

Uses The pale wood is used locally.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 12 m, up to 50 cm in diameter, bark surface fissured to scaly, black; leaves ovate-oblong to obovate-oblong, 5–20 cm × 1.5–6 cm, base acute to slightly cuneate, apex acuminate with a blunt point, glabrous, tertiary venation reticulate, prominent above, inconspicuous below; male flowers in 1–7-flowered cymes, 4(–5)-merous, stamens 16–18; female flowers in 1–5-flowered cymes, 4(–5)-merous, calyx lobes valvate, glabrous, corolla divided to the base, staminodes 8–10, ovary with 1 style and 3–5 uni-ovulate locules; fruit globose, 1.5–2.2 cm across, glabrous. *D. curranii* occurs along the coast and from savanna and shrub forest to tropical evergreen rain forest, up to 500 m altitude. The density of the wood is 710–855 kg/m^3 at 15% moisture content.

Selected sources 42, 77, 495, 527, 575.

Diospyros digyna Jacq.

Pl. hort. Schoenbr. 3: 35 (1798).

Synonyms *Diospyros nigra* (J.F. Gmelin) Perrottet (1825), *Diospyros ebenaster* Hiern (1873) non Retz.

Vernacular names Black persimmon, black sapote (En). Philippines: malatinta, zapote negro (Tagalog).

Distribution Native to Central America, introduced by Spanish colonizers to the Philippines. At present infrequently cultivated for its fruit in the Malesian area and other tropical countries, naturalized in the Moluccas and Sulawesi.

Uses *D. digyna* yields a whitish wood which is sometimes used. The fruits are edible and are also made into a drink and used in e.g. ice-cream. Unripe fruits have been used as fish poison in the Philippines and the West Indies. Various preparations of bark and leaves have been used medicinally against fever and skin disease.

Observations A small to medium-sized tree up to 25 m tall, bole long, bark surface rusty black; leaves elliptical-oblong to oblong-lanceolate, 7.5–30 cm × 3.5–8 cm, base decurrent to obtuse, apex obtuse, glabrous, tertiary venation reticulate, slightly prominent; flowers unisexual or hermaphrodite; male flowers in 3-flowered cymes, 4–6-merous, stamens 8–10 or 16–20; female and hermaphrodite flowers solitary or sometimes in 3–7-flowered cymes, 4–6-merous, calyx valvate, often plicate, densely appressed pubescent on both sides, corolla divided to about halfway, stamens 8–10 or 16–20 (staminodia 7–8 in female flowers), ovary with 2–5 styles and 8–12 uni-ovulate locules; fruit globose to depressed globose, 5–15 cm across, glabrous. *D. digyna* grows in tropical lowland to montane forest up to 600(–1800) m altitude, and is rather sensitive to drought.

Selected sources 42, 125, 247, 527, 673.

Diospyros discocalyx Merr.

Univ. Calif. Public. Bot. 15: 245 (1929).

Distribution Borneo (Sabah).

Uses The pale wood is used locally.

Observations A medium-sized tree, bole up to 75 cm in diameter; leaves lanceolate-elliptical to elliptical-oblong, 5–15 cm × 2.5–7 cm, base acute to obtuse, apex abruptly short acuminate, sparsely short pubescent below, tertiary venation reticulate, slightly prominent; flowers unknown; fruit depressed globose, 6–10 cm in diameter, 8–10-locular, glabrous. *D. discocalyx* is a still imperfectly known species which seems to be common in Sabah. The density of the wood is 600–815 kg/m^3 at 15% moisture content.

Selected sources 42, 77.

Diospyros durionoides Bakh.

Gard. Bull. Str. Settl. 7: 169 (1933).

Vernacular names Borneo ebony (En). Indonesia: arang durian, arang halus daon (Kutai, Kalimantan), mirung (Dayak, Kalimantan).

Distribution Borneo (Kalimantan, Sabah).

Uses *D. durionoides* is probably an important source of black or streaked ebony in Sabah.

Observations A large tree up to 45 m tall, bole up to 70 cm in diameter; leaves oblong to elliptical-oblong, 7–20 cm × 2.5–7 cm, base obtuse to rounded, apex short acute to obtusely acuminate, densely sericeous below when young, tertiary venation laxly reticulate, slightly prominent on both surfaces. *D. durionoides* is a still imperfectly known species which occurs at low altitude.

Selected sources 42, 77.

Diospyros ebenum Koenig

Physiogr. Salsk. Handl. (Lund) 1: 176 (1781).

Synonyms *Diospyros glaberrima* Rottb. (1783).

Vernacular names Ceylon ebony, Mauritius ebony (En).

Distribution Southern India and Sri Lanka; cultivated in Peninsular Malaysia.

Uses *D. ebenum* is said to produce the best commercial black ebony. It is mainly exported to China for furniture and to Europe as fancy wood. The gummy astringent fruits are used as a medicine and eaten in times of famine. They are also used as fish poison, and the tree has been planted in India as a shade tree for cardamom.

Observations A medium-sized tree up to 30 m tall, bole straight, up to 90 cm in diameter, with buttresses up to 2 m high, bark surface scaly, fissured, black to grey-black; leaves ovate-oblong to oblong-lanceolate, 5–13 cm × 2–6 cm, base cuneate to rounded, apex slightly acuminate to rounded, glabrous, tertiary venation reticulate, inconspicuous above, prominent below; flowers mostly male and bisexual; male flowers in 3–16-flowered cymes, 4-merous, stamens 16; female and bisexual flowers solitary, 3–4-merous, calyx lobes valvate, glabrous, corolla divided to about halfway, staminodes 8, ovary with a single 4–5-lobed style and 8 uni-ovulate locules; fruit depressed globose to subglobose, up to 1.5 cm across, glabrous. *D. ebenum* has been known for its black wood since ancient times. Its reported occurrence in Sulawesi and eastwards is erroneous. It occurs naturally in comparatively dry areas.

Selected sources 42, 104, 120, 204, 457, 586, 705.

Diospyros evena Bakh.

Gard. Bull. Str. Settl. 7: 163 (1933).

Synonyms *Maba motleyi* Hiern (1873) p.p.

Vernacular names Indonesia: malam (Malay, Belitung, Kalimantan), uwar haduk (Kalimantan).

Distribution Belitung and Borneo.

Uses The wood is used as ebony.

Observations A medium-sized tree up to 28 m tall, bole up to 40 cm in diameter; leaves elliptical to obovate-lanceolate, 2–9 cm × 1–3 cm, base obtuse to rounded, apex rounded to slightly truncate, appressed puberulous when young but glabrescent; female flowers solitary, 4-merous, calyx lobes valvate, densely tomentose outside, ovary 3-locular; fruit ovoid-oblong to ellipsoid, 2–3 cm × 1.2–1.7 cm, sparsely pubescent to glabrous. *D. evena* is found at low altitude. The density of the wood is 670–770 kg/m^3 at 15% moisture content.

Selected sources 42, 77, 576.

Diospyros ferrea (Willd.) Bakh.

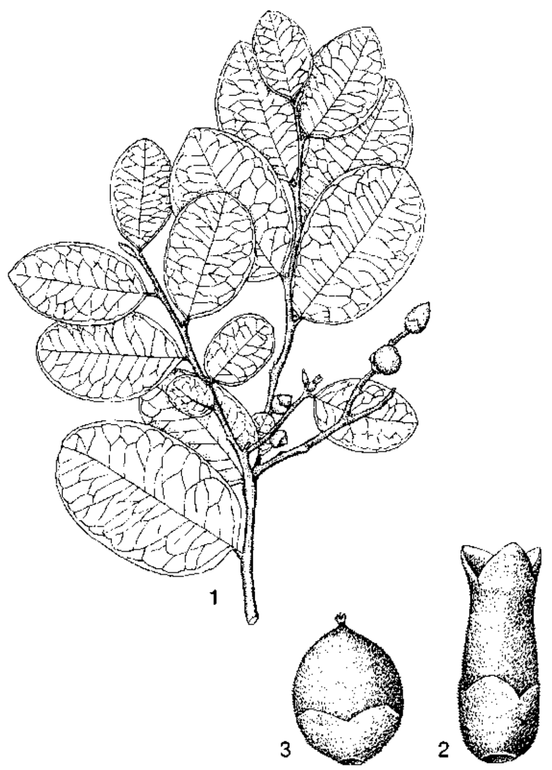
Gard. Bull. Str. Settl. 7: 162 (1933).

Synonyms *Maba buxifolia* (Rottb.) A.L. Juss. (1804), *Diospyros ferrea* (Willd.) Bakh. var. *buxifolia* (Rottb.) Bakh. (1936).

Vernacular names Indonesia: bibisan (Java), ai meten, wawama (Moluccas). Philippines: batulinau (Tagalog).

Distribution From West Africa to India, Indo-China, north to the Ryukyu Islands, east to the Malesian area, Australia, Melanesia and Polynesia.

Uses *D. ferrea* is reported to be an important



Diospyros ferrea (Willd.) Bakh. – 1, fruiting twig; 2, flower; 3, fruit.

source of black ebony, but this is doubtful because of the unsatisfactory taxonomy of the group involved.

Observations A small to medium-sized tree up to 30 m tall, bole branchless for up to 16 m, up to 50 cm in diameter, bark surface scaly, blackish; leaves elliptical or somewhat rhomboid to obovate, 1.6–6 cm × 0.8–3.1 cm, base acute to attenuate, apex rounded, retuse, or bluntly pointed, glabrous, tertiary venation reticulate, variably distinct; male flowers in (1–)3(–4)-flowered cymes, 3-merous, stamens (3–)12; female flowers solitary, 3-merous, calyx lobes valvate, tomentose on both surfaces, corolla divided to one-sixth, staminodes 6–12, ovary with a 3-fid style and 3 bi-ovulate locules; fruit ellipsoid to globose, 1–1.5 cm long, glabrous to sparsely hairy apically. *D. ferrea* is extremely variable and many varieties have been described. The taxonomy of this *D. ferrea* complex is far from clear: many separate species may be involved. It is common on dry places such as sandy or rocky coasts, and on limestone hills, but also behind mangrove vegetation, usually at low altitude. The density of the wood is about 1210 kg/m^3 at 15% moisture content.

Selected sources 42, 58, 104, 234, 324, 325, 374, 457, 527, 575, 586, 705.

Diospyros foxworthyi Bakh.

Gard. Bull. Str. Settl. 7: 171 (1933).

Vernacular names Malaysia: kayu arang (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as ebony.

Observations A small to medium-sized tree up to 25 m tall, bole columnar, up to 40 cm in diameter, without buttresses, bark surface deeply closely fissured, black; leaves lanceolate to oblong-elliptical, rarely obovate, 7–33 cm × 2–8 cm, base cuneate to rounded, apex acuminate, glabrous, the surface minutely wrinkled, tertiary venation vaguely reticulate or vaguely transverse; male flowers in condensed many-flowered panicles, 4-merous, stamens 12–17; female flowers in many-flowered clusters of condensed cymes, 4-merous, calyx lobes valvate-plicate, tomentose outside, sericeous inside, corolla divided to about one-quarter, staminodes 8, ovary with 8 uni-ovulate locules; fruit globose, 3.5–4.5 cm across, tomentose but glabrescent medially. *D. foxworthyi* is locally common on hillsides and ridges, up to 1100 m altitude.

Selected sources 42, 705.

Diospyros frutescens Blume

Bijdr. fl. Ned. Ind. part 13: 668 (1826).

Synonyms *Diospyros curtisii* King & Gamble (1905), *Diospyros kunstleri* King & Gamble (1905), *Diospyros cymosa* Ridley (1923).

Vernacular names Indonesia: ki gentel (Java), kayu siamang (Sumatra), madang suna (Sulawesi). Malaysia: merangat (Peninsular). Thailand: damplot (general).

Distribution Thailand, Peninsular Malaysia, Sumatra, western Java, Borneo (Kalimantan, Sabah), and Sulawesi.

Uses The wood is used as ebony, e.g. for tool handles.

Observations A small to medium-sized tree up to 25 m tall, bole up to 40 cm in diameter, bark surface smooth, black; leaves oblong to obovate, (6–)10–25(–37.5) cm × (2–)4–10(–13) cm, base cuneate to almost rounded, apex acuminate, glabrous, tertiary venation vaguely reticulate to vaguely transverse; male flowers in condensed many-flowered panicles, 4(–5)-merous, stamens 16(–20); female flowers in condensed many-flowered panicles, 4(–5)-merous, calyx lobes valvate-plicate, minutely pubescent on both surfaces, corolla divided to halfway or to two-thirds, staminodes 8, ovary with a single style and 4 uni-ovulate locules; fruit globose, 1.5–2.5 cm across, hairy but glabrescent. *D. frutescens* is uncommon and occurs in primary lowland evergreen forest, up to 700 m altitude.

Selected sources 42, 234, 456, 495, 575, 705.

Diospyros hasseltii Zoll.

Natuurk. Tijdschr. Ned. Ind. 14: 159 (1857).

Synonyms *Diospyros horsfieldii* Hiern (1873), *Diospyros brachiata* King & Gamble (1905).

Vernacular names Indonesia: kasemek, semak (Java), belang limus (Sumatra). Malaysia: baneng, merangat (Peninsular). Thailand: takosuan (general), tako, baneng.

Distribution Burma (Myanmar), Laos, Cambodia, Vietnam, Thailand, Peninsular Malaysia, Sumatra, Java and Bali.

Uses The wood is used as ebony. The seeds are edible. The juice of the fruit has been used as a varnish.

Observations A medium-sized tree up to 30 m tall, bole short, cylindrical, up to 50 cm in diameter, bark surface rough, greyish; leaves elliptical to oblong, 12–35 cm × 4–15 cm, base broadly cuneate to rounded, apex shortly obtusely acuminate, glabrous, tertiary venation reticulate, depressed above, distinctly prominent below; male flowers in 3-many-flowered cymes, 4–5-merous, stamens 12–16; female flowers in 1-many-flowered cymes, 4–5-merous, calyx lobes valvate-plicate, tomentose on both sides, corolla divided to two-thirds, staminodes 8–12, ovary with 4 styles and 8(–10) uni-ovulate locules; fruit globose to ovoid, 1.5–3.5 cm across, tomentose but soon glabrous. *D. hasseltii* is uncommon and often occurs near streams in evergreen lowland forest, up to 500 m altitude.

Selected sources 42, 234, 457, 495, 575, 673, 705.

Diospyros insularis Bakh.

Gard. Bull. Str. Settl. 7: 173 (1933).

Vernacular names Papua ebony (En).

Distribution New Ireland and the Solomon Islands.

Uses *D. insularis* is an important source of black ebony; the wood is exported.

Observations Leaves elliptical-oblong to linear-elliptical, 10–25 cm × 5–11 cm, base slightly to distinctly cordate, apex short obtusely acuminate, glabrous, tertiary venation reticulate, prominent on both surfaces; male flowers in many-flowered cymes, 4-merous, stamens 28–32; female flowers in 1–3-flowered cymes; fruit ellipsoid to subglobose, 2–2.5 cm across, with 8 seeds, sericeous when young, later glabrous. Not much is known about this species which, however, is apparently an important source of black ebony.

Selected sources 42, 204.

Diospyros ismailii Ng

Malaysian For. 40: 222 (1977).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as ebony.

Observations A medium-sized tree up to 27 m tall, bole up to 40 cm in diameter, bark surface lenticellate-scaly, black or dark brown, inner bark bright yellow on exposure; leaves elliptical to elliptical-ovate, 7–18 cm × 2.5–7 cm, base tapering, apex acuminate, glabrous, tertiary venation reticulate or vaguely scalariform, slightly raised on both surfaces; male flowers in 1–3-flowered cymes, 4–5-merous, stamens 12–18; female flowers in 1–3-flowered cymes; fruit globose, up to 6 cm across, with 8 or 10 seeds, glabrous except for the densely appressed hairy apex. *D. ismailii* is locally common in primary forest on hills and ridges, up to 1000 m altitude.

Selected sources 457, 458, 461, 463, 705.

Diospyros kurzii Hiern

Trans. Cambr. Phil. Soc. 12: 162 (1873).

Synonyms *Diospyros nitida* Merr. (1905), *Diospyros wrayi* King & Gamble (1905), *Diospyros pubicarpa* Ridley (1923).

Vernacular names Andaman ebony (En). Malaysia: hidong kelawar (Peninsular). Philippines: katilma (general), kanalum (Zambales), kunalon (Pampanga).

Distribution The Andaman Islands, Thailand, Peninsular Malaysia, the Philippines, and the Moluccas.

Uses The pale wood is used locally, e.g. for light construction and tool handles.

Observations A medium-sized tree up to 30 m tall, bole up to 65 cm in diameter; leaves elliptical to oblong or ovate-oblong, 2.5–14 cm × 1.5–4.5 cm, base acute and often slightly asymmetrical, apex acuminate, often hairy on the midrib above, tertiary venation reticulate, prominent on both surfaces; male flowers in (3–)5–many-flowered cymes, 4-merous, stamens 14–18; female flowers in 1–3(–7)-flowered cymes, 4-merous, calyx lobes valvate, sparsely appressed pubescent outside, corolla divided to halfway, staminodes 0–10, ovary with a single split or bilobed style and 4 uni-ovulate locules; fruit globose, 1–2 cm across, velvety. *D. kurzii* is usually uncommon but locally common in the Philippines and occurs in primary lowland and hill forest, sometimes on limestone hills, up to 700 m altitude. The density of the wood is 830–1085 kg/m^3 at 15% moisture content.

Selected sources 42, 115, 457, 527, 575, 705.

Diospyros lanceifolia Roxb.

Fl. India (Carey ed.) 2: 537 (1832).

Synonyms *Diospyros lucida* Wallich ex A.DC. (1844), *Diospyros pachyphylla* C.B. Clarke (1882), *Diospyros clavigera* C.B. Clarke var. *pachyphylla* (C.B. Clarke) Ridley (1923).

Vernacular names Indonesia: awa kehuluh, tuba buwah (Sumatra), melilin (Bangka). Malaysia: hitam mati, kayu arang, sengkawas (Peninsular).

Distribution India, Burma (Myanmar), Thailand, Peninsular Malaysia, Sumatra, Borneo and the Philippines.

Uses The wood is used as black ebony, e.g. for interior finishing. The fruits are possibly edible, but also reported as poisonous and inducing blistering; they are also used as a fish poison.

Observations A small to medium-sized tree up to 20 m tall, bole straight, up to 75 cm in diameter, bark surface smooth to finely fissured, brown to black, inner bark bright yellow on exposure; leaves oblong-elliptical to lanceolate, sometimes broader, 3–22.5 cm × 1.5–8 cm, base cuneate to obtuse, apex acute to abruptly shortly bluntly apiculate, midrib hairy below, tertiary venation reticulate, inconspicuous; male flowers in 3–8-flowered almost sessile clusters, 4–5-merous, stamens 12–18; female flowers in 1–3(–5)-flowered almost sessile clusters, 4–5-merous, calyx lobes valvate-plicate, densely sericeous on both surfaces, corolla divided to halfway, staminodes 8–10, ovary with a single style with 4 or 8 stigmas and 8 uni-ovulate locules; fruit globose with a short beak, 2–2.5 cm across, velvety but glabrescent. *D. lanceifolia* is common and occurs in lowland and hill forest, sometimes in coastal and heath forest, up to 700(–1350) m altitude. The density of the wood is 750–890 kg/m^3 at 15% moisture content.

Selected sources 42, 77, 78, 104, 140, 234, 457, 575, 595, 705.

Diospyros lolin Bakh.

Gard. Bull. Str. Settl. 7: 175 (1933).

Vernacular names Indonesia: lolin, lorin, kayu arang (Moluccas).

Distribution The Moluccas.

Uses The wood is used as streaked ebony. The ripe fruits are eaten raw or roasted.

Observations A medium-sized tree up to 32 m tall, bole branchless for up to 21 m, up to 50(–100) cm in diameter, with buttresses up to 2 m high, bark surface fissured, black to greyish mottled, inner bark reddish; leaves lanceolate to elliptical, 10–25 cm × (4–)6–10 cm, base obtuse to rounded, apex shortly acuminate, soon glabrescent, tertiary venation reticulate, prominent on both surfaces; male flowers in 3–5-flowered cymes, 4-merous, stamens 16–24; female flowers solitary, 4(–5)-merous, calyx lobes overlapping, sericeous outside, corolla divided to one-third, staminodes many, ovary with a single style and 8–10 uni-ovulate locules; fruit depressed globose, about 4 cm across, glabrous. *D. lolin* occurs up to 250 m altitude. The wood is of good quality and nicely figured, but difficult to work.

Selected sources 42, 403, 586, 673.

Diospyros macrophylla Blume

Bijdr. fl. Ned. Ind. part 13: 670 (1826).

Synonyms *Diospyros cystopus* Miq. (1861), *Diospyros suluensis* Merr. (1926), *Diospyros pachycalyx* Merr. (1929).

Vernacular names Indonesia: ki calung (Sundanese), siamang (Sumatra), mahirangan (Malay, Kalimantan). Philippines: tauailan (Panay Bisaya).

Distribution Sumatra, Java, Borneo, Sulawesi and the Philippines.

Uses The wood is used as streaked ebony, e.g. for building and furniture. The fruits are reported to be edible.

Observations A medium-sized to large tree up to 45 m tall, bole cylindrical, up to 70 cm in diameter, bark surface longitudinally fissured, black; leaves ovate to oblong-lanceolate, 7–35 cm × 3.5–15 cm, base rounded, apex acute to short obtusely acuminate, glabrous, tertiary venation reticulate, indistinct; male flowers in 3–many-flowered cymes, 4–5-merous, stamens 12–20; female flowers in 1–16-flowered cymes, 4–5-merous, calyx lobes valvate, velutinous outside, sericeous inside, corolla divided to one-third, staminodes 8–10, ovary with a single style with a 4–5-lobed stigma and 10 uni-ovulate locules; fruit globose to ovoid or ellipsoid, 5–7 cm across, apex and base pubescent when mature. *D. macrophylla* occurs up to 900 m altitude. The wood is reported to be non-durable, finely grained and red, and is not attacked by termites. The density of the wood is 440–750 kg/m^3 at 15% moisture content.

Selected sources 42, 77, 234, 595.

Diospyros maingayi (Hiern) Bakh.

Gard. Bull. Str. Settl. 7: 164 (1933).

Synonyms *Maba maingayi* Hiern (1873), *Maba motleyi* Hiern (1873) p.p., *Diospyros bilocularis* Oliv. (1894).

Vernacular names Indonesia: madang tampuai (Sumatra), aring pahe (Dayak, Kalimantan), maopinang (Kalimantan). Malaysia: kayu balum ijuk, nyatoh itam (Peninsular), mora pinang batu (Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as ebony.

Observations A medium-sized to fairly large, often monoecious tree up to 40 m tall, bole up to 100 cm in diameter, with short buttresses, bark surface smooth or cracked, brown to black, inner bark deep red to purple; leaves elliptical to obovate, rarely oblong, 5–17.5(–21) cm × 3–9(–11) cm, base cuneate to rounded, apex rounded with a short acumen or emarginate, glabrous or the midrib pubescent below, tertiary venation almost invisible; male flowers solitary but with 1–4 clustered together, 4–5-merous, stamens 20–63 with fused filaments; female flowers solitary but with 1–5 clustered together, 4–5-merous, calyx lobes imbricate, puberulous outside, corolla divided to more than halfway, staminodes 8–26, ovary topped with 2–3(–4) stigmatic lobes and with 2–3(–4) bi-ovulate locules; fruit oblong to elliptical-oblong, 3.5–7.5 cm × 2.5–3.5 cm, glabrous. *D. maingayi* is common and occurs in peat swamp and lowland to lower montane forest, up to 1100 m altitude. The density of the wood is 535–700 kg/m³ at 15% moisture content.

Selected sources 42, 140, 457, 458, 463, 464, 705.

Diospyros malabarica (Desr.) Kostel.

Allg. med.-pharm. Flora 1: 1099 (1834).

Synonyms *Diospyros glutinifera* Roxb. (1795), *Diospyros embryopteris* Pers. (1807), *Diospyros globularia* (Miq.) Koord. & Valeton (1898).

Vernacular names Malabar ebony (En). Indonesia: culiket (Sundanese), kledung (Javanese), klakur (Timor). Malaysia: kayu arang, kamoi bukit, kumun (Peninsular). Burma (Myanmar): plab, tako suam. Cambodia: tang kor. Laos: küa namz, hnang hèèwx, lang dam. Thailand: tako-suan (northern), tako-thai (general), phlap (peninsular). Vietnam: thi d[aa][uf] heo, cu[owx]m thi.

Distribution India, Sri Lanka, Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, Java, the Lesser Sunda Islands and Sulawesi.

Uses The wood is used as streaked ebony, but is apparently of limited value; it is used for boat building and construction. The seeds furnish a valuable astringent which is used as a medicine against diarrhoea and chronic dysentery. The young fruits contain tannin used for dyeing nets and clothes. They also furnish a gum which is used for caulking boats and as a glue. Ripe fruits are edible.

Observations A medium-sized to fairly large tree up to 37 m tall, bole up to 80 cm in diameter, fluted in old trees, bark surface rough, scaly, black, inner bark dark beefy red; leaves elliptical or ovate to oblong, 9–30 cm × 2.5–9.5 cm, base slightly cuneate to subcordate, apex obtuse to acuminate, glabrous, tertiary venation reticulate, prominent above; male flowers in 3–7-flowered cymes, 4(–5)-merous, stamens 24–64; female flowers solitary or rarely up to 5-flowered, 4(–5)-merous, calyx lobes valvate-plicate, velutinous outside, sericeous inside, corolla divided to one-quarter, staminodes 4–12, ovary with 4 styles and 8–12 uni-ovulate locules; fruit globose, 2.5–5 cm across, velutinous but glabrescent. The taxonomy of *D. malabarica* is still confused. Two varieties may be distinguished: var. *malabarica* and var. *siamensis* (Hochr.) Phengklai (synonym: *Diospyros siamensis* Hochr.). *D. malabarica* is often found along streams and rivers, up to 300(–650) m altitude. The density of the wood is about 800 kg/m³ at 15% moisture content.

Selected sources 42, 104, 120, 234, 369, 457, 575, 676, 705, 734.

Diospyros maritima Blume

Bijdr. fl. Ned. Ind. part 13: 669 (1826).

Synonyms *Diospyros laxa* (R.Br.) Bailey (1883), *Diospyros liukiuensis* Makino (1908), *Diospyros camarinensis* Merr. (1915).

Vernacular names Indonesia: kunyit (Java), belu itam perempuan (Seram), kayu itam lewo (Sulawesi). Philippines: malatinta, kanomai (general), tanag (Palawan).

Distribution The Ryukyu Islands, Taiwan, the Philippines, Sumatra, Java, Borneo, Sulawesi, the Moluccas, New Guinea, the Solomon Islands and northern Australia.

Uses The pale wood is used locally, e.g. for musical instruments, furniture, inlaying and novelties; it is also reported to produce good-quality charcoal. The fruits are used to poison fish.

Observations A small to medium-sized tree up to 25 m tall, bole cylindrical, short, up to 50(–100) cm in diameter, without buttresses, bark surface lenticellate, black, inner bark pale yellow; leaves ovate-elliptical to oblong-lanceolate, 5–35 cm × 3–12.5 cm, base obtuse to slightly attenuate, apex obtuse, glabrous, tertiary venation reticulate, inconspicuous; male flowers in 3–8-flowered cymes, 4(–5)-merous, stamens 15–18(–20); female flowers in 1–3-flowered cymes, 4-merous, calyx lobes valvate, sericeous outside and inside, corolla divided to about halfway, staminodes 4–10, ovary with a single style with 3–4 stigmatic lobes and 8 uni-ovulate locules; fruit depressed globose, 1.5–4 cm in diameter. *D. maritima* occurs in thickets and forest along the coast and inland, up to 150(–700) m altitude. The density of the wood is 620–795 kg/m³ at 15% moisture content.

Selected sources 42, 77, 125, 374, 527.

Diospyros mindanaensis Merr.

Philipp. Journ. Sci., Bot. 4: 309 (1909).

Synonyms *Diospyros rosenbluthii* Elmer (1912).

Vernacular names Philippines: ata-ata (general), malagait (Isabela), bantolinao (Camarines).

Distribution Borneo (Sabah) and the Philippines.

Uses The heartwood is used as black ebony, the sapwood as white *Diospyros* wood, e.g. for temporary or light construction and handles of agricultural instruments.

Observations A medium-sized tree up to 25 m tall, bole branchless for up to 8 m, up to 60 cm in diameter, bark surface rough, inner bark reddish; leaves elliptical-oblong to oblong-lanceolate, 7–37.5 cm × 2.5–11 cm, base obtuse to rounded, apex obtuse to acuminate, glabrous, tertiary venation reticulate, slightly prominent on both surfaces or sometimes distinctly prominent below; male flowers in 3-flowered cymes, 4-merous, stamens about 28; female flowers in 1–3(–5)-flowered cymes, 4-merous; fruit globose to depressed globose, 3–8 cm × 4–9 cm, glabrous. *D. mindanaensis* occurs in primary lowland to montane forest, up to 1700 m altitude. The density of the wood is 775–830 kg/m^3 at 15% moisture content.

Selected sources 42, 77, 527.

Diospyros montana Roxb.

Pl. Coromandel 1: 37 (1795).

Synonyms *Diospyros cordifolia* Roxb. (1795), *Diospyros diversilimba* Merr. & Chun (1935), *Diospyros calcarea* Fletcher (1937).

Vernacular names Indonesia: bidara gunung (Java), morotoalah (Sumba), morotombo (Sulawesi). Malaysia: mentua pungsu (Peninsular). Philippines: antinagam (Ilocos Norte), kamagong-bundok, kamagong-liitan (Filipino). Burma (Myanmar): gyok tawbut. Thailand: tan-dam, thanfaiphi.

Distribution India, Sri Lanka, Burma (Myanmar), Cambodia, Laos, Vietnam, Hainan, Thailand, Peninsular Malaysia, Sumatra, Java, the Lesser Sunda Islands, the Philippines, Sulawesi, and northern Australia.

Uses In India the wood is sometimes used as ebony for small objects. The fruit is edible.

Observations A small tree up to 15 m tall, bole up to 60 cm in diameter, twigs and trunk with occasional spines, bark surface smooth to flaky at base, black to yellowish-grey; leaves ovate to obovate, 1.5–15 cm × 1–7.5 cm, base rounded to cordate, apex obtuse to obtusely acuminate, sparsely pubescent above, pubescent below but glabrescent on both surfaces, tertiary venation reticulate, impressed above, inconspicuous below; male flowers in 3–10-flowered cymes, 4(–5)-merous, stamens 16–20; female flowers solitary, 4-merous, calyx lobes imbricate, pubescent to almost glabrous on both surfaces, corolla divided for halfway to two-thirds, staminodes 4–12, ovary with 4 styles and 8 uni-ovulate locules; fruit globose, 1–4 cm across, glabrous. *D. montana* is found in monsoon forest, primary as well as secondary, up to 600 m altitude.

Selected sources 42, 120, 457, 544, 575, 705.

Diospyros nutans King & Gamble

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 74 (extra numb.): 226 (1905).

Vernacular names Malaysia: pako susa, pako dali dali, susoh kuau (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is reputedly used for rafters and fuel.

Observations A small tree up to 17 m tall, bole up to 30 cm in diameter, bark surface fissured, black; leaves reduced to sessile scales at base of each flush, when fully developed oblong to ovate or obovate, 10–36 cm × 3–9 cm, base slightly cordate, apex acuminate, glabrous, tertiary venation reticulate, inconspicuous above, prominent below; male flowers in 7–many-flowered cymes, 4–5-merous, stamens 8–10; female flowers in 7–many-flowered cymes, 4–5-merous, calyx lobes imbricate, densely pubescent outside, corolla divided for halfway to one-third, staminodes 0–5, ovary with a single style with 3–4 stigmas and 6 or 8 uni-ovulate locules; fruit ellipsoid, beaked, 2–3 cm × 1.5–2 cm, densely hairy. *D. nutans* occurs scattered but is locally common in swamps, lowland forest and hill forest, up to 700 m altitude.

Selected sources 42, 78, 457, 705.

Diospyros papuana Valeton ex Bakh.

Gard. Bull. Str. Settl. 7: 180 (1933).

Distribution The southern Moluccas and New Guinea.

Uses In Papua New Guinea *D. papuana* is an important source of white *Diospyros* wood.

Observations Probably a medium-sized tree; leaves elliptical-lanceolate to obovate, 15–40 cm × 4–14 cm, base obtuse to rounded, apex obtusely acuminate, glabrous, tertiary venation densely reticulate, slightly prominent on both surfaces when dry; male flowers in many-flowered cymes, 4–5-merous, stamens 12–18; female flowers in 1–3-flowered cymes, 4–5-merous, calyx valvate, densely pubescent outside, inside glabrous or sparsely pubescent, corolla divided to halfway, staminodes 8–13, ovary with a single style with 4–5 stigmas and 8–10 uni-ovulate locules; fruit depressed globose, 7–10 cm across, glabrous. *D. papuana* is found at low altitude. The density of the wood is 650–750 kg/m^3 at 12% moisture content.

Selected sources 42, 58, 145.

Diospyros penangiana King & Gamble

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 74 (extra numb.): 227 (1905).

Vernacular names Malaysia: poko tumutuang, temereang (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as ebony.

Observations A medium-sized tree up to 27 m tall, bole up to 65 cm in diameter, bark surface smooth to cracked-scaly, grey to black; leaves oblong to oblong-obovate, 11–25 cm × 3–8 cm, base deeply cordate-auriculate, apex acuminate, glabrous except for the midrib above, veins pubescent below, tertiary venation scalariform, inconspicuous above, distinctly prominent below; male flowers unknown; female flowers in 3–5-flowered cymes, 4–5-merous, calyx lobes imbricate, tomentose outside, staminodes 5, ovary with a short style and 4 uni-ovulate locules; fruit globose, 2–2.5 cm across. *D. penangiana* is uncommon and occurs scattered in lowland and hill forest, up to 500 m altitude. The density of the wood is 770–845 kg/m^3 at 15% moisture content.

Selected sources 42, 140, 457, 705.

Diospyros pendula Hasselt ex Hassk.

Pl. jav. rar. descr.: 468 (1848).

Synonyms *Diospyros penduliflora* Zoll. (1857), *Diospyros oleifolia* Wallich ex Kurz (1871), *Diospyros fulginea* Hiern (1873).

Vernacular names Indonesia: ki camara, kayu areng (Java), pulut (Kalimantan). Malaysia: kayu arang, buey (Peninsular). Burma (Myanmar): chope pen, chok, magyi-pway. Thailand: lukin-pa (south-eastern).

Distribution Burma (Myanmar), Thailand, Peninsular Malaysia, Borneo and Java.

Uses The wood is used as black ebony.

Observations A medium-sized tree up to 30 m tall, bole up to 100 cm in diameter, bark surface smooth to finely fissured or finely scaly, black, inner bark pale yellow; leaves oblong to oblong-ovate or lanceolate, rarely oblong-obovate, 7–30 cm × 2–11 cm, base acute to obtuse, apex acuminate to acute or rarely rounded, glabrous, tertiary venation reticulate, faint to invisible on both sides; male flowers in (1–)3(–4)-flowered cymes, 4-merous, stamens 16–24; female flowers in 1(–2)-flowered cymes, 4-merous, calyx lobes valvate, tomentose outside, corolla divided to one-third, staminodes 10–12, ovary with a single style and 8–10 uni-ovulate locules; fruit ovoid to depressed globose, 3–5 cm in diameter, tomentose but glabrescent. *D. pendula* is common and occurs in lowland and lower montane rain forest, up to 1100 m altitude. The wood is apparently durable but not very attractively coloured. Its density is 640–955 kg/m^3 at 15% moisture content.

Selected sources 42, 140, 457, 458, 461, 463, 464, 575, 705.

Diospyros philippinensis A.DC.

Prodr. 8: 231 (1844).

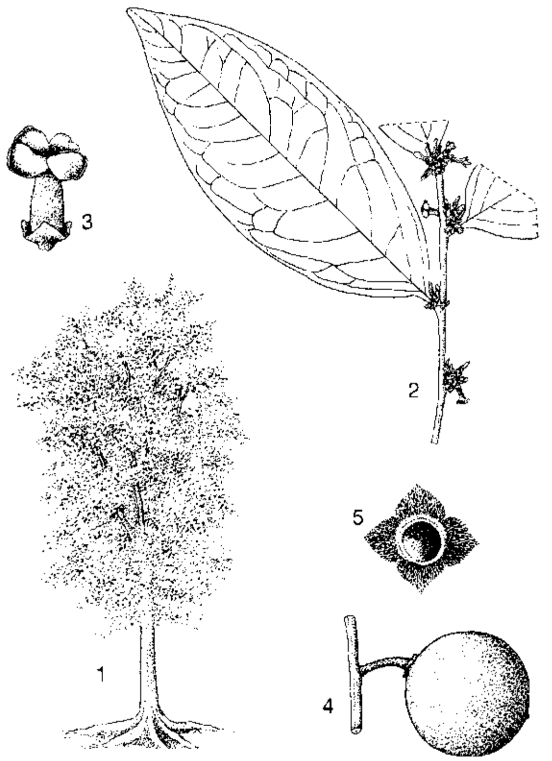
Synonyms *Diospyros cunalon* A.DC. (1844), *Diospyros cumingii* Gürke (1890), *Diospyros flavicans* Koord. (1898).

Vernacular names Indonesia: boniok (Sulawesi). Philippines: kamagong, ooi (general), bato bantilan (Mindoro).

Distribution Northern Sulawesi and the Philippines.

Uses The wood is used as black ebony.

Observations A medium-sized tree up to 30 m tall, bole up to 45 cm in diameter, bark surface black, inner bark red-brown; leaves ovate to elliptical-oblong, 6–15 cm × 2.5–6 cm, base cuneate to obtuse, apex shortly acuminate, glabrous except



Diospyros philippinensis A.DC. – 1, habit of young tree; 2, flowering twig; 3, flower; 4, fruit; 5, fruiting calyx.

for the midrib above, pubescent but glabrescent below, tertiary venation reticulate, prominent below; male flowers in 3–9-flowered cymes, 4-merous, stamens 8; female flowers in 1–5-flowered cymes, 4-merous, calyx lobes imbricate, densely pubescent outside, corolla divided to halfway, staminodes 4–6, ovary with a single 4–8-lobed style and 4 uni-ovulate locules; fruit globose to broadly obovoid, 4–5 cm across, glabrous when mature. *D. philippinensis* is found in primary forest, up to 200 m altitude. See also the table on wood properties.

Selected sources 42, 104, 124, 335, 527.

Diospyros pilosanthera Blanco

Fl. Filip.: 304 (1837).

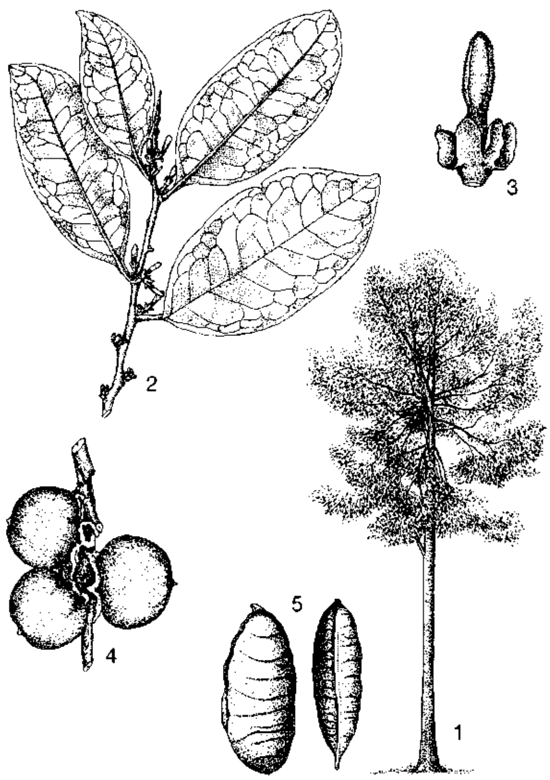
Synonyms *Diospyros hiernii* Koord. & Valeton ex Koord. (1922).

Vernacular names Indonesia: semetik (Sumatra), balun injuk (Java), kayu arang (Kalimantan). Malaysia: buey, kayu arang (Peninsular). Philippines: bolong-eta (general). Thailand: nian (peninsular), damdong (south-eastern), kaling (north-eastern).

Distribution Burma (Myanmar), Cambodia, Vietnam, Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, the Moluccas, and the Philippines.

Uses The wood is used as streaked ebony, e.g. for furniture.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 32 m, up to 85 cm in diameter, with buttresses up to 4 m high, bark surface fissured or scaly, black to purple; leaves elliptical to elliptical-oblong, 6–25 (–33) cm × 2.5–8(–11) cm, base rounded to acute, apex rounded to acuminate, glabrous, tertiary venation reticulate, inconspicuous; male flowers in 3–5-flowered cymes, 4-merous, stamens 8–18; female flowers in 1–3-flowered cymes, 4–5-merous, calyx lobes valvate-plicate, pubescent on both sides, corolla divided to halfway, staminodes 4–6, ovary with 2 styles and 10–16 uni-ovulate locules; fruit ovoid to globose, with a short beak, 2–5 cm across, tomentose but glabrescent. *D. pilosanthera* is apparently an extremely variable species, as no less than 8 varieties have been distinguished. These are var. *chikusensis* Ng, var. *elmeri* (Merr.) Ng (synonym: *Diospyros elmeri* Merr.), var. *helferi* (C.B. Clarke) Bakh. (synonym: *Diospyros helferi* C.B. Clarke), var. *oblonga* (Wallich ex G. Don) Ng (synonym: *Diospyros oblonga* Wallich ex G. Don), var. *pilosanthera*, var. *polyalthoides* (Korth. ex Hiern) Ng (synonym: *Diospyros polyalthoides* Korth. ex Hiern), var. *nurii* Ng, and var. *tayabensis* (Merr.) Bakh. (synonym: *Diospyros tayabensis* Merr.). Different authors, however, still do not agree on this taxonomic solution and treat several varieties as distinct species. *D. pilosanthera* occurs in primary lowland forest, sometimes in peat-swamp forest or swampy locations, up to 900 m altitude. The density of the wood is very variable and ranges from 545 to 965 kg/m³ at 15% moisture content. See also the table on wood properties.



Diospyros pilosanthera Blanco – 1, tree habit; 2, flowering twig; 3, flower; 4, branchlet with fruits; 5, lateral and dorsal view of seed.

Selected sources 42, 77, 104, 140, 234, 335, 403, 457, 458, 463, 527, 544, 575, 586, 705, 734.

Diospyros poncei Merr.

Philipp. Journ. Sci., Bot. 10: 335 (1915).

Vernacular names Philippines: Ponce's kamagong (general), balingagta (Cagayan), ituman (Suriago).

Distribution The Philippines.

Uses The wood is used as streaked ebony, e.g. for carvings and furniture.

Observations A small to medium-sized tree up to 20 m tall, bole branchless for up to 8 m, up to 40 cm in diameter; leaves elliptical-oblong to oblong-lanceolate, 4–15 cm × 1.2–4.5 cm, base cuneate to obtuse, apex acute to obtusely acuminate, sericeous below, tertiary venation densely reticulate, slightly prominent on both surfaces; male flowers in 1–3-flowered cymes, 4-merous, stamens 12; female flowers solitary, 4-merous, calyx lobes imbricate, sericeous outside, corolla divided to one-third, ovary with a single style and 4 uni-ovulate locules; fruit ovoid-globose, at least 2 cm in diameter, velutinous to sericeous. *D. poncei* occurs in primary forest, up to 900 m altitude. The density of the wood is about 1000 kg/m^3 at 15% moisture content.

Selected sources 42, 527.

Diospyros pyrrhocarpa Miq.

Fl. Ind. Bat., Suppl. 1(2, 3): 250, 583 (1861).

Synonyms *Diospyros asterocalyx* Hiern (1873), *Diospyros ahernii* Merr. (1909).

Vernacular names Philippines: anang (Tagalog).

Distribution India (Assam), Burma (Myanmar), Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo (Sarawak) and the Philippines.

Uses The wood is used as black ebony, e.g. for bowling balls, golf clubs and rulers. The fruit is edible and sweet.

Observations A medium-sized to fairly large tree up to 38 m tall, bole up to 50 cm in diameter, with small buttresses, bark surface smooth, grey to black; leaves oblong to oblong-obovate, 10–30 cm × 4–10 cm, base acute to rounded, apex shortly acuminate, glabrous, tertiary venation reticulate, prominent on both surfaces; male flowers in 3–7-flowered cymes, 4–5-merous, stamens 12–20; female flowers in 3–7-flowered cymes, 4–5-merous, calyx lobes valvate, tomentose on both sides, corolla divided to two-thirds, staminodes 4–5, ovary with a single style with 4–5 stigmas and 8 or 10 uni-ovulate locules; fruit globose to depressed globose, 3–6 cm across. *D. pyrrhocarpa* is rare but fairly common in the Philippines and occurs in lowland and hill forest, up to 900 m altitude.

Selected sources 42, 125, 457, 527, 575, 705.

Diospyros ridleyi Bakh.

Gard. Bull. Str. Settl. 7: 183 (1933).

Synonyms *Diospyros pyrrhocarpa* Miq. var. *andamanica* Kurz (1877).

Distribution Peninsular Malaysia.

Uses The wood is used as ebony.

Observations A medium-sized tree up to 30 m tall, bole up to 65 cm in diameter, bark surface brittle, finely fissured, black; leaves oblong-elliptical or elliptical to ovate, 5–20 cm × 3–8 cm, base rounded to bluntly pointed, apex obtusely acuminate to rounded, glabrous, tertiary venation finely reticulate, prominent on both surfaces; male flowers in 1–7-flowered cymes, 4–5-merous, stamens about 12; female flowers solitary, 4(–5)-merous, calyx lobes valvate-plicate, tomentose on both surfaces, corolla divided to one-third, staminodes 5, ovary with 4 or 8 uni-ovulate locules; fruit ovoid-globose to depressed globose, 5–8 cm in diameter, glabrescent. *D. ridleyi* is uncommon and occurs scattered in lowland and hill forest, often near streams, up to 1200 m altitude.

Selected sources 42, 457, 671, 705.

Diospyros rigida Hiern

Trans. Cambr. Phil. Soc. 12: 257 (1873).

Synonyms *Diospyros subrigida* Hochr. (1904).

Vernacular names Indonesia: balem juh (Sumatra). Malaysia: kayu arang (Peninsular), kayu areng (Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sarawak, Sabah).

Uses The pale wood is used locally.

Observations A medium-sized tree up to 30 m tall, bole straight, up to 50 cm in diameter, bark surface smooth to finely fissured or flaky, black; leaves oblong to oblong-lanceolate, 15–50 cm × 3–15 cm, base acute to slightly cordate, apex bluntly acute to rounded, glabrous, tertiary venation reticulate, prominent on both surfaces; male flowers in many-flowered panicles or fasciculate, 4–5-merous, stamens (20–)75; female flowers usually solitary, 4–5-merous, calyx lobes imbricate, tomentose on both surfaces, corolla divided for one-quarter to one-third, ovary with 8–10 uni-ovulate locules; fruit depressed globose to broadly ovoid, 4.5–6.5 cm across. *D. rigida* is uncommon and occurs scattered in lowland forest, up to 500 m altitude. The density of the wood is 770–895 kg/m^3 at 15% moisture content.

Selected sources 42, 77, 140, 457, 705, 734.

Diospyros rufa King & Gamble

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 74 (extra numb.): 228 (1905).

Vernacular names Malaysia: betala bukit, kayu arang, mentuba (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as ebony. The fruits have been used to poison fish.

Observations A medium-sized tree up to 27 m

tall, bole straight, up to 50 cm in diameter, bark surface smooth, brown to black; leaves oblong to oblong-obovate or elliptical, (8–)12–22 cm × (2.5–)4.5–8.5 cm, base cuneate to obtuse or rarely rounded, apex acuminate, glabrous, tertiary venation reticulate, nearly invisible; male flowers in up to 16-flowered dense clusters, 4-merous, stamens 16; female flowers in fewer-flowered clusters, 4-merous, calyx lobes valvate, tomentose on both sides, staminodes about 7, ovary with a 4-lobed style and 8 uni-ovulate locules; fruit globose with flattened apex and base, 2.5–3.5 cm wide, finely hairy but glabrescent. *D. rufa* is uncommon and occurs scattered in lowland to lower montane forest, up to 1300 m altitude.

Selected sources 42, 78, 457, 705.

Diospyros rumphii Bakh.

Gard. Bull. Str. Settl. 7: 184 (1933).

Synonyms *Diospyros utilis* Koord. & Valeton ex Koord. (1898) non Hemsl.

Vernacular names Macassar ebony (En). Indonesia: maitem, moyondi (Sulawesi), mologotu (Moluccas).

Distribution Sulawesi and the Moluccas.

Uses *D. rumphii* is an important source of black and streaked ebony.

Observations A medium-sized to large tree up to 47 m tall, bole branchless for up to 24 m, up to 200 cm in diameter, with buttresses up to 5(–10) m high, bark surface fissured, grey or brown to black, inner bark brown to red; leaves ovate-lanceolate to oblong-elliptical, 10–25 cm × 3–10 cm, base cuneate to obtuse, apex acuminate to obtuse, minutely white hirsute below, tertiary venation reticulate, depressed above when fresh but slightly prominent on both surfaces when dry; male flowers in 3-flowered cymes, 4-merous, stamens 16; female flowers in 1–3-flowered cymes, 4-merous, calyx lobes imbricate, sericeous on both sides, corolla divided to halfway; fruit depressed globose, 3.5–5 cm wide, glabrescent except for the apex and base, with 4–10 seeds. *D. rumphii* occurs in lowland forest, up to 400 m altitude. The heartwood may be either entirely black, or black with greyish or red streaks.

Selected sources 42, 115, 234, 376, 403, 586.

Diospyros scortechinii King & Gamble

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 74 (extra numb.): 212 (1905).

Synonyms *Diospyros nana* Bakh. (1933).

Vernacular names Malaysia: kayu arang (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as ebony.

Observations A medium-sized tree up to 27 m tall, bole up to 45 cm in diameter; leaves oblong-elliptical, ovate, obovate, or elliptical, 3.5–20 cm × 1.5–7.5 cm, base acute to rounded, apex acuminate, glabrous, tertiary venation vaguely reticulate; male flowers in 3–5-flowered cymes, 4-merous, stamens about 13; female flowers solitary; fruit oblong-ellipsoid to oblong-ovoid, 1.7–3 cm × 0.7–1.5 cm, pubescent, with 1–4 seeds. *D. scortechinii* is uncommon and occurs scattered in hill and montane forest, at 400–1500 m altitude.

Selected sources 42, 457, 705.

Diospyros siamang Bakh.

Gard. Bull. Str. Settl. 7: 184 (1933).

Vernacular names Indonesia: siamang, serang (Sumatra), tuwih buwa (Kalimantan).

Distribution Peninsular Malaysia, Sumatra and Borneo (Kalimantan, Sarawak).

Uses The wood is reputed to be used as black ebony.

Observations A large tree up to 47 m tall, bole straight, cylindrical, up to 80 cm in diameter, with buttresses up to 1 m high, bark surface black or grey, inner bark turning yellow on exposure; leaves ovate to elliptical, 7–19 cm × 3.5–9 cm, base obtuse to rounded, apex acuminate to somewhat rounded, slightly glaucous below, tertiary venation reticulate, inconspicuous above, slightly prominent below; male flowers 4–5-merous, stamens 12–15; female flowers in 3–5-flowered cymes, calyx lobes imbricate, tomentose on both sides, corolla divided to about halfway, staminodes 8–10, ovary with a 4–5-lobed style and 8–10 uni-ovulate locules; fruit urn-shaped, 3–4 cm × 2.5–3.5 cm, densely velvety. *D. siamang* is locally common and occurs in peat-swamp forest at low altitude.

Selected sources 42, 457, 595, 705.

Diospyros singaporensis Bakh.

Gard. Bull. Str. Settl. 7: 185 (1933).

Synonyms *Diospyros kochummenii* Ng (1977).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as ebony.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 95 cm in diameter, bark surface smooth to fissured, black, grey, or green; leaves ovate to elliptical-obovate, 3.5–10 cm × 1.8–4 cm, base cuneate to rounded, apex obtusely broadly long acuminate, glabrous, tertiary venation reticulate, slightly prominent on both surfaces; male flowers in 2–3-flowered cymes, 4-merous, stamens about 15; female flowers in 1–2-flowered cymes, 4-merous, calyx lobes imbricate, densely pubescent outside, corolla divided for one-quarter to one-third, staminodes 4, ovary with a short 4-lobed style and 4 uni-ovulate locules; fruit globose to ellipsoid, up to 2.9 cm in diameter, glabrous. *D. singaporensis* is fairly common and occurs in lowland and hill forest, sometimes in peat swamp, up to 600 m altitude.

Selected sources 42, 457, 463, 705.

Diospyros styraciformis King & Gamble

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 74 (extra numb.): 216 (1905).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo (Sarawak, Brunei, Sabah).

Uses The wood is reputed to be used as ebony.

Observations A medium-sized tree up to 30 m tall, bole up to 40 cm in diameter, bark surface cracked to finely fissured, black, inner bark yellow on exposure; leaves elliptical-oblong to lanceolate, 5–17 cm × 2–7 cm, base of blade decurrent to the petiole, apex bluntly pointed to acuminate, sparsely puberulous but glabrescent, tertiary venation laxly reticulate to vaguely transverse; male flowers in many-flowered condensed cymes, 4-merous, stamens 12–16; female flowers in 3–many-flowered fascicles, 4-merous, calyx lobes valvate, tomentose outside, corolla divided to halfway, ovary with 8 uni-ovulate locules; fruit globose, beaked, 1.5–2.5 cm across, velvety. *D. styraciformis* is divided into 2 varieties: var. *styraciformis* occurring in Peninsular Malaysia, Singapore and Sumatra, and var. *sarawakana* (Bakh.) Ng (synonym: *Diospyros sarawakana* Bakh.) occurring in Borneo. The latter has fruits solitary or in pairs, instead of clusters of 3 or more. *D. styraciformis* is uncommon and found scattered in lowland to montane forest, up to 1750 m altitude.

Selected sources 42, 457, 705.

Diospyros sumatrana Miq.

Pl. Jungh. 1: 203 (1852).

Synonyms *Diospyros graciliflora* King & Gamble (1905), *Diospyros hendersonii* Ridley (1925), *Diospyros velutinosa* Bakh. (1941).

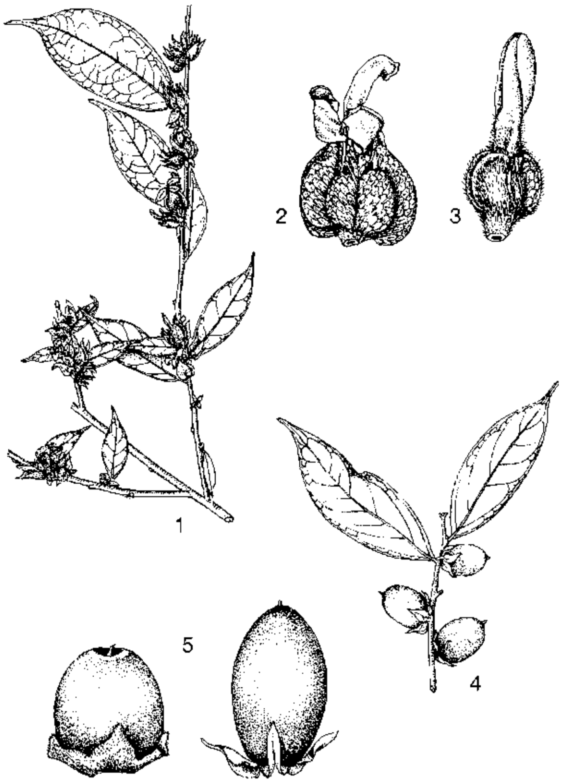
Vernacular names Malaysia: kayu arang, kayu sihangus, meribut (Peninsular). Thailand: lakkhoeilakklua, nian, dam (peninsular).

Distribution Thailand, Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as black ebony.

Observations A medium-sized tree up to 30 m tall, bole up to 40 cm in diameter; leaves oblong or ovate to obovate, 2–20 cm × 1.2–7.5 cm, base acute to narrowly tapering, apex acuminate, glabrous to densely pubescent below, glabrescent above, tertiary venation reticulate to vaguely transverse; male flowers in (1–)3–10(–16)-flowered cymes, 4-merous, stamens 8–16(–20); female flowers in 1–5-flowered cymes, 4-merous, calyx lobes valvate-plicate, pubescent on both sides, corolla divided to halfway, staminodes 8–9, ovary with a 2-forked style and 4 uni-ovulate locules; fruit ellipsoid or ovoid to globose, rarely obovoid, 1.2–2.5 cm × 0.7–2.4 cm, glabrous to hairy. *D. sumatrana* is a polymorphic species with a large variation in size and hairiness of leaves, number of secondary veins and tertiary venation pattern. It is common and occurs in lowland to montane forest, up to 1700 m altitude. The density of the wood is 615–865 kg/m^3 at 15% moisture content.

Selected sources 42, 78, 140, 457, 458, 461, 463, 575, 705.



Diospyros sumatrana Miq. – 1, flowering twig; 2, flower; 3, flower bud; 4, fruiting twig; 5, fruits.

Diospyros sundaica Bakh.

Gard. Bull. Str. Settl. 7: 186 (1933).

Synonyms *Diospyros pseudo-ebenus* Koord. & Valeton (1894).

Vernacular names Indonesia: kayu areng (Sundanese), budengan (Javanese), klicung (Bali).

Distribution Java and Bali.

Uses The wood is used as black ebony, e.g. for tool handles.

Observations A medium-sized to fairly large tree up to 35 m tall, bole cylindrical, up to 150 cm in diameter, bark surface fissured, brown to black; leaves elliptical-oblong, 5–15 cm × 1.5–6 cm, base cuneate to almost rounded, apex obtusely acuminate to subcaudate, glabrous, tertiary venation densely reticulate, slightly prominent on both surfaces; male flowers in 3-flowered cymes, 4-merous; female flowers solitary, 4-merous, calyx lobes valvate, pubescent outside, minutely sericeous inside, staminodes 7–8, ovary with a single style with 4–5 stigmas and 8 uni-ovulate locules; fruit depressed globose, 4–6 cm in diameter, glabrescent. *D. sundaica* is rare, also because of heavy logging, and occurs up to 400 m altitude. *D. pseudo-ebenus* Koord. & Valeton is regarded as a later homonym of *D. pseudebenum* (E. Mey. ex DC.) Parment. which renders it invalid. The wood is reported to be durable.

Selected sources 42, 234.

Diospyros toposia Buch.-Ham.

Trans. Linn. Soc., London 15: 115 (1827).

Synonyms *Diospyros incisa* Buch.-Ham. ex Wallich (1831), *Diospyros foveo-reticulata* Merr. (1909), *Diospyros collinsae* Craib (1920).

Vernacular names Malaysia: keruping besi, kayu arang pokok ikan mati (Peninsular). Philippines: bulatlat (Tagalog), kulitum (Iloko). Cambodia: kulen prey (Kmer), guingni (Moi). Thailand: mao-lek (south-western, peninsular), phlap-khaihan (peninsular). Vietnam: c[aa]y thi (Annam).

Distribution India, Sri Lanka, Cambodia, Vietnam, Thailand, Peninsular Malaysia, Borneo and the Philippines.

Uses The wood is used as black ebony. The ripe fruits are edible and used to poison fish. The gum exuding from freshly cut trees has been used against toothache.

Observations A medium-sized tree up to 27 m tall, bole up to 50 cm in diameter, bark surface smooth, brown to black, inner bark reddish; leaves oblong-ovate to oblong-obovate, 5–33 cm × 2–14 cm, base acute to rounded, apex acuminate, glabrous, tertiary venation finely reticulate, prominent on both sides; male flowers in 3–12-flowered cymes, 4-merous, stamens (18–)32–96; female flowers in 1–5-flowered cymes, 3–4-merous, calyx lobes valvate-plicate, velutinous on both sides, corolla divided to one-quarter, staminodes 12–16, ovary with (3–)4 short styles and 4–10 uni-ovulate locules; fruit ovoid to ellipsoid, 2–6 cm × 2–5 cm, glabrous except for the apex and base. *D. toposia* has been divided into 2 varieties: var. *toposia* and var. *toposioides* (King & Gamble) Phengklai (synonym: *Diospyros toposioides* King & Gamble). The latter has secondary veins which are distinctly impressed above and hairy filaments. *D. toposia* occurs scattered in lowland and hill forest, up to 1000 m altitude.

Selected sources 42, 120, 457, 495, 544, 575.

Diospyros transitoria Bakh.

Gard. Bull. Str. Settl. 7: 186 (1933).

Vernacular names Malaysia: kayu hitam (Peninsular). Thailand: maphlap-thong (south-eastern).

Distribution Southern Thailand and Peninsular Malaysia.

Uses The wood is used as ebony for cabinet work.

Observations A medium-sized tree up to 30 m tall, bole up to 50 cm in diameter, with small buttresses, bark surface cracked to fissured, black, inner bark brown to red or orange-red; leaves oblong-ovate to lanceolate or elliptical, 4.5–21 cm × 1.5–8 cm, base acute to tapering, apex acute to acuminate, pubescent but glabrescent above, usually velutinous at least on the midrib below, tertiary venation reticulate, prominent below or on both surfaces; male flowers in 3–4-flowered cymes, 4–5-merous, stamens c. 12; female flowers solitary, 4–5-merous, calyx lobes valvate-plicate, woolly on both sides, corolla divided to halfway, staminodes 4, ovary with a single style and 4(–5) stigmas and 8(–10) uni-ovulate locules; fruit ovoid to depressed ovoid, 2.5–3.5 cm in diameter, velvety. *D. transitoria* is locally common in lowland or hill forest, especially on limestone hills, up to 500 m altitude. The density of the wood is 875–1060 kg/m^3 at 15% moisture content.

Selected sources 42, 140, 457, 575, 705.

Diospyros venosa Wallich ex A.DC.

Prodr. 8: 233 (1844).

Synonyms *Maba merguensis* Hiern (1873), *Maba teysmannii* (Hassk.) Hiern (1873), *Diospyros hermaphroditica* (Zoll.) Bakh. (1933).

Vernacular names Indonesia: kayu budeng

(Javanese), ki lutung (Sundanese), lala-lalar bungo (Sumatra). Malaysia: kumoi (Peninsular). Singapore: timah-timah. Thailand: khaomai, dam, mai (peninsular).

Distribution Burma (Myanmar), Laos, Cambodia, Vietnam, Thailand, Peninsular Malaysia, Sumatra, Java, Borneo and the Moluccas.

Uses The wood is used as black ebony.

Observations A medium-sized tree up to 27 m tall, bole straight, branchless for up to 20 m, up to 80 cm in diameter, bark surface smooth, black; leaves elliptical or ovate to lanceolate, 4–25 cm × 2–12 cm, base cuneate to rounded, apex acute to acuminate, glabrous above, below sparsely hairy especially on the midrib, tertiary venation reticulate, often depressed above, prominent below; male flowers in 9-many-flowered cymes, 3–4-merous, stamens (6–)12–25; female and bisexual flowers in 3-many-flowered cymes, 3–4-merous, calyx lobes valvate-plicate, pubescent to glabrescent outside, usually glabrous inside, corolla divided to one-quarter, staminodes 3–6, ovary with 3–4 styles free or connate at base and 6–8 uni-ovulate locules; fruit oblong, ellipsoid or globose, 1.3–2.5 cm × 1.0–1.7 cm, glabrous except for a basal ring of hairs. *D. venosa* is a highly variable species within which 2 varieties have been distinguished: var. *venosa* and var. *olivacea* (King & Gamble) Bakh. (synonym: *Diospyros olivacea* King & Gamble). The latter is characterized by its velvety lower leaf surface, twigs, and inflorescences. The status of a third variety (var. *borneensis* Bakh.) is uncertain. *D. venosa* occurs scattered in lowland to lower montane forest, up to 1300 m altitude.

Selected sources 42, 234, 457, 575, 705.

I. Soerianegara (general part),
D.S. Alonzo (properties),
S. Sudo (wood anatomy),
M.S.M. Sosef (selection of species)

Dracontomelon Blume

Mus. Bot. Ludg.-Bat. 1: 231 (1850).
ANACARDIACEAE
x = unknown; *D. dao*: n = 18

Trade groups Dao: lightweight to medium-weight hardwood, e.g. *Dracontomelon dao* (Blanco) Merr. & Rolfe.

Vernacular names Dao: New Guinea walnut, Papua New Guinea walnut, Pacific walnut (En, Am). Indonesia: dahu (general), sengkuang (Kalimantan), basuong (Irian Jaya). Malaysia: sengkuang (Peninsular, Sabah), unkawang (Sarawak). Papua New Guinea: mon (Pidgin), laup (Tolai). Philippines: dao (general). Burma (Myanmar): nga-bauk. Thailand: phrachao ha phra ong (Chiang Mai). Vietnam: s[aas]u.

Origin and geographic distribution *Dracontomelon* consists of about 8 species which are distributed in India, Burma (Myanmar), Indo-China, China, Thailand, the Malesian area (3 species), towards the Solomon Islands, New Caledonia, and Fiji. *D. dao* has the largest area of distribution, from India to the Solomon Islands.

Uses The usually colourful timber is extensively used for furniture and interior finish, and also for joinery, cabinet work, shop fittings, decorative (sliced) veneers, plywood, panelling, moulding, flooring, light construction, fence posts, house posts, rafters, boat-building, shop fittings, cladding, lining, boxes, matches, turnery, carving and artifacts.

The fruits of most species are edible but sour; the kernel of the seeds is also edible. Locally, flowers and leaves are cooked and eaten as vegetable, and they may also be used as food flavouring, or medicinally. The bark is occasionally used in traditional medicine. Furthermore, the tree is planted as an ornamental in roadside plantings and used for firewood.

Production and international trade The export of dao from the Philippines varied considerably in the 1980s, but was never significant; in 1982 about 75 m^3 of processed timber was exported with a value of US$ 15 000 (US$ 200/m^3), and in 1987 only 5 m^3 with a value of US$ 900 (US$ 180/m^3). In Papua New Guinea, dao timber is ranked in MEP (Minimum Export Price) group 1, which fetches comparatively high prices; in 1992 the minimum export price for saw logs was US$ 80/m^3 and the best quality logs fetched US$ 140/m^3. Its importance has declined from a major export timber to contributing less than 1% of the total volume exported from Papua New Guinea in 1993. Japan imports it mainly from Papua New Guinea.

Properties Dao is a lightweight to medium-weight hardwood. The heartwood is greyish, greenish-yellow to walnut brown, often with irregular dark brown to nearly black bands or fine streaks; it is more or less clearly defined from the paler sapwood (pale yellow with pinkish or greyish tinge), which is up to 10 cm wide. The density is (330–)370–790 kg/m^3 at 15% moisture content. The grain is straight or interlocked, texture medium to coarse; a stripe or ribbon figure with black pencil-like streaks is usually present on quarter-sawn surfaces.

At 12% moisture content, the modulus of rupture is 81–100 N/mm^2, modulus of elasticity 11 000–12 600 N/mm^2, compression parallel to grain 46–49.5 N/mm^2, compression perpendicular to grain c. 7.5 N/mm^2, shear 10.5–11 N/mm^2, cleavage c. 48 N/mm radial and 67 N/mm tangential, Janka side hardness 3650–5030 N and Janka end hardness 4050–5580 N.

The rates of shrinkage are moderate: from green to 15% moisture content 0.7–1.4% radial and 2.4–3.7% tangential, from green to 12% moisture content 1.2–2.1% radial and 3.0–4.6% tangential, and from green to oven dry 2.5–4.1% radial and 5.7–8.7% tangential. Air drying under cover occasionally results in some surface checking, twisting and cupping in back-sawn boards. Weighting of stacks is recommended. It takes about 2 months to air dry boards 25 mm thick from green to 15% moisture content, and 9–10 days to kiln dry boards 25 mm thick from green to 12% moisture content. Deformation on cross section (collapse) may be severe during kiln drying. The wood is stable in service once dry.

The wood is readily converted and easy to work with hand and machine tools, but tension wood is sometimes present, giving rise to a slight woolly surface on sawn material. It is easy to saw, as it is non-siliceous, and generally it can be planed to a smooth finish. Dao produces decorative veneer and plywood with satisfactory gluing properties and a good finish and polish. It is very easy to peel without pretreatment at a peeling angle of 91° for 1.5 mm thick veneer. The wood is moderately suited for particle board, fibreboard and pulping and not suited for cement board.

The durability of the heartwood is variable depending on area of origin, but in general it is regarded as non-durable and not resistant to termite and marine borer attack. The sapwood is also susceptible to powder-post beetle attack. The wood is susceptible to staining. The penetration of preservatives in both sapwood and heartwood is unsatisfactory. The retention of heartwood by the pressure treating method is only 22 kg/m^3, but that of the sapwood is much better: 370 kg/m^3.

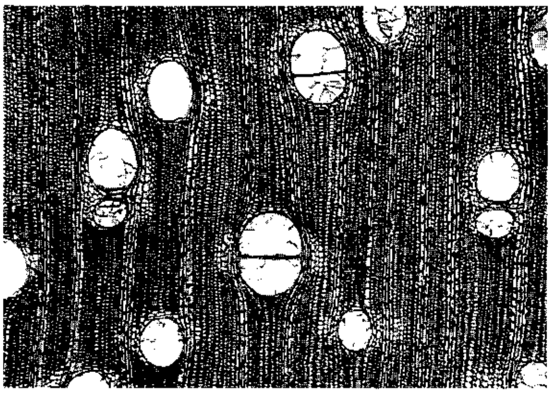
The wood contains 42–46% cellulose, 25–34% lignin, 9–10.5% pentosan and 0.8–2.2% ash. The solubility is 2.2–3.4% in alcohol-benzene, 2.4–4.5% in cold water, 4.7–7.5% in hot water and 14.0–18.1% in a 1% NaOH solution. The energy value is about 16 600 kJ/kg. Unlike many other species of *Anacardiaceae*, dao contains no irritant sap.

Description Medium-sized to large evergreen or sometimes deciduous trees up to 45(–55) m tall; bole straight, branchless for up to 20(–25) m, up to 100(–150) cm in diameter, with distinct, thin buttresses up to 5 m high; bark surface smooth except for greenish-brown or grey-brown scales irregularly peeling off and forming depressions, inner bark soft, straw-brown or bright yellow to pinkish, exuding some watery, pale pink sap; crown rounded, spreading, heavily branched, branchlets with large leaf scars. Leaves arranged spirally, crowded towards the end of twigs, large, imparipinnate; leaflets opposite to alternate, slightly asymmetrical, ovate to oblong, entire, usually with hairy or glabrous domatia below. Inflorescence axillary or terminal, paniculate; bracts and bracteoles caducous. Flowers bisexual, actinomorphic, 5-merous, slightly fragrant, white to greenish-white; calyx lobed; petals valvate but imbricate at the apical part, puberulous outside or on both surfaces, or glabrous; stamens 10, in 2 whorls, those opposite the calyx lobes longer than those alternating with them, filaments glabrous, anthers dorsifixed; disk intrastaminal, puberulous but glabrescent, or glabrous; pistil composed of 5 carpels which are free but connate at base and apically, ovary superior, 5-celled, with a single ovule in each cell, styles 5, stigma capitate with the stigmatic tissue lateral. Fruit a drupe, 5-celled, or seemingly 1-celled by abortion, each cell with a distinct operculum, endocarp woody and hard. Seed pendulous from an apical, axial placenta; testa free from the endocarp. Seedling with epigeal germination; cotyledons free, plano-convex; first 2 leaves trifoliolate and opposite, subsequent leaves arranged spirally, with increasing numbers of leaflets.

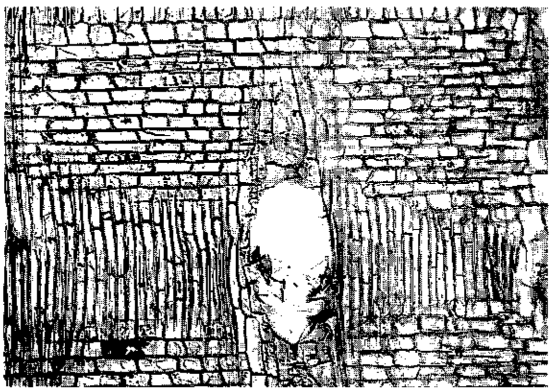
Wood anatomy

– Macroscopic characters:

Heartwood greyish or greenish-yellow to walnut grey-brown or reddish-brown, with irregular dark brown to black streaks, often clearly demarcated from the wide pinkish or greyish-yellow sapwood. Grain straight or interlocked. Texture moderately coarse to coarse and even, lustrous, wavy grain sometimes producing a coarse fiddle-back figure. Growth rings not evident, but occasionally darker bands of tissue present due to streaks; vessels large and distinct to the naked eye, evenly distributed; parenchyma abundant, paratracheal, vasicentric to aliform with some confluence, with occasional wide bands of parenchyma; rays moderately sized, visible to the naked eye as individual rays; ripple marks absent.



transverse section (×25)



radial section (×75)

tangential section (×75)

Dracontomelon dao

– Microscopic characters:
Growth rings inconspicuous, occasionally with narrow zones of thicker-walled fibres. Vessels diffuse, 1–3(–5)/mm^2, solitary and in radial multiples of 2–3(–6), mostly oval, tangential diameter 100–300 μm; perforations simple; intervessel pits alternate, coarse, rounded to polygonal, 10–14 (–18) μm in diameter; vessel-ray pits large, with strongly reduced borders or simple, mostly irregular, sometimes elongated; helical thickenings absent; tyloses abundant. Fibres 1.2–2.0 mm long, mostly septate, moderately thin-walled, with inconspicuous simple to minutely bordered pits confined to the radial walls. Parenchyma paratracheal, vasicentric, aliform to confluent particularly in smaller pores, with occasional wide bands, in 2–4-celled strands. Rays 5–7/mm, (1–)2–3(–5)-seriate, 400–600 μm (15–30 cells) high, heterocellular with 1–2 rows of square or upright cells (Kribs type heterogeneous II). Prismatic crystals abundant in procumbent and marginal ray cells. Silica absent. Horizontal intercellular canals absent.
Species studied: *D. dao*.
Superficially *Mangifera* wood with dark streaks may resemble dao wood, but it can be easily distinguished by the absence of septate fibres and consistent apotracheal bands of parenchyma.

Growth and development Young trees of *D. dao* reach a height of 3–4 m after 2 years and 6.5 m after 5.5 years. Larger branches develop in tiers.
In Peninsular Malaysia, Sarawak and Brunei *D. dao* is deciduous, shedding its leaves for only a short while after marked periods of dry weather. In Papua New Guinea the genus is deciduous to semi-deciduous and leaves are often shed just before the rainy season. Inflorescences are produced at the base of new shoots and the tree flowers just before all old leaves have fallen and new bronze-coloured leaves appear. However, *D. dao* is also reported to bear flowers almost throughout the year.
Dao is regarded as having bat-adapted fruits with colours duller than those of bird-dispersed fruits and a strong musty odour. The fruits ripen on the tree and at some distance from the foliage, to facilitate visits by bats.

Other botanical information The genus *Dracontomelon* belongs to the tribe *Spondieae*, together with e.g. the genera *Koordersiodendron* and *Spondias*. This tribe is characterized by the presence of compound leaves, united carpels with a pendulous ovule and number of stamens being twice the number of petals. Unlike many *Anacar-*

diaceae, most of the species in this tribe are not allergenic.
There is some confusion about the number of species within *Dracontomelon*, mainly because of the great variability within *D. dao*, especially in leaf hairiness. Many of the formerly recognized species have proven to be conspecific with *D. dao*, resulting in many synonyms. In Papua New Guinea, many of the former species are referred to as varieties of *D. dao*.
In the literature the generic name is often misspelled as *Dracontomelum*.

Ecology *Dracontomelon* species occur scattered in primary or secondary, evergreen or semi-deciduous (monsoon) forest at low altitude, rarely at 500–1000 m altitude. Dao occurs particularly in areas of high rainfall. In South Kalimantan, it is usually found on organosols, gley humus soils or red-yellow podzolic soils where annual rainfall is 1800–2900 mm. The species are found on well-drained to poorly drained soils, mainly on alluvial flats and in swampy areas.

Propagation and planting Propagation is usually by seed. Seed should be extracted immediately after the fleshy fruits have been collected, to avoid fermentation and heating. Pulp and seed can be separated by maceration. For *D. dao*, one kg contains 520–620 seeds or about 70 fresh fruits. Seed does not retain its viability for a long time: the germination rate is approximately 33% when sown fresh, 11% when stored for one month, 7% when stored for two months, and 0.5% when stored for 4 months, whereas no germination was observed after 6 months of storage under ambient conditions for *D. dao* in Java. In Malaysia, 85–95% of fresh seed of *D. dao* is reported to germinate and germination takes 28–67 days. Seedlings can be planted out whithout problems. In trial plantations in Java where direct sowing had been practised, trees were present in 70% of the sown spots after 5 years. A trial plantation of *D. dao* in Java was established through direct sowing with a spacing of 1 m × 3 m. When clearing land for shifting cultivation, trees may be retained for their fruit production.

Silviculture and management In the Philippines stands of natural forest have been encountered with 8–10 trees per ha over 20 m tall. In the Bismarck Archipelago (Papua New Guinea), dao may contribute up to 7% of the total volume of commercial standing timber (trees over 50 cm in diameter) with an average of 30 m^3/ha.
Dao regenerates easily in abandoned agricultural plots. The canopy of a plantation of *D. dao* planted at 1 m × 3 m closes after 8 years. In Papua New Guinea, dao plantations have been established under the taungya system. *D. dao* tolerates shade. Since natural pruning is good, artificial pruning is seldom necessary, although big wounds heal very easily.

Harvesting In a trial with experimental felling of *D. dao* in Papua New Guinea a very high percentage of the trees appeared to be defective having hollow stems due to over-maturity. This phenomenon has also been recorded in Irian Jaya and Java. Younger trees do not show this defect.

Yield A 15-year-old plantation of *D. dao* in Java had a mean annual increment of 5.4 m^3/ha. Even after 15 years, planted trees had hardly formed any heartwood.

Handling after harvest Logs are debarked when still fresh and should be sprayed immediately with insecticides to prevent attack of *Platypus* spp., *Xyleborus* spp. and *Heterobostrycus aequalis*. Dao logs sink in water.

Genetic resources *D. dao* is considered a vanishing timber in the Philippines. Elsewhere, e.g. in Papua New Guinea, the importance of *Dracontomelon* is also decreasing as resources are depleted. Since the area of distribution of *D. dao* is extensive, it is expected that its genetic variation may be considerable.

Prospects Streaked dao wood is particularly sought after and is highly valued. Provenance trials might allow the selection of superior trees with desirable wood characteristics (e.g. the presence of nicely figured wood) and growth rates for the establishment of timber plantations. More research should be conducted on the silviculture of dao and the economic viability of commercial plantations.

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Selection of species

Dracontomelon costatum Blume

Mus. Bot. Lugd.-Bat. 1: 232 (1850).

Vernacular names Brunei: lengkubong. Indonesia: senlang (Sumatra), landur (Bassap Dayak, Kalimantan), senkuang (Malay, Samarinda).

Distribution Sumatra and Borneo (not recorded from Sarawak).

Uses The wood is reputed to be used as dao.

Observations A medium-sized tree up to 30(–35) m tall, bole branchless for up to 15 m and up to 80 cm in diameter, with buttresses up to 5 m high and 2 m wide, bark surface smooth, yellowish-brown, twigs with ovate lenticels; leaf rachis 10–35 cm long, leaflets 9–15, opposite, 6–22 cm × 3.5–9.5 cm, glabrous, without domatia; flowers 4–5 mm long, in panicles of up to 35(–70) cm long, disk glabrous; fruit ovoid, seemingly 1-celled due to abortion. *D. costatum* is found in primary forest below 150 m altitude, on sand or limestone, in marshy areas and on river terraces. The density of the wood is 460–710 kg/m^3 at 15% moisture content.

Selected sources 77, 162, 711.

Dracontomelon dao (Blanco) Merr. & Rolfe

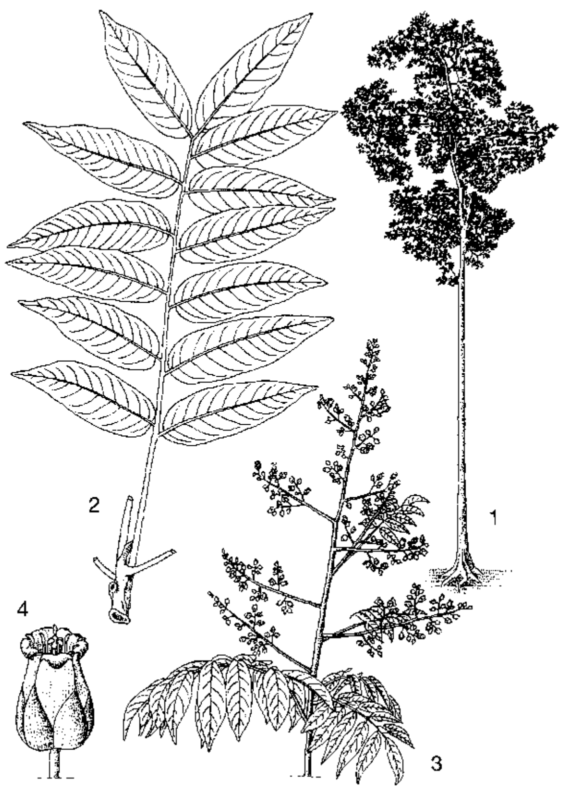
Philipp. Journ. Sci., Bot. 3: 108 (1908).

Synonyms *Dracontomelon mangiferum* Blume (1850), *Dracontomelon sylvestre* Blume (1850), *Dracontomelon puberulum* Miq. (1861), *Dracontomelon edule* (Blanco) Skeels (1912).

Vernacular names Indonesia: dahu (general), sengkuang (Kalimantan), basuong (Irian Jaya). Malaysia: sengkuang (Peninsular, Sabah), unkawang (Sarawak), sarunsab (Dusun, Sabah). Papua New Guinea: New Guinea walnut (general), mon (Pidgin). Philippines: dao (general), maliyan (Tagalog). Thailand: ka-kho, sang-kuan (peninsular), phrachao ha phra ong (Chiang Mai).

Distribution India, Burma (Myanmar), Thailand, Cambodia, southern China, thoughout the Malesian area towards the Solomon Islands.

Uses *D. dao* is the main source of dao timber (see general part). The tree is planted as an ornamental in roadside plantings. The fruit is edible but considered inferior and eaten mostly by chil-



Dracontomelon dao (Blanco) Merr. & Rolfe – 1, tree habit; 2, branchlet with leaf; 3, flowering twig; 4, flower.

dren; the kernel of the seed is also edible. Locally, flowers and leaves are cooked and eaten as a vegetable (Papua New Guinea), and they may also be used as food flavouring (the Moluccas), or medicinally (e.g. in Papua New Guinea). The bark is occasionally used in traditional medicine against dysentery (e.g. in Malaysia).

Observations A large tree up to 45(–55) m tall, bole branchless for up to 20(–25) m, up to 100(–150) cm in diameter, with narrow buttresses up to 6 m high, bark surface irregularly scaly, greyish-brown with brown or greenish patches, inner bark pink to red; leaf rachis 6–25(–44) cm long, leaflets (7–)9–19, alternate to opposite, 4.5–20(–27) cm × 2–7(–10.5) cm, glabrous or sometimes pubescent below, with hairy domatia; flowers 7–10 mm long, in panicles of up to 50 cm long, disk puberulous; fruit globose, 5-celled. *D. dao* occurs in primary or secondary evergreen to semi-deciduous forest in areas with high rainfall or less frequently in areas with a short dry season where it is deciduous or partly so. It is found scattered on clayey to stony soils, at 0–500(–1000) m altitude. The density of the wood is (330–)370–790 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 60, 62, 68, 69, 77, 78, 104, 125, 145, 162, 163, 176, 192, 225, 234, 261, 266, 271, 272, 278, 303, 330, 331, 334, 404, 453, 465, 526, 527, 544, 574, 595, 607, 655, 660, 703, 705, 709, 711, 727, 728, 731.

Dracontomelon lenticulatum Wilkinson

Journ. Nat. Hist., London 1: 505 (1967).

Vernacular names Papua New Guinea: habere (Suku), urau (Vailala).

Distribution New Guinea; also cultivated in the Botanic Garden at Lae (Papua New Guinea).

Uses The wood is reputed to be used as dao.

Observations A medium-sized to fairly large tree up to 37 m tall, bole branchless for about two-thirds of the total tree height, up to 120 cm in diameter, occasionally buttressed up to 3.6 m high, bark surface irregularly fissured, brown to grey-green; leaf rachis 22–57 cm long, leaflets 9–19, alternate to opposite, 22.5–32.5 cm × 5–13 cm, glabrous except for the hairy domatia below; flowers 4.5–5 mm long, in panicles up to 30 cm long, disk puberulous; fruit depressed globose, 5-celled. *D. lenticulatum* is found in lowland rain forest, commonly on raised alluvial flats and swampy ground.

Selected sources 162, 660, 710.

B. Louman (general part, selection of species),
W.G. Keating (properties),
J. Ilic (wood anatomy)

Duabanga Buch.-Ham.

Trans. Linn. Soc. Lond. 17: 177 (1837).
SONNERATIACEAE
$x = 12$; *D. grandiflora*, *D. moluccana*: $2n = 48$

Trade groups Duabanga: lightweight hardwood, *Duabanga grandiflora* (Roxb. ex DC.) Walp. and *D. moluccana* Blume.

Vernacular names Duabanga. Indonesia: benuang laki (Kalimantan), gayawas hutan (Moluccas), kalanggo (Sumbawa). Malaysia: magasawih, berembang bukit (Peninsular), magas (Sabah). Philippines: loktob (general). Burma (Myanmar): myaukngo. Cambodia: dlom chloeu ter. Laos: phay. Thailand: lamphu-pa (peninsular), tum ten (northern), lamphaen (Trang). Vietnam: b[oo]ng s[uw].

Origin and geographic distribution *Duabanga* consists of 2 species and is distributed from the eastern Himalayas to New Guinea: eastern India, Burma (Myanmar), Indo-China, Thailand, and Malesia (except Sumatra and western Java). *D. grandiflora* is confined to mainland South-East Asia (south to central Peninsular Malaysia), *D. moluccana* to the eastern part of the geographical range of the genus (west to Borneo and the Philippines).

Uses *Duabanga* timber is used for dugout boats, fishnet floats, floaters for the extraction of sinker logs, temporary construction, interior fittings and furniture, mouldings, cupboards, and matches and matchboxes. It has good properties for the production of veneer and plywood, being used for outer layers as well as core layers.

The young fruits are edible but sour. In Indonesia a decoction of the bark has been used in mixtures with other plants to dye matting black.

Production and international trade *Duabanga* is only locally commercially important. In Sumbawa (Indonesia), it is locally gregarious; the production was about 9000 m^3 in 1983. In 1992, the export of logs from Sabah was 37 000 m^3 and of sawn timber 4500 m^3 with a total value of US$ 3.6 million. Its availability in Papua New Guinea is variable, but *Duabanga* is rated as having commercial potential. Small amounts are imported by Japan, mainly from Sabah and Sarawak.

Properties *Duabanga* is a lightweight and comparatively soft wood. The heartwood is white or pale yellow to pale reddish-brown or greyish-brown, and not clearly demarcated from the 6–9 cm wide sapwood, which is slightly paler than the heartwood. The density is 270–560 kg/m^3 at 15% moisture content. The grain is usually shallowly interlocked, sometimes straight, texture coarse but even.

At 12% moisture content, the modulus of rupture is 43–90 N/mm^2, modulus of elasticity 6670–8285 N/mm^2, compression parallel to grain 30–44 N/mm^2, compression perpendicular to grain c. 7 N/mm^2, shear 6–11 N/mm^2, cleavage c. 37.5 N/mm tangential, Janka side hardness about 1380–4275 N and Janka end hardness c. 4740 N.

The rate of shrinkage is moderate: from green to oven dry about 3.7–3.9% radial and 6.6–7.2% tangential. The wood air dries rapidly and without serious degrade, but often darkens considerably on drying. Kiln drying may result in slight warping and splitting. In Burma (Myanmar), it is recommended to girdle the standing log several months before felling to facilitate drying.

The wood is easy to saw (it contains no silica), plane, shape, bore, turn and sand, but finishing is more difficult because of its softness. It holds nails and screws well and gluing is not a problem. Peeling properties are good, but care should be taken to prevent fungal attack when veneer or plywood is stacked tightly. Drying of veneer presents no problems.

The wood is perishable and susceptible to staining and termite attack. The wood of *D. moluccana* is reported as easy to impregnate, but that of *D. grandiflora* is sometimes more resistant to treatment with preservative.

Wood of *D. moluccana* contains 54% cellulose, 29% lignin, 16% pentosan and 0.6% ash. The solubility is 4.3% in alcohol-benzene, 4.4% in cold water, 11.5% in hot water and 20.6% in a 1% NaOH solution. The energy value is 19 660 kJ/kg.

Description Medium-sized to fairly large trees, up to 35(–45) m tall; bole cylindrical, up to 100 cm in diameter, buttresses absent or insignificant; bark surface smooth, lenticellate, becoming rough, inner bark soft, fibrous, yellow or reddish; crown monopodial, tall, oblong, rather open; twigs pendulous, 4-angled or winged, later becoming terete, with reddish young leaves towards the tips. Leaves opposite, biseriate, simple and entire, leathery, ovate-oblong with cordate or rounded base, glabrous or very soon glabrescent, conspicuously veined with numerous secondary veins, glaucous beneath; petiole short, stipules absent. Flowers in terminal 5–many-flowered corymbs, bisexual, 4–8-merous; calyx thickly leathery, gamosepalous, persistent, tube obconical or cup-shaped; petals equal in number to and alternating with sepals, broad and wrinkled, white; stamens 12 or numerous, inserted on the calyx, with long, slender filaments inflexed in bud; ovary superior, 4–8-celled, style long and robust with a capitate and lobed stigma. Fruit a loculicidally 4–8-valved capsule, many-seeded. Seed small, lacking albumen, tailed at both ends. Seedling with epigeal germination.

Wood anatomy

– Macroscopic characters:

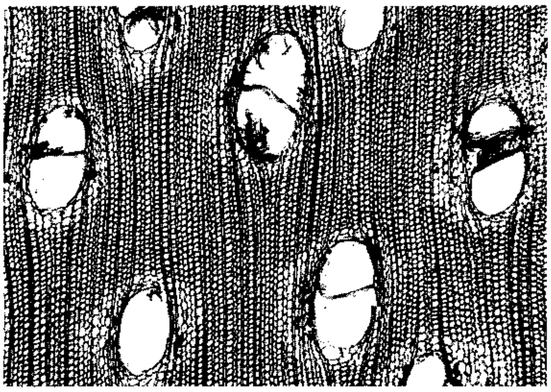
Heartwood comparatively soft, white or grey to pale reddish-brown, often streaked or tinted with yellow to pale brown, indistinctly demarcated from the paler sapwood. Grain straight to shallowly interlocked or wavy. Texture coarse. Growth rings indistinct or absent; vessels visible to the naked eye, with occasional tyloses visible with hand lens; parenchyma sometimes visible to the naked eye as pale halos around the vessels; rays not visible to the naked eye, barely distinct with a hand lens; ripple marks absent.

– Microscopic characters:

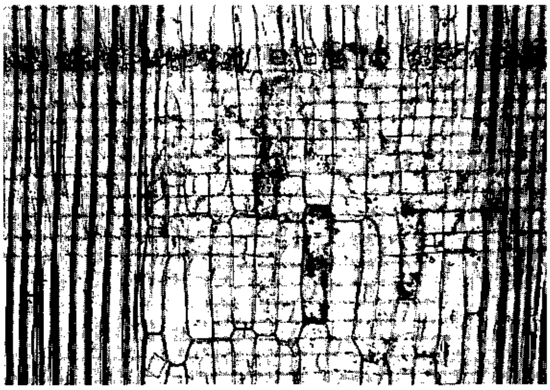
Growth rings indistinct or absent. Vessels diffuse, mostly 2–7/mm^2, usually in short radial multiples of 2–4, mostly 160–250 μm in diameter (sometimes up to 350 μm); perforation plates simple; intervessel pits alternate, circular or oval, vestured, 8–12(–14) μm; vessel-ray pits simple or with much reduced borders, enlarged, round to somewhat horizontally to vertically elongated (sometimes difficult to locate); tyloses common to infrequent. Fibres typically 1.2–1.4(–2.3) mm long, non-septate, very thin-walled to thick-walled, with simple to minutely bordered pits mainly confined to the radial walls. Parenchyma scarce to frequent, vasicentric to slightly aliform (lozenge type), 8 or more cells per parenchyma strand. Rays mostly 8–10/mm, exclusively uniseriate or nearly so, (400–)600–1200(–1600) μm high, homocellular to heterocellular with one row of upright and/or square marginal cells; storied structure absent. Prismatic crystals in upright and/or square marginal ray cells and in procumbent ray cells of *D. grandiflora*, and in non-chambered parenchyma cells of *D. moluccana*, mostly one crystal per cell or chamber, but sometimes two distinct sizes of crystals in one cell or chamber. Silica absent.

Species studied: *D. grandiflora*, *D. moluccana*.

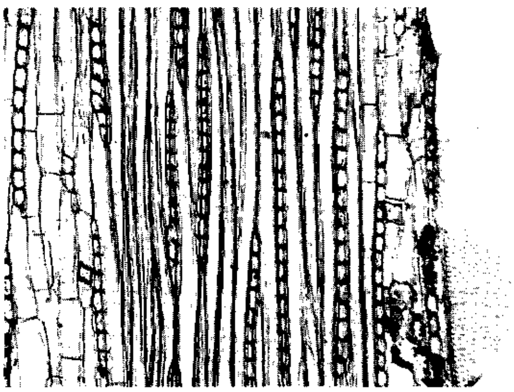
Growth and development *Duabanga* trees are light-demanding and fast growing. The average annual increment in height and in diameter is



transverse section (×25)



radial section (×75)



tangential section (×75)

Duabanga moluccana

reported as 67 cm and 2.5 cm, respectively, for *D. moluccana* in Indonesia; it grows to 60–70 cm in diameter in 25 years. In open places in India, an annual growth rate in height of almost 3 m has been achieved for *D. grandiflora* in a 10-year-old plantation. The latter species can reach a diameter more than 50 cm in 40 years in unthinned stands. Logs of up to 35 cm diameter and a merchantable height of 17.5 m have been obtained from an 11-year-old plantation of *D. moluccana* in the Philippines.

The architecture of *D. grandiflora* trees is according to Massart's model. The trunk is orthotropic and monopodial with leaves arranged spirally. It produces close series of branches as a result of rhythmic growth; the trunk shows regular tiers of 3–5 branches and proceeds to the top of the crown. The branches are plagiotropic, have opposite leaves and become pendulous with age.

The trees are evergreen or leafless for a short period in the dry season. They start to flower at an age of about 4–6 years. Trees often flower more or less continuously. The flowers, which are borne at the tips of branches, open after sunset and have a strong, sour to musty smell. They are pollinated by bats (e.g. *Eonycteris spelaea* and *Macroglossus sobrinus* for *D. grandiflora* in Peninsular Malaysia) and fall the next morning. The very light seeds have wings and are dispersed by wind.

Other botanical information Together with *Sonneratia*, a genus of mangrove trees, *Duabanga* constitutes the family *Sonneratiaceae*. These genera are sometimes placed in *Lythraceae*, and occasionally *Duabanga* is considered to represent a separate family: *Duabangaceae*.

A third species has been described in the genus from trees growing in a botanical garden in Sri Lanka (probably raised from seeds from the botanical garden in Bogor, Indonesia): *D. taylorii* Jayaweera. It shows several intermediate characters between the other 2 species and is possibly of hybrid origin. Its pollen and seed, however, showed good fertility.

Ecology *Duabanga* is characterized as a pioneer or early successional species just like kadam (*Anthocephalus chinensis* (Lamk) A. Rich. ex Walp.) and *Trema* and *Macaranga* species, and is found up to 1200 m altitude. The seedlings are very light-demanding and grow only in open sites. After the original forest has been disturbed, *D. moluccana* may form an almost pure stand (e.g. in Sumbawa), which is, however, not stable and gradually becomes dominated by other species such as *Syzygium* spp. In Papua New Guinea, *D.*

moluccana usually occurs on the edges of freshwater swamps and floodplains. *D. grandiflora* occurs more scattered in Peninsular Malaysia along rivers, especially in hilly country.

Propagation and planting The winged seed of *Duabanga* is very small and a single fruit contains 7000–8000 seeds. The weight of 10 000 seeds is about 1 g. Since *Duabanga* starts to flower when about 4 years old and ripe fruits can be harvested twice a year, it is usually easy to obtain seed for propagation.
It is recommended to select superior mother trees to obtain good-quality seed. Sowing in open seedbeds gives poor results, because seeds are washed away or seedlings are destroyed by rain. In India, the best results are obtained either by mixing seed with fine sand and sowing on very fine porous soil on raised seedbeds, on powdered charcoal or on fine sand in covered boxes. Water should be applied by spraying. Seeds will germinate within 20 days. The germination rate of *D. grandiflora* is 65–75% after 8 days. Weeding is recommended 2 months after germination as weed competition may reduce seedling growth by up to 30%. The seedlings are transplanted into polyethylene bags towards the end of the following rainy season, when they are 3–6 cm tall. The can be planted out in the 3 months after this, preferably at the beginning of the rainy season. Wildlings and stumps are also commonly planted. The planting distance is 4–7 m × 4–7 m. Thinning is practised to obtain an eventual spacing of 15 m × 15 m or about 40 trees/ha.

Silviculture and management Selective logging does create open areas where the light-demanding *Duabanga* seedlings can establish, but in areas with a low logging intensity other species which are more adapted to shade will predominate. Partial logging or group logging was adopted in Sumbawa (Indonesia) where areas of 5–10 ha were almost clear cut and subsequently planted with *D. moluccana*. A rotation of 50–70 years is recommended.

Diseases and pests Insects, deer and cattle feed on seedlings and young plants. In South Kalimantan (Indonesia), an unidentified stem borer was found to attack trees in the field, disturbing their growth and reducing the quality of the timber. Tunnels made by this insect were about 30 cm long and 1.5 cm in diameter.

Harvesting In Sumbawa (Indonesia), bulldozers are used for clear cutting and yarding. On slopes yarding by sky-line cables minimizes forest destruction. However, mechanized harvesting was noted to destroy approximately 115 m^3/ha of other timber species.

Yield *D. moluccana* has a mean annual increment of 4 m^3/ha. In a 50-year-old plantation with about 40 trees/ha, the logs had a diameter of 70–100 cm: with a timber volume of 5–10 m^3/tree the total standing stock was 200–250 m^3/ha. A 10-year-old plantation in India is reported to have produced 160 m^3/ha.

Handling after harvest *Duabanga* timber should be removed rapidly from logging areas, as it is susceptible to fungal and insect attack. The initial moisture content of timber can be very high (up to 120%) and fresh logs may even sink in water.

Genetic resources and breeding *Duabanga* easily invades disturbed areas and does not seem to be at immediate risk of genetic erosion. The occurrence of variation in density of green timber (about 90% of fresh logs float in water, about 10% sink) and of a putative hybrid may offer possibilities of breeding to obtain good planting stock for timber plantations.

Prospects *Duabanga* is a fast-growing tree with promising economic prospects for timber plantations. It may be suitable for reforestation of denuded areas. However, not much is known about silvicultural aspects and more research is needed.

Literature |1| Balai Teknologi Reboisasi Banjarbaru, Kalimantan Selatan, 1992. Pengelolaan hutan Duabanga di Calabai – Nusa Tenggara Barat [Management of Duabanga forest in Calabai – West Nusa Tenggara]. Penerbitan No 1: 43–49. |2| Dahms, K.-G., 1982. Asiatische, ozeanische und australische Exporthölzer [Asiatic, Pacific and Australian export timbers]. DRW-Verlag, Stuttgart. pp. 106–107. |3| Desch, H.E., 1954. Manual of Malayan timbers. Malayan Forest Records No 15. Vol. 2. Malaya Publishing House LTD., Singapore. pp. 564–567. |4| Jayaweera, D.M.A., 1967. The genus Duabanga. Journal of the Arnold Arboretum 48: 89–100. |5| Manan, S., 1991. Tinjauan silvikultur dan suksesi hutan alam Duabanga moluccana di Sumbawa [A review of the silviculture and succession of Duabanga moluccana natural forest in Sumbawa]. Kehutanan Indonesia 1991/1992 No 1: 3–7. |6| Sagala, A.P.S., 1992. Pengelolaan hutan alam Duabanga dan pembangunan tanaman Duabanga supplement di Calabai – Nusa Tenggara Barat [The management of Duabanga natural forest and the establishment of supplementary Duabanga plantations in Calabai – West Nusa Tenggara]. Kehutanan Indonesia

1991/1992 No 1: 9–10. |7| Susila, I.W.W., 1991. Model taksiran isi dolok kalanggo (Duabanga moluccana) di HPH VPI Sumbawa [Log volume estimation models of kalanggo (Duabanga moluccana) for the VPI forest concession in Sumbawa]. Santalum 7: 1–7. |8| Troup, R.S., 1921. The silviculture of Indian trees. Vol. 2: Leguminosae (Caesalpiniaceae) to Verbenaceae. Clarendon Press, Oxford. pp. 605–608. |9| Backer, C.A. & van Steenis, C.G.G.J., 1951. Sonneratiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 4. Noordhoff-Kolff N.V., Djakarta. pp. 280–289. |10| Whitmore, T.C., 1983. Sonneratiaceae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. A manual for foresters. 2nd Edition. Vol. 1. Forest Research Institute Malaysia. Longman Malaysia SDN. Berhad. pp. 442–444.

Selection of species

Duabanga grandiflora (Roxb. ex DC.) Walp.

Repert. bot. syst. 2: 114 (1843).

Synonyms *Duabanga sonneratioides* Buch.-Ham. (1837).

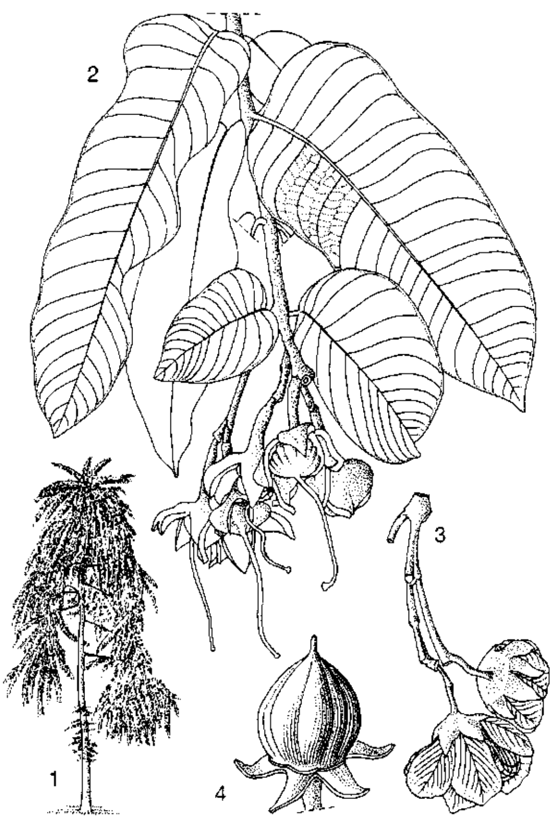
Vernacular names Malaysia: magasawih, berembang bukit, pedada bukit (Peninsular). Burma (Myanmar): myaukngo, lampati. Cambodia: dlom chloeu ter. Laos: phay. Thailand: lamphu-pa (peninsular), tum ten (northern), lamphaen (Trang). Vietnam: b[oo]ng s[uw], b[awx]ng l[af]ng b[aax]n, mi[as] t[uw][ow]ng.

Distribution Eastern India, Burma (Myanmar), Cambodia, Laos, Vietnam, Yunnan (China), Thailand, the Andaman Islands and northern Peninsular Malaysia (south to Negeri Sembilan).

Uses The timber is used especially for interior construction, furniture, crates and boxes, and veneer. The fruits are edible but sour.

Observations A medium-sized tree up to 30 m tall, but sometimes reaching 40 m, with cylindrical bole up to 80 cm in diameter, scarcely buttressed, completely glabrous; leaves ovate-oblong, 10–30 cm × 5–10 cm; flowers 5–8-merous, stamens more than 50; fruit ovoid. *D. grandiflora* often occurs scattered on open sites in hilly country up to 1000 m altitude. The density of the wood is about 450–565 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 78, 79, 104, 113, 115, 140, 162, 163, 185, 191, 205, 216, 264, 265, 380, 431, 447, 465, 523, 526, 529, 561, 648, 667, 705, 721.



Duabanga grandiflora (Roxb. ex DC.) Walp. – 1, habit of young tree; 2, twig with old flowers; 3, inflorescence; 4, fruit.

Duabanga moluccana Blume

Mus. Bot. Lugd.-Bat. 1: 109 (1850).

Vernacular names Indonesia: benuang laki (Kalimantan), gayawas hutan (Moluccas), kalanggo (Sumbawa). Malaysia: magas, tagahas (Sabah). Papua New Guinea: duabanga. Philippines: loktob (general), arek (Cagayan, Pangasinan), bukag (Cagayan, Ilocos).

Distribution Borneo, the Philippines, eastern Java, the Lesser Sunda Islands, Sulawesi, the Moluccas and New Guinea.

Uses The timber is used especially for temporary construction, furniture, boats and veneer. A decoction of the bark has been used in Indonesia for dyeing matting black.

Observations A medium-sized to fairly large tree up to 35 m tall, but sometimes reaching 45 m, with columnar bole up to 100 cm in diameter, not buttressed but slightly fluted at base, young parts brownish hairy; leaves ovate, oblong or sometimes lanceolate, 7–30 cm × 4–12 cm; flowers 4-merous, stamens 12; fruit ellipsoid. *D. moluccana* is locally co-dominant, along streams, on slopes, along logging tracks and in regrowth in former cultivation areas, up to 1200 m altitude. The density of the wood is 270–510 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 14, 30, 31, 36, 43, 60, 77, 92, 113, 115, 135, 162, 173, 191, 205, 264, 265, 286, 395, 396, 406, 408, 426, 431, 468, 474, 475, 516, 526, 531, 540, 615, 616, 622, 625, 667, 684, 708.

B. Sunarno (general part, selection of species),
N. Tonanon (properties),
R.H.M.J. Lemmens (properties),
R.B. Miller (wood anatomy)

Durio Adans.

Fam. 2: 399 (1763).
BOMBACACEAE
x = unknown; *D. zibethinus*: $2n = 56$

Trade groups Durian: lightweight to medium-weight hardwood, e.g. *Durio carinatus* Masters, *D. graveolens* Becc., *D. lowianus* Scort. ex King, *D. oxleyanus* Griffith, *D. zibethinus* Murray.

Vernacular names Durian (general). Malaysia: durian daun (Peninsular). Thailand: thurian (general).
Timber from *Coelostegia* spp. and *Neesia* spp. is sometimes also traded under the name durian. Durian timber has been traded as red meranti or in mixed consignments.

Origin and geographic distribution *Durio* consists of about 30 species and is distributed in Burma (Myanmar), Thailand, Peninsular Malaysia, Sumatra, Borneo and the southern Philippines (Palawan). Borneo is the richest in species (about 20 of which 14 are endemic), followed by Peninsular Malaysia (11, 3 endemic) and Sumatra (8, 1 endemic). The 'true' durian (*D. zibethinus*) is much cultivated for its fruits from southern India and Sri Lanka, throughout Malesia, to New Guinea, and occasionally outside this area (Australia, Hawaii, Zanzibar).

Uses Durian timber is used for construction under cover; in such conditions it is moderately durable. It is, however, not durable in exposed conditions, but treated durian can be used for door and window frames. Durian is also used for cheaper furniture, cabinets, light-traffic flooring, fittings, panelling, partitioning, plywood, chests, boxes, wooden slippers, low-quality coffins and ship building.

The fruits of *D. zibethinus* are much appreciated in South-East Asia because of the highly flavoured and pungent arils around the seeds which are eaten fresh or used for flavouring ice-cream and cakes, or fermented. Several other species also have fruits with edible seed arils. Boiled or roasted seeds are eaten as a snack, whereas young shoots and unripe fruits may be cooked and used as a vegetable. The dried fruit rind is used as fuel, in particular to smoke fish, and the ash is sometimes used for whitening silk and as a lye with dyes. The bark and the seeds are used medicinally. The bark is sometimes used for tanning, and occasionally also for roofing and wall covering.

Production and international trade *Durio* timber is traded as durian together with timber of the other *Bombacaceae* genera *Coelostegia* and *Neesia*. Durian is exported in fairly large amounts from Sarawak and Sabah, chiefly to Japan, and little from other areas. The total export of durian round logs from Sabah in 1987 was 5300 m^3 with a value of US$ 355 000 (US$ 67/m^3), and in 1992 it was 8500 m^3 (10% as sawn timber, 90% as logs) with a value of US$ 655 000 (US$ 170/m^3 for sawn timber, US$ 68/m^3 for logs).

Properties *Durio* yields a lightweight to medium-weight hardwood. The heartwood is pinkish-brown, red to deep red-brown, and usually distinctly demarcated from the whitish to pale yellow-brown or pale reddish-yellow sapwood. The density is 400–750(–850) kg/m^3 at 15% moisture content. The grain is straight to interlocked, texture coarse to very coarse and uneven. The wood has a foetid smell when freshly sawn.
At 15% moisture content, the modulus of rupture is 60.5–77 N/mm^2, modulus of elasticity 9595–12 740 N/mm^2, compression parallel to grain 35.5–42.5 N/mm^2, compression perpendicular to grain c. 4 N/mm^2, shear 4.5–10 N/mm^2, cleavage 36–37 N/mm radial and 40–46.5 N/mm tangential, Janka side hardness 2685–3210 N and Janka end hardness 3305–3955 N.
The rates of shrinkage are moderately low to moderately high: c. 2.4% radial and 4.0% tangential for *D. oxleyanus* wood from green to 15% moisture content, and 3.0–3.5% radial and 4.9–6.6% tangential for *D. carinatus* and *D. zibethinus* wood from green to oven dry. Durian wood can be air dried fairly rapidly without significant defects, but thin boards should be stacked properly as they tend to cup easily. Boards of *D. oxleyanus* wood 15 mm thick take about 3 months to air dry, boards 40 mm thick take 4 months. In Malaysia kiln schedule D is used and durian wood is generally

easy and rapid to kiln dry, but boards of *D. oxleyanus* wood 70 mm thick take up to 1.5 month to dry. It is recommended to air dry the timber for at least 2 weeks before kiln drying.

Durian wood can be sawn easily, but sometimes the wood surface tends to have a slightly raised grain. Wood of *D. griffithii* and *D. wyatt-smithii* has been reported to contain silica, which may cause difficulties in sawing. Tests on the machining properties of *D. oxleyanus* and *D. zibethinus* wood showed good results for planing, shaping and sanding, but only moderate results for boring, mortising and turning. The wood polishes reasonably well, and nails well. It can be peeled to make veneer at a 90° peeling angle without pretreatment. Gluing with urea-formaldehyde produces plywood meeting the German standard. Durian is suitable for manufacturing both structural and utility plywood.

Durian wood is classified as non-durable under tropical conditions. Test sticks of *D. lowianus* wood of 50 mm × 50 mm × 600 mm had decomposed in graveyard tests in Malaysia in 1.7 years. *Durio* wood is susceptible to dry-wood termite attack. During drying it is prone to powder-post beetle attack. Damage caused by pinhole borers also occurs frequently. The treatability of *D. zibethinus* wood with copper-chrome arsenic preservatives using the vacuum-pressure process is classified as moderate to difficult. Wood of *D. oxleyanus*, however, absorbed preservatives very readily when soaked in a cold mixture of creosote and diesel fuel.

Durio wood contains 51% cellulose, 24.5–27.5% lignin, 12–15% pentosan and 0.6–1.0% ash. The solubility is 1.4–5.1% in alcohol-benzene, 0.4–2.6% in cold water, 5.3–5.8% in hot water, and 14.8–17.2% in a 1% NaOH solution. The energy value of *D. zibethinus* wood is 18 640 kJ/kg.

Description Small to large trees up to 50(–60) m tall, with straight and cylindrical bole branchless for up to 35 m and up to 120(–140) cm in diameter, buttresses usually present, usually small and rounded to sometimes large, pneumatophores (knee roots) sometimes present in trees growing in marshy places; bark surface smooth or rough, flaky, scaly or fissured, often reddish-brown or dark brown but sometimes greyish or fawn coloured, inner bark pink, deep red, reddish-brown to dark brown; crown spreading and cauliflower-shaped, with large twisting branches. Twigs, inflorescences and leaf undersurfaces more or less densely covered with peltate scales, those on leaf undersurface subtended by stellate hairs which are sometimes exposed owing to absence or paucity of scales. Leaves alternate, simple and entire, generally oblong to elliptical or lanceolate, often copper-brown scaly below, secondary veins usually not prominent, generally curving and joining within the margin; petiole usually slender and swollen towards the apex; stipules present but usually soon shed. Inflorescence consisting of few-flowered cymes on twigs, older branches or bole. Flowers pedicelled, subtended by small or large, persistent or caducous bracts, with epicalyx closed over the bud and splitting into 2 lobes at anthesis; calyx 5-lobed but sometimes splitting into 5 free sepals, the base usually becoming sac-like; petals (4–)5(–6), free, longer than the calyx, white, yellow, pink or red; stamens numerous, free or united into 5 bundles, the bundles themselves free or united at base, each filament bearing 1–many unilocular anthers opening by a slit or an apical pore; ovary superior, sessile, (3–)5(–6)-celled with 2–many ovules in each cell, style 1, long and slender, stigma head-like, small. Fruit a large, woody, globose to ellipsoid capsule covered with spines, usually opening by 5 valves either on the tree or after falling. Seeds in 2 rows in each compartment of the fruit, usually with a prominent aril, with rather thin seed-coat and thick cotyledons. Seedling with epigeal germination ('durian type') with cotyledons remaining in the seed-coat, sometimes hypogeal, with long sturdy taproot and strongly enlarging hypocotyl, first leaves scale-like, normally developed leaves long-petioled with cuspidate apex, resembling those of mature trees but thinner.

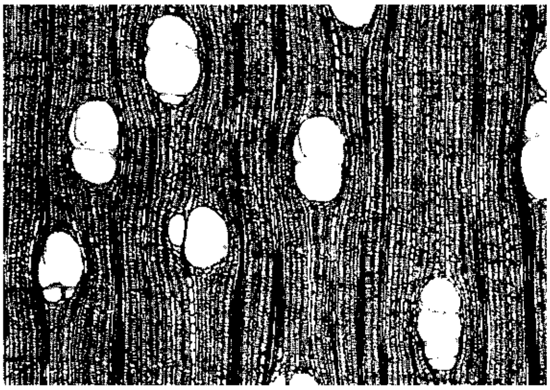
Wood anatomy

– Macroscopic characters:

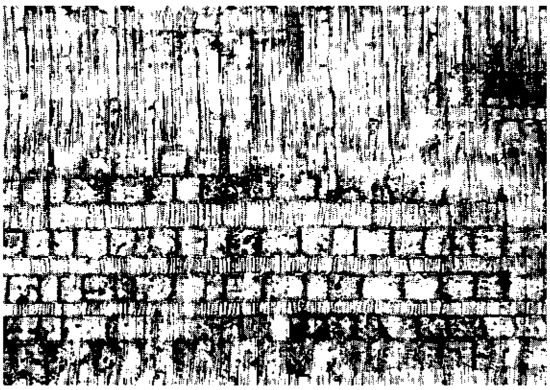
Heartwood pinkish-brown, red or deep red-brown, often but not always clearly distinct from the whitish, pale yellow-brown or pale reddish-yellow sapwood. Grain straight to interlocked. Texture coarse to very coarse and uneven. Growth rings absent; vessels visible to the naked eye, tyloses absent; parenchyma not visible to the naked eye, but distinct with a hand lens as diffuse-in-aggregates or fine narrow bands; rays barely visible to the naked eye; ripple marks absent.

– Microscopic characters:

Growth rings indistinct or absent. Vessels diffuse, mostly 1–5/mm^2, solitary and in short radial multiples of 2–3, round to oval, mostly 240–300 μm in tangential diameter; perforation plates simple; intervessel pits alternate, circular to oval, 6–8 μm; vessel-ray pits similar but half-bordered; tyloses absent. Fibres 0.7–2.0 mm long, non-septate, thin-



transverse section (×25)



radial section (×75)

tangential section (×75)

Durio oxleyanus

walled to thick-walled, with simple to minutely bordered pits mainly occurring in the radial walls. Axial parenchyma abundant, predominantly diffuse to diffuse-in-aggregates, or banded resulting from organized diffuse-in-aggregate parenchyma, generally in narrow bands or lines, up to 3 cells wide, reticulate, with 8 or more cells per parenchyma strand. Rays 5–8/mm, 800–2200(–3000) μm high, heterocellular with more than 4 rows of upright and/or square marginal cells, mostly 3–5(–6) cells wide; tile cells present of the same height as the procumbent ray cells ('durio' type); storied structure absent. Prismatic crystals in non-chambered axial parenchyma cells and in chambered axial parenchyma, generally in short chains of 2–5 chambers, 1 crystal per cell or chamber. Silica usually absent, but small silica bodies observed in axial parenchyma cells in one specimen of *D. oxleyanus*.

Species studied: *D. dulcis*, *D. lowianus*, *D. oxleyanus*, *D. zibethinus*.

Growth and development Germination of *D. zibethinus* seeds is observed to be 'epigeal-like' when seeds are sown with the micropyle pointing downwards and hypogeal when the micropyle is pointing upwards or when seeds are sown vertically in the soil. The 'durian germination' may be distinguished as a specific and distinctive type. It is characterized by the developing hypocotyl which lifts the seed body well above the ground before shedding it, with the cotyledons still enclosed. Most species have this type of germination, but a few species (e.g. *D. malaccensis* and *D. singaporensis*) show hypogeal germination with a shoot growing out at one end of the seed and a root from the other end. These latter species show delayed germination, and in their seed the embryo is represented by a swollen hypocotyl filling up the seed; cotyledons and radicle seem to be absent.

In Sabah, the mean annual diameter increment of *Durio* spp. is 0.3–0.5 cm.

Durio trees grow according to Roux's architectural model, i.e. a monopodial orthotropic trunk which shows continuous growth and has plagiotropic branches. Flowers are borne on the main limbs ('ramiflory') and when borne on the trunk ('cauliflory') flowers may even be found at ground level. Flowering is often seasonal, gregarious and regular and for some species twice a year. The flowering intensity of 35 *D. griffithii* trees in Peninsular Malaysia in four consecutive years was 60%, 57%, 5% and 89%. This species is self-incompatible and in natural forest only 8% of the flowers were found to be successfully fertilized; hence fruit set is very low. Other understorey species such as *D. acutifolius* and *D. malaccensis* also flower annually, but the emergent species *D. lowianus* and *D. oxleyanus* flower only at long intervals, like members of the *Dipterocarpaceae*. In some species floral initiation occurs 8 months prior to anthesis. Flowering within a tree is usually completed within 2–3 weeks. The flowers often have a sour smell and they usually open in the late afternoon. Ripe fruits usually fall from the trees 13–15 weeks after flowering.

Pollen of *D. zibethinus* and *D. graveolens* has been found in guano samples from *Eonycteris spelaea*, a nectarivorous bat, thus indicating that flowers of these species are pollinated by bats. Possibly other *Durio* species are also truly chiropterophilous. Flowers of *D. griffithii* are thought to be pollinated by large insects. The fruits are much sought after by animals (the attraction of wild durian fruits to orang-utans is well-known), which eat the arils and disperse the seeds.

Other botanical information *Durio* is closely related to *Coelostegia* and *Neesia*. *Coelostegia* differs in the epicalyx not completely covering the flower bud and the calyptriform corolla being shed a whole, while *Neesia* differs in the fruit wall having irritating hairs inside.

Two subgenera are distinguished: subgenus *Durio* having anthers dehiscent by a slit, and subgenus *Boschia* (Korth.) Kosterm. & Soegeng (formerly considered as a separate genus *Boschia*) having anthers opening by a pore.

Ecology Durian occurs in lowland rain forest up to 1000(–1300) m altitude, mostly in lowland dipterocarp forest, sometimes also in swamp forest and kerangas. The trees are usually scattered and uncommon, but some species are locally very common or even gregarious, e.g. *D. carinatus* in peat-swamp forest in Peninsular Malaysia and *D. lanceolatus* on sandy soils in dipterocarp forest in East Kalimantan. *D. zibethinus* is widely cultivated and sources disagree about its occurrence in the wild.

Propagation and planting Durian seed usually germinates rapidly, within a few days to a few weeks. As the seed often cannot withstand desiccation or low temperatures and hence cannot be stored, it is considered 'recalcitrant'. The following germination rates have been found for fresh seed: 95% in 5–19 days for *D. graveolens*, 85% in 8–58 days for *D. griffithii*, 100% in 12–21 days for *D. lowianus*, 85% (12 out of 14 seeds) in 9–36 days for *D. oxleyanus*, and 80–100% in 3–26 days for *D. zibethinus*. Some species, like *D. malaccensis* and *D. singaporensis* have staggered and delayed germination. *D. malaccensis* seed was found to have 90% germination in 48 days to over one year and *D. singaporensis* had 55% germination in 77 days to almost two years. Different grafting techniques are used to propagate *D. zibethinus* when aiming at fruit production.

Silviculture and management The *Durio* species of primary forest occur only scattered; in Peninsular Malaysia an average of 3.7 large trees in 40 ha was found. In a 50 ha plot of lowland forest in Peninsular Malaysia only 10 trees of *D. oxleyanus* with a diameter more than 30 cm, and 26 trees of *D. singaporensis* with a diameter more than 10 cm were found. The density of *D. griffithii* was, however, fairly high in the same plot, i.e. 120 trees of more than 10 cm in diameter. Natural regeneration in the forest is poor, and seedlings occur scattered. Therefore, management systems do not specifically take into account the occurrence and regeneration of durian. Only the species occurring in peat-swamp forest are more abundant, e.g. *D. carinatus*, which constitutes 25% of the timber volume of this forest type in Riau, Sumatra. However, natural regeneration of durian in forest in Sarawak is reported as good.

Diseases and pests *D. zibethinus* trees planted for their fruits may suffer from many diseases and pests; the most serious disease is patch canker caused by *Phytophthora palmivora*. Certain other species, such as *D. lowianus*, have showed resistance to this disease. Nothing is known about diseases and pests of *Durio* trees planted for timber.

Harvesting The logs of *Durio* are often spongy around the pith, which reduces the volume of timber.

Yield In a forest plot in East Kalimantan the estimated timber volume of *Durio* is 2.9–4 m^3/ha.

Handling after harvest The logs are susceptible to insect attack and should be extracted from the forest soon after felling. Some logs float in water and can be transported by river.

Genetic resources South-East Asia harbours a wide variety of genetic resources of *Durio*. However, extensive genetic erosion is reported for cultivated *D. zibethinus* in Indonesia, Malaysia and Thailand. Some genetic erosion occurs in wild *D. dulcis*, *D. grandiflorus*, *D. graveolens*, *D. kutejensis* and *D. oxleyanus* in Indonesia and in wild *D. graveolens* and *D. oxleyanus* in Malaysia. The trees occur in low density in the forest; this, coupled with the often poor natural regeneration, mean that protection is required. This is also important for improvement of durian cultivated for fruits, and in the future possibly also for timber.

Breeding It is known that *D. griffithii* is self-incompatible and thus an outbreeder. The wild durians may be very important for breeding currently cultivated species, such as *D. kutejensis*, *D. oxleyanus* and, particularly, *D. zibethinus*.

Prospects Although at present *Durio* contributes comparatively little to the timber industry, there is potential to plant non-clonal material of *D. zibethinus* in forest plantations so that financial returns can be obtained from the fruits while waiting for the trees to reach timber size. Preliminary trials of planting durian trees at edges of logged forest have been carried out in Malaysia.

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Selection of species

Durio acutifolius (Masters) Kosterm.

De Tropische Natuur 33: 34 (1953).

Synonyms *Boschia acutifolia* Masters (1875), *Durio griffithii* (Masters) Bakh. var. *acutifolius* (Masters) Bakh. (1924).

Vernacular names Indonesia: tupaloh, durian burung, durian anggang (Dayak, Kalimantan). Malaysia: durian daun runcing (Sabah), durian burong (Sarawak).

Distribution Borneo (Sarawak, Sabah and Kalimantan).

Uses The wood is reputed to be used as durian.

Observations A medium-sized tree up to 28 m tall, with bole branchless for up to 14 m and up to 50 cm in diameter having broad buttresses up to 5 m high, bark surface initially smooth and hoop-marked, becoming slightly flaky or fissured, pale brown; leaves elliptical-oblong, 6–15 cm × 2.5–6 cm, densely copper-brown scaly below; flowers usually solitary in leaf axils, petals c. 10 mm long, pale yellow, stamens free, opening by a pore; fruit narrowly ovoid to spindle-shaped, up to 6 cm long, outside wine-red with pyramidal spines. *D. acutifolius* grows on poor sandy and clay-rich yellow soils, often periodically inundated, up to 400 m altitude; it is locally common as understorey tree, but usually occurs scattered.

Selected sources 26, 77, 99, 234, 312, 576.

Durio affinis Becc.

Malesia 3: 246, t. 24 (1889)

Vernacular names Malaysia: punggai (Iban, Sarawak).

Distribution Peninsular Malaysia, Borneo (Sarawak, Brunei, Sabah, Kalimantan).

Uses The wood is reputed to be used as durian.

Observations A medium-sized to fairly large tree up to 35 m tall, with bole up to 50 cm in diameter having short buttresses or slightly fluted at base, bark surface smooth, grey-brown; leaves lanceolate, 8–18 cm × 2–4 cm, densely scaly below; flowers in short, hardly branched inflorescence on branches, petals up to 65 mm long, white, stamens united into a tube, opening by a slit; fruit ellipsoid-globose, up to 9.5 cm long, outside orange-yellow with broadly pyramidal spines. *D. affinis* is closely related to *D. testudinarum* and possibly conspecific and only differs in the position of the inflorescence on the tree. It occurs in lowland forest up to 300 m altitude. *D. affinis* is rare in Peninsular Malaysia and probably not common in Borneo; in Sarawak it occurs infrequently on loamy soils in dipterocarp forest.

Selected sources 12, 26, 77, 312, 576, 705, 724.

Durio carinatus Masters

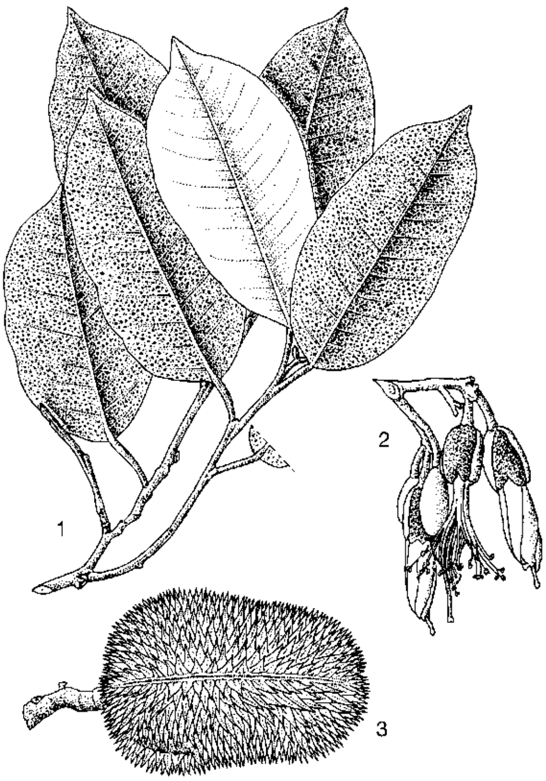
Journ. Linn. Soc. Bot. 14: 500 (1875).

Vernacular names Indonesia: durian burung, durian paya, durian hantu (Sumatra). Malaysia: durian paya (Peninsular, Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sarawak).

Uses The timber is used for light interior construction. The bark is used for roofing and wall covering. The aril around the seed is edible but rather tasteless.

Observations A medium-sized to large tree up to 45 m tall, with bole branchless for up to 27 m and up to 120 cm in diameter, usually without buttresses but large trees often with small buttresses up to 1.5 m high, sometimes with knee roots, bark surface superficially grooved or scaly, silvery pink to reddish-brown, with large white corky lenticels near base of trunk; leaves ovate-oblong, elliptical to lanceolate, 6–15(–25) cm × 2–7(–10) cm, densely pale brown scaly below; flowers in usually many-flowered inflorescence on old branches or in axils of leaves, petals up to 65 mm long, yellowish or salmon-coloured, stamens united into a tube at basal half, opening by a slit; fruit ovoid to ellipsoid, up to 13 cm long, outside pale orange-yellow with stiff pyramidal spines. *D. carinatus* occurs in marshy locations, especially in peat-swamp forest, sometimes gregariously, also on ground-water podzols in kerangas. The wood is greyish-red; the density is 400–670 kg/m^3 at 15% moisture content. See also the table on wood properties.



Durio carinatus Masters – 1, twig with leaves; 2, inflorescence; 3, fruit.

Selected sources 26, 234, 403, 458, 465, 576, 622, 705, 724.

Durio dulcis Becc.

Malesia 3: 243, t. 19 (1889).

Synonyms *Durio conicus* Becc. (1889).

Vernacular names Indonesia, Malaysia (Borneo): lahong, layung, durian bala (Dayak), durian merah (Malay), durian isa (Iban), pesasang (Tidung).

Distribution Throughout Borneo; occasionally also cultivated for the fruits.

Uses The wood is reputed to be used. *D. dulcis* is probably one of the principal sources of durian timber in Sarawak. The aril around the seed is edible and very sweet and fragrant.

Observations A fairly large tree up to 40 m tall, with bole up to 80 cm in diameter having large buttresses up to 4 m high, bark surface rough, superficially fissured or irregularly flaky, reddish-brown; leaves elliptical or obovate-elliptical, 7–14 cm × 3.5–6 cm, densely scaly below; flowers in short inflorescence clustered on older branches, petals up to 45 mm long, pink, stamens in bundles, opening by a slit; fruit globose, up to 15 cm in diameter, outside dark red to dark brown-red with long slender spines, very strong smelling. *D. dulcis* occurs in lowland forest up to 800 m altitude; it is found scattered in mixed dipterocarp forest on sandy clay soils and friable clay loams. The heartwood is pink to dark red-brown.

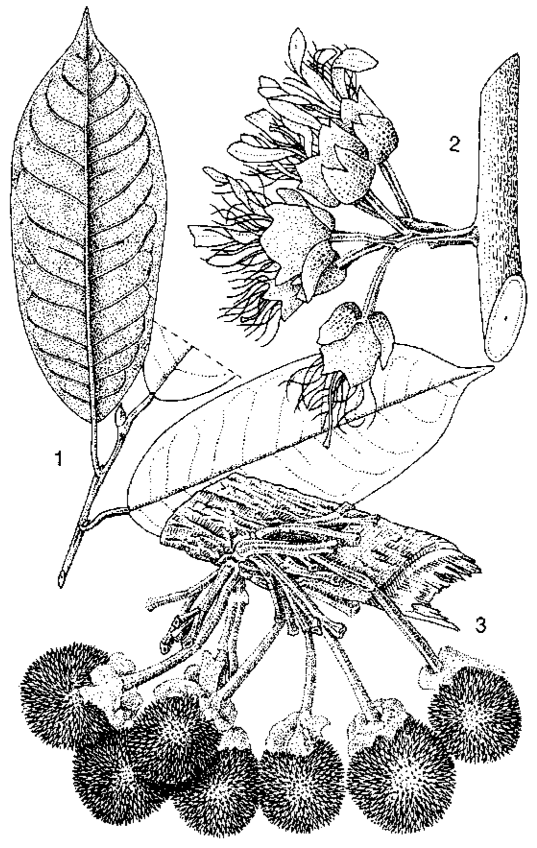
Selected sources 26, 77, 312, 576, 673.

Durio excelsus (Korth.) Bakh.

Bull. Jard. Bot. Buitenzorg, sér. 3, 6: 227, 250 (1924).

Synonyms *Boschia excelsa* Korth. (1839).

Vernacular names Indonesia: apun, durian daun, begurah, kumpang suluh (Dayak, Kalimantan).



Durio dulcis Becc. – 1, twig with leaves; 2, branch with inflorescence; 3, part of branch with infructescence.

Distribution Borneo (Kalimantan, Sarawak and Brunei).

Uses The wood is reputed to be used as durian.

Observations A medium-sized tree up to 30 m tall, with bole branchless up to 19 m and up to 60 cm in diameter, often buttressed up to 3 m high, bark surface deeply fissured, grey or fawn-coloured; leaves elliptical to oblong, 6–18 cm × 3–7 cm, densely covered with very small greyish-white stellate hairs below; flowers solitary or 2–3 together in axils of fallen leaves or on older branches, petals c. 30 mm long, white or pale green, stamens free, opening by a pore; fruit obovoid, up to 11 cm long, outside pinkish to orange or yellow with compressed conical spines. *D. excelsus* occurs in lowland mixed dipterocarp forest on sandy clay soils, up to 200 m altitude. The heartwood is whitish-brown.

Selected sources 12, 26, 312, 576.

Durio grandiflorus (Masters) Kosterm. & Soegeng

Commun. For. Res. Inst. Bogor 61: 10, fig. 7 (1958).

Synonyms *Boschia grandiflora* Masters (1875).

Vernacular names Brunei: sukang. Malaysia: durian munyit, durian hantu hutan, sukang (Sarawak, Sabah).

Distribution Northern Borneo (Sarawak, Brunei, Sabah); occasionally also cultivated for the fruits (e.g. in Brunei).

Uses The wood is reputed to be used as durian. The aril around the seed is edible.

Observations A medium-sized tree up to 30 m tall, with bole up to 50 cm in diameter, buttresses low and rounded, bark surface initially smooth and hoop-marked, becoming longitudinally cracked and flaky, and mauve-brown; leaves oblong to obovate, 9–24 cm × 3.5–8.5 cm, densely pale golden-brown scaly below; flowers solitary or 2 together, almost sessile in axils of fallen leaves or on older branches, petals up to 25 mm long, white, stamens partly in bundles, partly free, opening by a pore; fruit ellipsoid, up to 20 cm long, outside with pyramidal, stiff spines. *D. grandiflorus* resembles *D. excelsus*, but differs in the scaly lower leaf surface, the presence of a calyx tube, the stellately haired petals and the stamens partly arranged in bundles. It is locally common (especially in Sabah) in lowland mixed dipterocarp forest on clay-rich soils, up to 500 m altitude.

Selected sources 26, 77, 99, 312, 576, 673.

Durio graveolens Becc.

Malesia 3: 242, t. 26 (1889).

Vernacular names Indonesia: durian rimba, durian burung, tinambela (Sumatra). Indonesia, Malaysia: durian anggang, ta-bela (Dayak, Borneo), durian isa (Iban, Borneo). Malaysia: durian merah (Peninsular), durian burong (Malay, Sarawak). Thailand: thurian-rakka (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo (Sabah, Sarawak, Kalimantan); also cultivated in Sabah and Brunei.

Uses The wood is used as durian. *D. graveolens* is one of the important sources of durian timber in Sarawak. The aril around the seed is edible but not very juicy, fragrant or tasty.

Observations A large tree up to 50 m tall, with straight, cylindrical bole branchless for up to 25 m and up to 100 cm in diameter having steep buttresses up to 3 m high, bark surface smooth, finely cracked or flaky, reddish-brown or greyish-mauve;

leaves elliptical to oblong, 10–26 cm × 4–10 cm, densely copper-brown scaly below; flowers in short cymes on branches, petals 25–35 mm long, white, stamens in 5 bundles, opening by a slit; fruit globose, up to 15 cm in diameter, outside orange-yellow with sharp pyramidal spines. *D. graveolens* closely resembles *D. dulcis* but differs in the colour of the fruit. Moreover, the fruit opens while still on the tree showing the dark red arils, whereas the fruit of *D. dulcis* drops unopened and has dark yellow arils. *D. graveolens* occurs in lowland forest up to 1000 m altitude, in Sarawak on clay-rich soils in mixed dipterocarp forest and on shale ridges. The density of the wood is about 700 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 312, 463, 465, 576, 596, 673, 705, 724.

Durio griffithii (Masters) Bakh.

Bull. Jard. Bot. Buitenzorg, sér. 3, 6: 227 (1924).

Synonyms *Boschia griffithii* Masters (1874).

Vernacular names Indonesia: simartarutung, beberas (Sumatra), lai kuyu (Borneo). Malaysia: durian tupai, dendurian (Peninsular), lisoh (Kayan, Sarawak). Thailand: thurian-nok (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo (Sarawak, Sabah, East Kalimantan).

Uses The wood is used for house and ship building but is only moderately durable. The bark is sometimes used for tanning.

Observations A medium-sized tree up to 30 m tall, with slightly angular bole branchless for up to 15 m and up to 60 cm in diameter, but often much less, having small buttresses, bark surface smooth but becoming slightly rough, fissured and remotely cracked to powdery flaky on the butt, grey to pinkish-brown; leaves elliptical-oblong or obovate-oblong, 7–22 cm × 2.5–9 cm, densely covered with whitish stellate hairs below and with scattered scales especially on the veins; flowers solitary or in 2–3-flowered cymes in leaf axils, petals c. 11 mm long, yellowish-white or greenish-white, turning orange, stamens free, opening by a pore; fruit ellipsoid-obovoid, up to 7.5 cm long, outside scarlet with short, sharp, pyramidal spines. *D. griffithii* occurs in lowland mixed dipterocarp forest, up to 700 m altitude; in Sarawak it is usually confined to fertile clay-rich soils. The heartwood is pinkish-brown to reddish-brown; the density is 550–850 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 78, 104, 140, 211, 234, 458, 463, 465, 576, 703, 705, 724, 740, 741.

Durio kutejensis (Hassk.) Becc.

Malesia 3: 251, t. 21 (1889).

Synonyms *Lahia kutejensis* Hassk. (1858).

Vernacular names Brunei: durian kuning. Indonesia: lai, sekawi (Dayak, Kalimantan), durian tinggang (Malay, Kalimantan). Malaysia: durian merah (Sabah), rian isu (Iban, Sarawak).

Distribution Borneo (Kalimantan, Sarawak, Brunei, Sabah); often cultivated elsewhere in Malesia (e.g. Java) for the fruits or as an ornamental tree.

Uses The wood is reputed to be used as durian. The aril around the seed is edible and the fruit is popular.

Observations A small to medium-sized tree up to 30 m tall, with bole branchless up to 12 m and up to 40 cm in diameter having low, rounded buttresses, bark surface initially smooth and hoop-marked, later rather rough and flaky, grey to reddish-brown; leaves elliptical-oblong, (10–)20–33 cm × (3–)6–12 cm, densely pale golden-brown scaly below; flowers in irregular racemes on older branches, petals up to 90 mm long, red, stamens free, opening by a slit; fruit ovoid or ellipsoid, up to 20 cm long, outside dirty yellow with pyramidal often somewhat curved spines. *D. kutejensis* occurs wild in foothills of central Borneo; in Sarawak, it occurs locally on fertile clay-rich soils on undulating land in mixed dipterocarp forest. The heartwood is reddish-brown.

Selected sources 26, 36, 77, 99, 234, 312, 673.

Durio lanceolatus Masters

Journ. Linn. Soc. Bot. 14: 499 (1875).

Vernacular names Indonesia, Malaysia: kelincing, durian pelanduk, durian anggang (Borneo).

Distribution Throughout Borneo.

Uses The wood is used as durian. *D. lanceolatus* is one of the principal sources of durian timber in Sarawak.

Observations A large tree up to 50 m tall, with straight, cylindrical bole branchless for up to 35 m and up to 130 cm in diameter having large buttresses up to 3 m high, bark surface very rough and deeply fissured or flaky, rufous to dark brown; leaves oblong to lanceolate, 6–9 cm × 1.5–3 cm, densely dark copper-brown scaly below; flowers in many-flowered cymes in fascicles on old branches, petals up to 30 mm long, pale yellow, stamens all free or some slightly united at base, opening with a slit; fruit globose or slightly ellipsoid, up to 10 cm in diameter, outside dirty yellowish with pyramidal spines. *D. lanceolatus* is locally common, especially in East Kalimantan where it occurs on sandy soils together with bangkirai (*Shorea laevis* Ridley) and *Dipterocarpus confertus* v. Slooten. In Sarawak, it is locally common on loamy soils and friable clay soils on ridges up to 1100 m altitude. The heartwood is dark red.

Selected sources 26, 77, 312, 576.

Durio lowianus Scort. ex King

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 60: 51 (1891).

Synonyms *Durio wrayi* King (1891), *Durio zibethinus* Murray var. *roseiflorus* Corner (1939).

Vernacular names Malaysia: durian daun, durian sepeh, durian au (Peninsular). Thailand: thurian-don (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia and Sumatra.

Uses The wood is reputed to be used as durian. The aril around the seed is edible.

Observations A medium-sized to large tree up to 50 m tall, with bole up to 90 cm in diameter having steep, short buttresses, bark surface minutely reticulately fissured, flaking into irregular scales, purplish-brown; leaves oblong or ovate-oblong, 8–18 cm × 3–7 cm, densely to sparsely scaly below; flowers in many-flowered axillary cymes, petals up to 30 mm long, bright red, stamens in 5 bundles, opening by a slit; fruit globose, ovoid or ellipsoid, up to 25 cm long, outside green or yellowish with slender spines. *D. lowianus* is closely related to *D. dulcis* but differs in the fruit colour. It occurs in rain forest up to 150 m altitude. The density of the wood is 560–730 kg/m³ at 15% moisture content.

Selected sources 12, 78, 104, 140, 312, 463, 465, 673, 705, 724.

Durio macrophyllus (King) Ridley

Fl. Mal. Pen. 1: 264 (1922).

Synonyms *Durio testudinarum* Becc. var. *macrophyllus* King (1891).

Vernacular names Malaysia: durian daun besar (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as durian.

Observations A small to medium-sized tree up to 30 m tall having small buttresses, bark surface smooth, slightly lenticellate, pale greyish fawn coloured; leaves oblong, (18–)20–42.5 cm × (4–)5.5–15 cm, golden-brown scaly below; flowers in short cymes on the branches and sometimes on the trunk, petals up to 60 mm long, white, sometimes pink, stamens in 5 bundles joined in a tube, opening by a slit; fruit globose, up to 10 cm in diameter, outside bluish-green with sharp pyramidal spines. *D. macrophyllus* occurs in lowland rain forest up to 150 m altitude. The density of the wood is about 700 kg/m³ at 15% moisture content.

Selected sources 78, 104, 140, 312, 705, 724.

Durio malaccensis Planch. ex Masters

Hook.f., Fl. Brit. India 1: 351 (1874).

Vernacular names Indonesia: durian bangko, durian bangkolo (Sumatra). Malaysia: durian batang (Peninsular).

Distribution Peninsular Malaysia and Sumatra.

Uses The wood is reputed to be used as durian.

Observations A small to medium-sized tree up to 25 m tall, with bole up to 40 cm in diameter, buttressed or slightly fluted, bark surface rough, pinkish-brown; leaves oblong to lanceolate, 10–26 cm × 3–8 cm, densely minutely appressed silvery-brown scaly below; flowers in very short cymes on trunk and branches, petals up to 65 mm long, white or creamy white, stamens in 5 bundles united into a tube at base, opening by a slit; fruit globose, up to 13 cm in diameter, outside red with broadly conical spines. *D. malaccensis* occurs in rain forest up to 800 m altitude. The density of the wood is about 700 kg/m³ at 15% moisture content.

Selected sources 78, 104, 140, 312, 463, 465, 703, 704, 705, 724.

Durio oxleyanus Griffith

Calc. Journ. Nat. Hist. 5: 115 (1845).

Vernacular names Indonesia: durian daun (Sumatra), kerantongan, lotong, ladyin tedak (Kalimantan). Malaysia: durian beludu, durian burong (Peninsular), durian isa (Iban, Borneo).

Distribution Peninsular Malaysia, Sumatra and Borneo; sometimes cultivated.

Uses The timber is used for planks in house building. The small aril around the seed is edible and sweet. An extract from the bark is taken against malaria and grated seed is applied to ulcerations and wounds.

Observations A fairly large tree up to 40 m tall, with bole branchless for up to 30 m and up to 100(–140) cm in diameter having buttresses up to 3 m high, bark surface very rough, deeply fissured, peeling off in long pieces, dark brown or dark rusty brown; leaves broadly elliptical to oblong, 7–20 cm × 3–7.5 cm, densely covered with greyish stellate hairs below, scaly on veins; flowers in irregular cymes fascicled on twigs or on older branches, petals c. 15 mm long, white or pale cream, stamens in bundles alternating with 4 free stamens; fruit globose, up to 20 cm in diameter, outside greyish-green with large, stiff, broadly pyramidal, slightly curved spines. *D. oxleyanus* usually occurs as an emergent in moist locations in lowland rain forest, especially on frequently flooded clay-rich alluvium, up to 400 m altitude. The heartwood is reddish or pale red; the density is 530–750 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 12, 26, 77, 78, 104, 140, 234, 312, 403, 463, 465, 576, 705, 724, 740, 741.

Durio singaporensis Ridley

Journ. Roy. As. Soc. Straits Br. 73: 143 (1916).

Vernacular names Malaysia: durian bujor (Peninsular).

Distribution Peninsular Malaysia and Singapore.

Uses The wood is reputed to be used as durian.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole up to 60 cm in diameter having short thin buttresses or without buttresses, bark surface smooth to rough with horizontal ridges, reddish-brown; leaves oblong, (7.5–)13–30 cm × (2.5–)4–8.5 cm, densely appressed coppery scaly below; flowers in a short few-flowered inflorescence on branches, petals up to 70 mm long, white, stamens in bundles united at base into a long tube, opening by a slit; fruit globose, rarely slightly ellipsoid, up to 11 cm in diameter, outside greenish with slender spines; seed without aril. *D. singaporensis* is locally common in lowland rain forest up to 1000 m altitude. The density of the wood is about 750 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 312, 463, 465, 705, 724.

Durio testudinarum Becc.

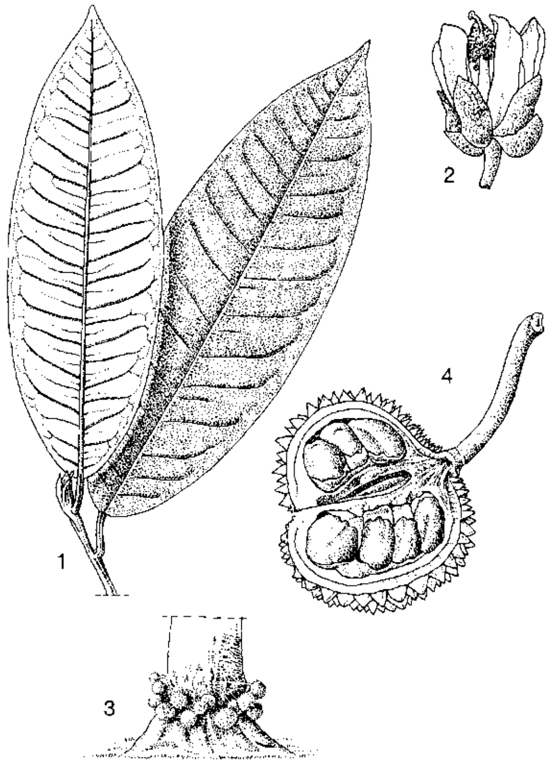
Malesia 3: 245, t. 13, 14, 36, fig. 17–19 (1889).

Vernacular names Indonesia, Malaysia: durian kura, luyian beramatai (Borneo).

Distribution Borneo (Sarawak, Brunei, Sabah and western Kalimantan); sometimes cultivated (e.g. in Brunei).

Uses The wood is reputed to be used as durian. The fleshy yellow arils around the seeds are edible.

Observations A medium-sized tree up to 25 m tall, with bole up to 40 cm in diameter having low and rounded buttresses; leaves elliptical, 19–26 cm × 6–9 cm, densely appressed scaly below; flowers in short inflorescence on the trunk in a ring close to the ground, petals up to 70 mm long, white, stamens in bundles united at base into a long tube, opening by a slit; fruit globose, up to 15 cm in diameter, outside greenish-yellow with conical-pyramidal spines. *D. testudinarum* is closely related to and possibly conspecific with *D. affinis*. *D. testudinarum* occurs in lowland mixed dipterocarp forest, often in hilly country; in Sarawak it is locally frequent on clay-rich well-drained soils up to 700 m altitude. The density of the wood is 520–740 kg/m^3 at 15% moisture content.



Durio testudinarum Becc. – 1, twig with leaves; 2, flower; 3, base of trunk with fruits; 4, opened fruit.

Selected sources 26, 77, 99, 312, 576, 673.

Durio wyatt-smithii Kosterm.

Commun. For. Res. Inst. Bogor 62: 17, fig. 6, 7 (1958).

Vernacular names Malaysia: durian ijau laut, durian burung (Peninsular).

Distribution Peninsular Malaysia; possibly also Borneo (Sarawak, Brunei).

Uses The wood is reputed to be used as durian.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole up to 90 cm in diameter having large, spreading buttresses up to 4 m high, bark surface cracking and scaly, chocolate-brown; leaves oblong to elliptical, 10–19 cm × 4–7 cm, densely appressed glaucous scaly below; flowers in few-branched inflorescence on older branches and trunk, petals c. 40 mm long, greenish-white or creamy white, stamens in 5 free bundles, opening by a slit; fruit subglobose, up to 12 cm in diameter, outside with rather slender spines having a broad base. *D. wyatt-smithii* is closely related to *D. zibethinus* but differs in the shorter calyx and more slender fruit spines. It is locally very common. The density of the wood is about 635 kg/m³ at 15% moisture content.

Selected sources 77, 104, 312, 705, 724.

Durio zibethinus Murray

Syst. Nat. Veg. ed. 13: 581 (1774).

Synonyms *Durio acuminatissima* Merr. (1926).

Vernacular names Durian (general). Indonesia: duren, ambetan (Javanese, Java), kadu (Sundanese, Java). Malaysia: durian kampong (general), durian puteh (Sabah). Philippines: dulian (Sulu). Burma (Myanmar): du-yin. Cambodia: thuréén. Laos: thourièn. Thailand: thurian (general), rian (peninsular). Vietnam: s[aaf]u ri[ee]ng.

Distribution Trees which are probably wild are found in Sumatra and Borneo. *D. zibethinus* is cultivated for its fruits in the area ranging from Sri Lanka and southern India to New Guinea.

Uses The timber is used for interior construction, cheaper types of furniture and packing cases. The tree is, however, much more appreciated for the aril around the seed, which is eaten fresh or used for flavouring ice-cream, drinks and cakes. The boiled or roasted seeds are eaten as a snack, whereas young shoots and unripe fruits may be cooked as a vegetable. The rind of the fruit is used as fuel. Several parts of the tree are used medicinally.

Observations A medium-sized to fairly large tree up to 40 m tall, with straight cylindrical bole up to 100 cm in diameter having prominent steep buttresses, bark surface peeling off in small flakes, dark reddish-brown; leaves elliptical or lanceolate-elliptical, 10–25 cm × 3–9 cm, densely silvery or golden scaly below; flowers in corymbs fascicled on older branches, petals c. 60 mm long, white or yellowish-white, stamens in 5 free bundles; fruit globose, ovoid or ellipsoid, up to 25 cm long, outside green to yellow or brownish with sharp broadly pyramidal spines. The heartwood is dark red; the density is 420–690 kg/m³ at 15% moisture content. See also the table on wood properties.

Selected sources 2, 12, 26, 77, 78, 99, 104, 125, 140, 216, 217, 234, 312, 403, 458, 463, 465, 526, 596, 621, 673, 703, 704, 705, 724.

S.K. Yap (general part, selection of species),
A. Martawijaya (properties),
R.B. Miller (wood anatomy),
R.H.M.J. Lemmens (selection of species)

Dyera Hook.f.

Journ. Linn. Soc., Bot. 19: 293 (1882).

APOCYNACEAE

x = unknown; $2n$ = unknown

Trade groups Jelutong: lightweight hardwood, *Dyera costulata* (Miq.) Hook.f. and *D. polyphylla* (Miq.) v. Steenis.

Vernacular names Jelutong. Indonesia: jelutung. Thailand: teen-pet daeng (peninsular), yeluu-tong, luu-tong (Malay, peninsular).

Origin and geographic distribution *Dyera* consists of only 2 species and is found in peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo, and intervening islands.

Uses Jelutong timber is light and soft, is easy to work and exceptionally stable but not at all durable. It has a number of specialty uses such as pattern making in foundry work, for drawing boards, pencils, picture frames, dowels, carving, blackboards, wooden toys, clogs, brush handles and battery separators, and it is also used for furniture parts, door knobs, ceilings, partitioning, matchsticks, matchboxes and packing cases. Similar to *Alstonia* wood, the presence of latex traces may limit the utilization of jelutong. The roots are used as a substitute for cork and their wood for axe handles.

The latex, which can be tapped, is used in the manufacture of chewing gum, but is hardly exported nowadays. In earlier days, before the arrival of para rubber (*Hevea brasiliensis* (Willd. ex A.L. Juss.) Muell. Arg.), it was used as rubber, but of low quality. The latex has also been used in paints, as priming for concrete, or for sizing paper. Follicles are occasionally used as torches by the local population or burnt to repel mosquitoes.

Production and international trade In the period from 1980–1990 the export of jelutong sawn timber from Peninsular Malaysia was 32 000–44 000 m³/year with a value of US$ 5.1–10.8 million/year; in 1992 it was 19 000 m³ with a value of US$ 8.3 million (US$ 440/m³). The export from Sabah was 67 000 m³ in 1987 with a value of

US$ 4.5 million, and 23 000 m^3 (55% as sawn timber, 45% as logs) in 1992 with a total value of US$ 3.5 million (US$ 215/m^3 for sawn timber, US$ 82/m^3 for logs). Japan imports comparatively large amounts of jelutong, mainly from Sarawak and Sabah.

In Malaysia, the trade in latex has declined since the peak production period 1930–1940. The export of jelutong latex from Indonesia was still 3500 t in 1989.

Properties Jelutong is a lightweight hardwood. The heartwood is creamy white or pale yellowish-white, the surface partially pinkish when freshly cut and darkening on exposure, indistinctly demarcated from the sapwood. The density is 220–560 kg/m^3 at 15% moisture content. The grain is straight, texture moderately fine to moderately coarse and even.

At 15% moisture content, the modulus of rupture is 36–50 N/mm^2, modulus of elasticity 5780–8100 N/mm^2, compression parallel to grain 17.5–27 N/mm^2, compression perpendicular to grain 2.5 N/mm^2, shear 3–6 N/mm^2, cleavage 20.5–36 N/mm radial and 28.5–41 N/mm tangential, Janka side hardness 775–1780 N and Janka end hardness 1255–1725 N.

The rates of shrinkage are fairly low: from green to 15% moisture content 0.8% radial and 2.0% tangential, and from green to 12% moisture content 1.3% radial and 3.6% tangential. The wood dries easily with a slight tendency to check and warp, but discoloration is a problem. Boards 10 mm, 25 mm and 40 mm thick take 1.5 months, 2 months and 3 months, respectively, to air dry from 70% to 15% moisture content. In Malaysia kiln schedule H is recommended. It takes about 6 days to kiln dry 25 mm thick boards from 50% to 10% moisture content.

Jelutong is easy to saw, although saw teeth may be clogged by latex. It is easy to work by hand and machine tools. In general, planing, turning, mortising and sanding give good results, but boring and shaping may give only moderate results. It can easily be polished, nailed and screwed, glued, stained and varnished. Jelutong wood can easily be peeled without pretreatment at a peeling angle of 90°; the resulting veneer can be glued without difficulty.

Jelutong wood is non-durable. Graveyard tests in Malaysia showed an average service life of stakes in contact with the ground of less than 6 months to 1.5 years. The wood is susceptible to pinhole borer, powder-post beetle and termite attacks. It is also very susceptible to blue stain, and the resistance to wood-rotting fungi varies from poor to moderate. The wood is easy to treat with preservatives by both the vacuum-pressure process and cold soaking. The wood may absorb more than 480 kg/m^3 of preservative using the open tank method and an equal mixture of creosote and diesel fuel.

Wood of *D. costulata* contains 57% cellulose, 13% pentosan, and 0.6% ash. The solubility is 3.2% in alcohol-benzene, 1.0% in cold water, 5.6% in hot water and 14.5% in a 1% NaOH solution.

The latex contains principally the triterpene lupeol, α-amyrin and β-amyrin (as acetates).

Description Large to very large deciduous trees, up to 50(–65) m tall; bole straight, columnar, branchless for up to 30 m, up to 250 cm in diameter, without buttresses, sometimes with pneumatophores; bark surface smooth, with small squarish scales leaving dippled patches, greyish-red or brown to dark grey, inner bark mottled, pale brown to whitish, with copious latex; crown monopodial at first, with whorled branches; branchlets 5–8-angled. Leaves verticillate, (5–)7 (–8) in a whorl, glabrous. Flowers in slender axillary panicles, 5-merous, small, fragrant; calyx lobes rounded, margin frilled, with glands at the base inside; corolla with a short slightly angled tube, with a ring of hairs inside, white, fragrant, the lobes overlapping to the right; stamens inserted on the tube above the ring of hairs, the connective prolonged into a fleshy appendage; ovary semi-inferior, pubescent, style single, short. Fruit a pair of large woody spreading follicles, dehiscing along a dorsal suture. Seeds 12–24 in each follicle, flat, elliptical, glabrous, surrounded by a membranous wing. Seedling with epigeal germination, cotyledons leafy, hypocotyl elongated; first few pairs of leaves opposite, leaves appearing later whorled.

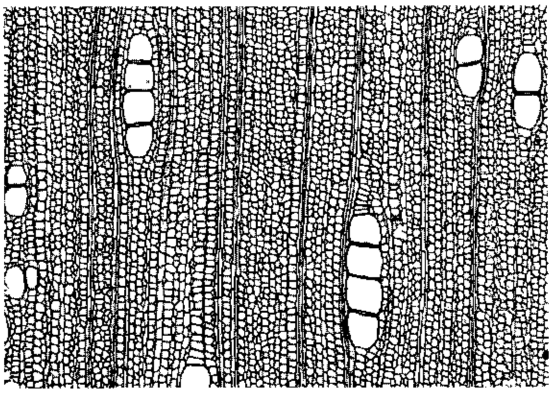
Wood anatomy

– Macroscopic characters:

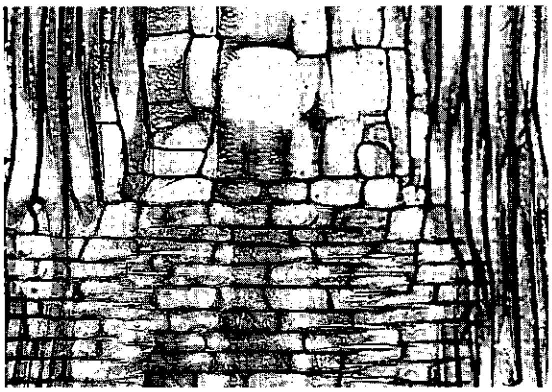
Heartwood creamy white to pale straw-coloured, not differentiated from the sapwood. Grain usually straight. Texture fine to medium and even. Growth rings absent or indistinct; vessels and rays only visible with a hand lens; parenchyma visible with a hand lens. Latex traces commonly present, lens-shaped in tangential surface, up to 1 cm high.

– Microscopic characters:

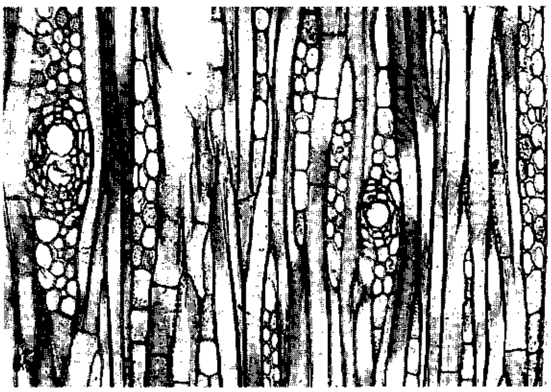
Growth rings absent or indistinct, but, when present, marked by slight differences in fibre wall thickness. Vessels diffuse, c. 6/mm^2, partly solitary but mainly in radial multiples of 2–4(–6), round to oval, average tangential diameter 140



transverse section (×25)



radial section (×75)



tangential section (×75)

Dyera costulata

μm; perforations simple; intervessel pits obscurely vestured, alternate, round to oval, 2–4(–6) μm; vessel-ray and vessel-parenchyma pits similar but half-bordered; helical thickenings, deposits and tyloses absent. Fibres c. 1300 μm long, non-septate, thin-walled, with small but distinctly bordered pits mainly confined to the radial walls. Parenchyma fairly abundant, diffuse-in-aggregates or in short tangential lines and scanty paratracheal, in 2–4-celled strands. Rays c. 6/mm, (1–)2–4 cells wide, (100–)400–700(–1000) μm high, heterocellular, composed of procumbent body ray cells and 1–2(–4) rows of square to upright marginal cells; some rays fusiform and containing wide laticifers, larger than the other rays. Crystals absent.

Species studied: *D. costulata*, *D. polyphylla*.

Growth and development Early growth of jelutong is rather slow, but after the establishment of a well developed root system growth becomes more vigorous. In some sample plots the average annual diameter increment of *D. costulata* is as high as 1.5 cm, whereas trees planted in arboreta may even reach a diameter increment of almost 2 cm/year. After 40 years, trees planted in an arboretum in Peninsular Malaysia reached a diameter of 75 cm, sample-plot trees almost 60 cm, and trees in an unmanaged plantation only 37 cm. The average diameter of planted *D. polyphylla* 17 years after planting is 19 cm. There is a marked decline in growth when trees reach a diameter of about 115 cm. The annual height increment reported for 2–3-year-old seedlings varies from 40 to 90 cm.

Young trees are often crooked but straighten out later. In Peninsular Malaysia *D. costulata* trees are usually deciduous once a year. They are leafless for a few days and all the trees in a certain area tend to change their leaves at the same time. Flowering occurs from July to December. Flowers develop together with the young leaves. Flowers open during the night or early in the morning and the corollas are shed before 9 a.m. Fruits ripen in 8–9 months after anthesis. The flattened and winged seeds are distributed by wind.

Other botanical information *Dyera* is closely related to *Alstonia* (pulai) and may be confused with it. *Dyera* can be recognized by its massive columnar bole, its massive spreading follicles containing seeds with a membranous wing all around, and the short style. *Alstonia* species have a fluted or buttressed bole, slender, drooping follicles with comose or ciliate seeds, and a longer slender style.

Ecology The 2 species of jelutong are scattered emergent trees of primary (often dipterocarp) evergreen rain forest, but favour different habitats. *D. costulata* prefers well-drained, level but more often undulating land, along ridges, on clay-rich friable laterite or alluvial soils. *D. polyphylla* is typical of swamp forest or in 'kerangas' on groundwater podzol.

Propagation and planting Jelutong may be propagated by seed or by stumps made from seedlings from the natural forest. Seed weight varies greatly: there are 7500–20000 seeds of *D. costulata* in one kg. Fruits should be collected from the tree when they just begin to split, as they do not drop until all seeds have been released. The great height of the tree, however, not only renders it difficult to judge when the fruits are ready for collection but also means that the tree is hard to climb.

About 90% of the fresh seed of *D. costulata* germinate in 14–28 days, although a period of up to 4 months has also been reported. The viability of seed stored for 8 months at 22–24°C and a relative humidity of 60% (in an air-conditioned room) is still 70%. Storage temperatures below 10°C are detrimental. Seed of *D. polyphylla* germinates well in 5-12 days.

Seed is sown flat and should be pressed into the soil. To enhance germination, seed should be soaked in water for about 2 hours. When the seed has germinated and is raised above the ground, it should not be allowed to dry out and harden, because then the cotyledons and the plumule risk becoming trapped inside the seed-coat. Seedlings should be grown under shade, as full sunlight adversely affects their growth. Optimal development of seedlings was obtained under experimental conditions with about 33% relative light intensity. One-year-old seedlings of *D. polyphylla* are ready for planting. In Peninsular Malaysia, 5–10-month-old seedlings of *D. costulata* were planted in the field at a spacing of 1.8 m × 1.8 m.

On the south coast of Kalimantan, stumps of 2-3 year old *D. polyphylla* seedlings were rooted under moist conditions and planted out in lines in natural forest by the local population. The soil there consisted of 1.5–2 m peat overlying mineral soil. In Peninsular Malaysia, direct sowing for enrichment planting was not very successful.

Silviculture and management Natural regeneration is generally fairly abundant, but sometimes it is noticeably absent in secondary forest and, as reported for Sarawak, seeds seem to require specific conditions for germination. Growth is vigorous when light is abundant. Jelutong trees are valuable for their timber and latex, have a good form, grow fast and are therefore favoured if they occupy a dominant or co-dominant position in regenerated forest. Any competition with neighbouring trees not belonging to the most important commercial timbers should be prevented. In Peninsular Malaysia, *D. costulata* is chosen for enrichment planting because it is easy to handle in the nursery, survives well when planted out, has a good rate of growth, and has good market potential. Prolonged contact with acid water in peat forest harms young plants. *D. costulata* is a very light-demanding species and once a young tree is well established in full light, it tends to spread its crown and develop into a pronounced 'wolf tree'. Sudden opening of the canopy is favourable for its development. In southern Kalimantan, line planting of *D. polyphylla* by the local population needed thinning two years after planting to provide more light for the planted stumps.

D. costulata coppices readily and is extremely resistant to girdling.

Diseases and pests *Botryodiplodia theobromae* (the imperfect state of *Physalospora rhodina*) causes blue stain in logs, but can also infect living trees producing swelling and splitting of the bark. *Batocera rufomaculata*, a large longhorn beetle, is a secondary parasite of *D. costulata* in Peninsular Malaysia. It is a wound parasite of the latex-tapping panels, but in old and weak trees infestations may extend over the entire stem. Eggs are laid on dead bark or where the bark is completely removed; if they were to attack living bark, the larvae would be trapped by the copious stream of latex. *Diapus pusillimus* and *D. quinquespinatus*, two small ambrosia beetles, are other wound parasites, often occurring in association with *Batocera rufomaculata*. They cause degrade of the timber by numerous 'pinholes' and associated stain. *Platypus vethi*, another ambrosia beetle, occurs frequently in fallen trees of *D. costulata* or in trees injured or weakened by unskilled tapping or by *Batocera rufomaculata*. In Peninsular Malaysia, white rot and brown rot caused by the fungi *Coriolus versicolor* and *Piptoporus betulines* has been observed in *D. costulata*.

Harvesting *D. costulata* trees have an excellent form and a long branchless bole. In Sarawak and Brunei, many logs of *D. costulata* contain a small area of spongy heart, irrespective of the good protection from the copious flow of latex when injured.

Tapping of plantation-grown *D. polyphylla* may start 30–35 years after planting when trees reach a diameter of about 35 cm. In Sarawak, there were restrictions on the felling of *D. costulata* and *D. polyphylla* in the 1950s because of the value of the latex. Prolonged latex-tapping invariably leads to the death of the tree.

Yield In Sarawak and Brunei, about one large tree of *D. polyphylla* is found per ha on average, and only about one *D. costulata* tree of over 40 cm diameter per 5 ha.
A single jelutong tree may yield up to 30(–50) kg of latex per year, but high yields generally lead to a rapid destruction of the trees.

Handling after harvest Logs left in the forest are prone to borer attack, although the bark protects felled trees against insect attacks by exuding latex for some months after felling. Quick and careful drying is necessary to prevent blue stain.

Genetic resources In the 1930s and 1940s the threat of extinction was recognized, as the widespread tapping of the trees caused them to die. Jelutong occurs scattered and there is a risk of over-exploitation for timber and latex. However, it often regenerates readily in logged-over forest and grows fast, which may reduce this risk.

Breeding There seems ample scope for selection and perhaps breeding, as individual trees of *D. costulata* show a considerably faster growth than the average for a population, e.g. 5.8 m and 2.4 m high, respectively, 4 years after planting, and 8.8 m and 4.0 m high, respectively, 7 years after planting.

Prospects Although the wood quality of jelutong is only moderate, it seems to have good prospects for specific uses, especially for veneer and plywood production. Jelutong seems to be suitable for the establishment of commercial timber plantations and is now recommended for planting in large plantations in Peninsular Malaysia. However, more research is needed on methods of propagation and on silvicultural aspects.

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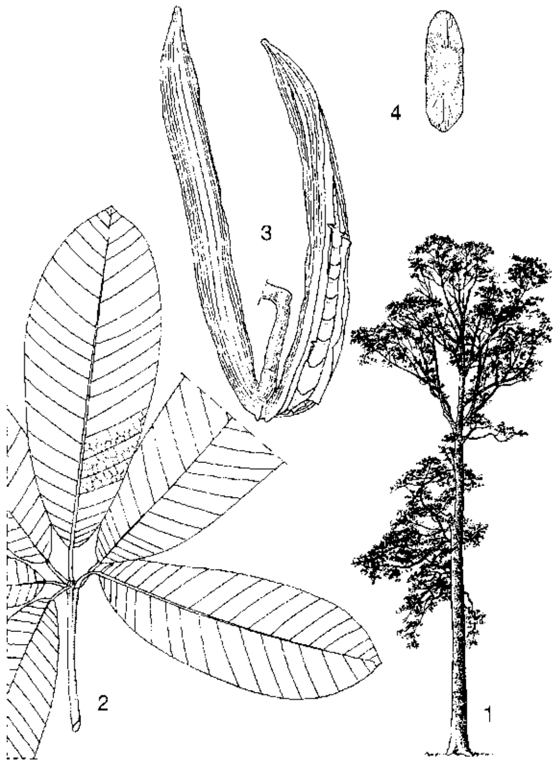
Selection of species

Dyera costulata (Miq.) Hook.f.

Journ. Linn. Soc., Bot. 19: 293 (1882).

Synonyms *Alstonia costulata* Miq. (1861), *Dyera laxiflora* Hook.f. (1882).



Dyera costulata (Miq.) Hook.f. – 1, tree habit; 2, twig with leaves; 3, fruit; 4, seed.

Vernacular names Hill jelutong (En). Indonesia: jelutung bukit (general), melabuai (Sumatra), pantung gunung (Kalimantan). Malaysia: jelutong bukit (general), jelutong pipit, jelutong daun lebar (Peninsular). Thailand: teen-pet daeng (peninsular), ye-luu-tong, luu-tong (Malay, peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo, and intervening islands.

Uses As given for the genus.

Observations A large to very large tree, up to 65 m tall, bole branchless for up to 30 m, up to 250 cm in diameter, without buttresses; leaves elliptical to obovate or narrowly so, rounded to subcordate at base, short acuminate to rounded at apex, secondary veins well-spaced. *D. costulata* occurs in primary lowland or hill forest in well-drained locations, up to 300 m altitude. The density of the wood is 220–560 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 17, 26, 69, 70, 77, 78, 99, 115, 175, 234, 241, 340, 403, 432, 445, 463, 465, 466, 526, 575, 595, 686, 703, 705, 739.

Dyera polyphylla (Miq.) v. Steenis

Blumea 14: 316 (1966).

Synonyms *Alstonia polyphylla* Miq. (1861), *Dyera lowii* Hook.f. (1882), *Dyera borneensis* Baillon (1898).

Vernacular names Swamp jelutong (En). Indonesia: jelutung paya (general), gapuk (Sumatra), pantung (Borneo). Malaysia: jelutong paya (Sabah, Sarawak).

Distribution Sumatra, Borneo and intervening islands.

Uses As given for the genus.

Observations A medium-sized to fairly large tree, up to 35 m tall, bole straight, columnar, up to 95 cm in diameter, without buttresses; leaves spatulate-elliptical, cuneate at base and decurrent on the petiole, rounded to slightly emarginate at apex, secondary veins close-set. *D. polyphylla* is found in swamp forest, peat-swamp forest, and on groundwater podzols in kerangas, at low altitudes. The density of the wood is 270–460 kg/m^3 at 15% moisture content.

Selected sources 26, 69, 77, 99, 105, 445, 668, 669, 703.

Rudjiman (general part, selection of species),
A. Martawijaya (properties),
N. Tonanon (wood anatomy)

Elmerrillia Dandy

Kew Bull.: 261 (1927).
MAGNOLIACEAE
x = probably 19, as in most *Magnoliaceae*; $2n$ = unknown

Trade groups Wau beech: lightweight hardwood, e.g. *Elmerrillia ovalis* (Miq.) Dandy, *E. tsiampacca* (L.) Dandy.

In Indonesia and Malaysia (Sabah) the wood of *Elmerrillia* is traded together with that of *Michelia* spp. and sometimes of *Magnolia* spp.

Vernacular names Wau beech. Indonesia: cempaka, cempaka hutan (general). Malaysia: chempaka (Sabah).

Origin and geographic distribution *Elmerrillia* consists of 4 species which occur in Sumatra, Borneo, Sulawesi, the Moluccas, central and the southern Philippines, and New Guinea including New Britain. Two species are endemic to the Philippines, where they are uncommon and usually small trees, the third (*E. ovalis*) occurs only in Sulawesi and the Moluccas, whereas the fourth (*E. tsiampacca*) is more widespread from Sumatra to New Britain.

Uses The timber is very durable and much sought-after for house construction (boards, beams, flooring). Furthermore it is used for furniture, cabinet work, panelling, fine finishing, door and window frames, boat building (including decking), canoes, freshwater piling, sporting goods, musical instruments, carving, handicrafts, coffins, drawing material, pencils, moulding and plywood.

Production and international trade *Elmerrillia* timber is considered as the most valuable and most demanded timber of northern Sulawesi, but it has become scarce. The export of 'chempaka' timber (from *E. tsiampacca* plus some other *Magnoliaceae* species) from Sabah is only small: in 1992 it was about 900 m^3 (16% as sawn timber, 84% as logs) with a total value of US$ 87 000 (US$ 270/m^3 for sawn timber, US$ 65/m^3 for logs). In Papua New Guinea, Wau beech is a fairly important export timber. It is ranked in MEP (Minimum Export Price) group 3; saw logs fetched in 1992 a minimum price of US$ 50/m^3. Japan imports Wau beech from Papua New Guinea.

Properties Wau beech is a lightweight hardwood. The heartwood is pale brown or pale yellowish-brown to golden-brown, often with a greenish tinge, darkening slightly to distinctly upon exposure, generally clearly defined from the straw-coloured or whitish sapwood (1.5–5 cm wide). The density is (300–)400–500(–650) kg/m^3 at 15% moisture content. The grain is straight to interlocked, texture moderately fine to moderately coarse. The wood has a persistent spicy odour and a distinct fine lustre. An attractive ribbon figure is present on quarter-sawn surfaces.

A test of *E. tsiampacca* wood from Papua New Guinea showed the following mechanical properties at 12% moisture content: the modulus of rupture 79.5 N/mm^2, modulus of elasticity 9800 N/mm^2, compression parallel to grain 45.5 N/mm^2, shear 11 N/mm^2, cleavage 35 N/mm tangential, and Janka side hardness 3025 N.

The rates of shrinkage are low to moderate: from green to oven dry approximately 3.7% radial and 6.7% tangential. Although the initial moisture content is rather high (94–102%), the timber air dries rapidly and without serious defects. Kiln drying at a temperature of 55–80°C is easy and without defects; the wood can be kiln dried in 4 days. Once dry, the movement in service is low.

Wau beech saws, machines and works well and a high-class and smooth finish can be readily obtained with hand tools; it takes a high polish and finishes with a satiny lustre. It nails, screws and glues well. The steam bending properties are fairly good. The paintability is satisfactory. The peeling and slicing properties are good; the wood is suitable for the manufacturing of plywood.

Wau beech is classified as durable, even when used in contact with the ground under tropical conditions. The wood is rarely attacked by termites, but reports on *Lyctus* attack are contradictory. The permeability of heartwood to preservatives is reported as variable: from permeable to highly resistant when using a pressure treatment. Hot soaking for 5 hours and cold soaking for one day with BFCA preservative resulted in 24 mm penetration and a retention of 15.2 kg/m^3. Cold soaking in a 10% BFCA solution for 5 days resulted in 16 mm penetration and a retention of 15.1 kg/m^3.

The wood contains 65.5–79.5% holocellulose, 24.3–27.5% lignin, 6.5–17% pentosan and 0.1–0.3% ash. The solubility is 1.7–7.1% in alcohol-benzene, 1.8–2.2% in cold water, 3–3.2% in hot water and 14.2–16.3% in a 1% NaOH solution. The wood is not suitable for charcoal manufacturing.

Description Medium-sized to very large, evergreen trees up to 60 m tall; bole up to 150(–200) cm in diameter, sometimes with short buttresses; bark surface smooth but becoming cracked or fissured, or peeling off in large flakes, pale grey or grey to grey-brown, inner bark brown to yellow or green with brown patches, without exudate, odoriferous. Leaves arranged spirally, simple and entire, pinnately veined; stipules present, enclosing innovations, free from the petiole, caducous and leaving annular scars around the nodes. Flowers on axillary brachyblasts, solitary or sometimes 2–3 together, bisexual, actinomorphic; tepals spiral or more or less in whorls, (9–)12–17, subequal, 20–35 mm long, white to yellow; stamens numerous, free, arranged spirally, anthers linear, 2-locular, introrse, connective produced into a short appendage; gynoecium sessile, carpels many, arranged spirally, basally sunken in the torus, free or concrescent, ovules 2–6 in each carpel. Fruiting carpels free, crowded, dehiscent along the dorsal suture, finally 2-valved, or concrescent to form a fleshy syncarp. Testa free from the endocarp, externally arilloid.

Wood anatomy

– Macroscopic characters:

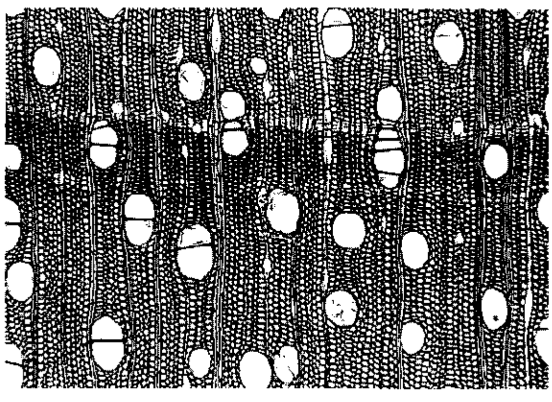
Heartwood pale yellowish-brown with a greenish tinge, fairly distinctly demarcated from the yellowish-white sapwood. Grain straight or shallowly interlocked. Texture moderately coarse. Growth rings fairly distinct; white chalky substance occasionally present in the vessels.

– Microscopic characters:

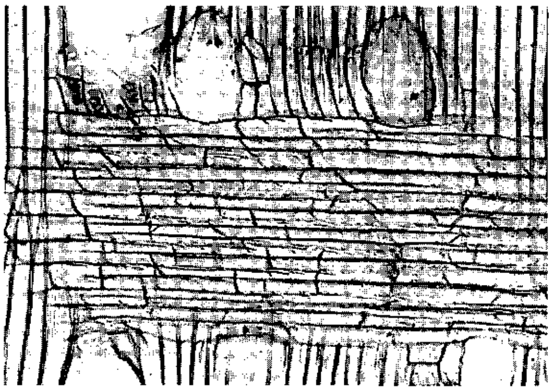
Growth rings fairly distinct, marked by marginal parenchyma bands. Vessels diffuse, usually 10–20/mm^2, solitary and in radial multiples of 2–4 and in clusters, oval or slightly angular, 90–200 μm in tangential diameter; perforations scalariform, with up to 6(–10) bars; intervessel pits opposite to scalariform; vessel-ray and vessel-parenchyma pits with strongly reduced borders, scalariform, large; chalky substance present; tyloses present. Fibres 1.0–2.4 mm long, very thin-walled to thin-walled (walls 2–3 μm thick), with small but fairly distinctly bordered pits. Parenchyma in marginal bands, fairly irregularly spaced, in strands of 5–7(–8) cells. Rays 4–7/mm, uniseriate rays sparse, mostly 2–4-seriate, 270–690 μm high, heterocellular with several rows of upright and square marginal cells, Kribs type heterogeneous II(–III). Crystals and silica bodies not observed. Large oil cells present, associated with axial parenchyma and in the marginal rows of ray parenchyma cells, sometimes in the central rows, up to 140 μm high, numerous.

Species studied: *E. tsiampacca*.

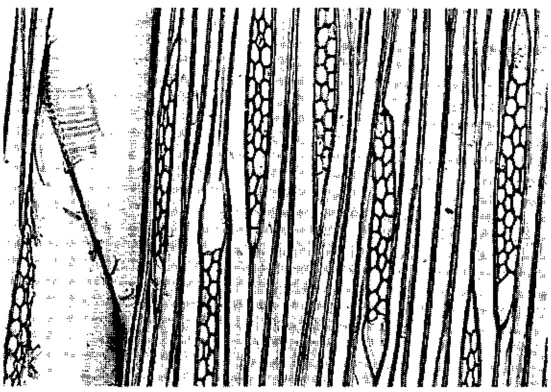
Growth and development Trees of *E. ovalis* in trial plantations in Java reached a height of 12–17 m and a diameter of 12–23 cm 6–7 years after planting (mean annual diameter increment of



transverse section (×25)



radial section (×75)



tangential section (×75)

Elmerrillia tsiampacca

2–3 cm), and had straight boles branchless for 6–9 m.

The trees show Roux's architectural growth model, determined by a monopodial orthotropic trunk with continuous growth; the branches are plagiotropic and flowering does not influence the architecture.

Other botanical information *Elmerrillia* is closely related to *Michelia*, from which it differs in having a sessile instead of stipitate gynoecium. The two genera form the tribe *Michelieae* (within the subfamily *Magnolioideae*), characterized by a monopodial growth. The species of *Elmerrillia* are closely related. The main differences can be found in the number of tepals (the outer whorl might be considered sepals) and in the fruit consisting of nearly free or concrescent carpels.

Ecology *Elmerrillia* species occur in primary and secondary rain forest, in both lowland and montane forest up to 2000 m altitude. In Sulawesi, they occur on fertile volcanic sandy soils and loamy soils in locations without waterlogging.

Propagation and planting Wau beech can be propagated by seed, but seed loses its viability when dried. Therefore, storage of seed is unlikely to be feasible. Viability of *E. ovalis* seed is very low. There are about 91 000 *E. ovalis* seeds in one kg. Seeds are sown under shade and germinate after about 20 days.

When seedlings have developed 2–4 leaves, shade can be removed. Seedlings can be planted out when they are 10–15 cm tall. *E. ovalis* was reported to be in cultivation at the end of the last century in North Sulawesi. Apart from trials in West Java, it has not been planted elsewhere.

Silviculture and management Locally, especially in North Sulawesi, *E. ovalis* is the most important species of the natural forest, e.g. on Mount Klabat it accounts for 11% of all trees over 20 cm diameter at breast height. Here, natural regeneration is practically absent, since only 22 young plants were counted in a survey covering 25 ha. Natural regeneration, however, is abundant in secondary vegetation, implying that this type of forest evolved after a major disturbance. In Irian Jaya, the natural regeneration of *E. tsiampacca* is very sparse, due to low seed production and 0.25 trees/ha survived from the initial 19 seedlings/ha.

Harvesting As selective cutting will not favour the regeneration of *Elmerrillia* the harvesting technique proposed for North Sulawesi is to clear cut blocks of the forest. The rotation of harvesting is proposed to be 100 years. Trees can reach considerable dimensions, but older trees are often hollow. In South Sulawesi, trees for carving may be harvested 6–7 years after planting.

Yield The *E. ovalis* forest in North Sulawesi has an estimated timber volume of 45 m^3/ha. The annual volume increment of 6–7-year-old trial plantations in West Java is 15–25 m^3/ha. Locally in Irian Jaya, the estimated timber volume of *E. tsiampacca* is 2.8 m^3/ha.

Handling after harvest The recovery rate of green sawn timber is 56% and 44% after seasoning, resawing and grading. 20% of the sawn timber is of export quality.

Genetic resources Wau beech has been a popular timber for a long time, but it has become scarce in areas where it once occurred gregariously (e.g. in Sulawesi). In other regions (e.g. in New Guinea), it is still locally common and not yet subject to genetic erosion. Although it was reported to be cultivated as far back as the end of the 19th Century, it has never been planted on a large scale. The two Philippine species (*E. platyphylla* (Merr.) Nooteboom and *E. pubescens* (Merr.) Dandy) are uncommon. Caution in logging these timbers seems justified.

Prospects Trial plantations established around 1945 in Java showed excellent growth, and Wau beech has been recommended for large-scale planting because of its potentially high yield and excellent wood quality (wood with comparatively low density and yet moderately durable, good drying and working properties, attractive colour and figure). Wau beech should be considered as a promising plantation tree for timber, but more research is needed to develop appropriate methods of propagation and selection of superior tree types. Research is also necessary on the regeneration in natural forest after logging and the proper harmonization of forest management and cutting cycles.

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Selection of species

Elmerrillia ovalis (Miq.) Dandy

Kew Bull.: 261 (1927).

Synonyms *Talauma ovalis* Miq. (1868), *Talauma vrieseana* Miq. (1868), *Elmerrillia vrieseana* (Miq.) Dandy (1927).

Vernacular names Indonesia: cempaka hutan kasar (Sulawesi).

Distribution Sulawesi and the Moluccas (Morotai, Ambon).

Uses The wood is used as Wau beech. It is very durable and applied for house construction, especially for boards and beams, also for freshwater piling. It is also important for carving, as in Tanah Toraja for the traditional decoration of rice barns and houses.

Observations A large tree up to 45 m tall, bole cylindrical, branchless for up to 12(–16) m, up to 200 cm in diameter; twigs, stipules and petioles glabrous or yellowish villous but soon glabrescent;

leaves elliptical, 7–36 cm × 4–16 cm, glabrous or minutely pubescent below; tepals c. 16, white or creamy; fruiting carpels concrescent. *E. ovalis* is locally common in forest at low and medium altitudes, up to 1000 m. The density of the wood is 310–500 kg/m^3 at 15% moisture content.

Selected sources 162, 218, 227, 228, 234, 397, 471, 474, 528, 600.

Elmerrillia tsiampacca (L.) Dandy

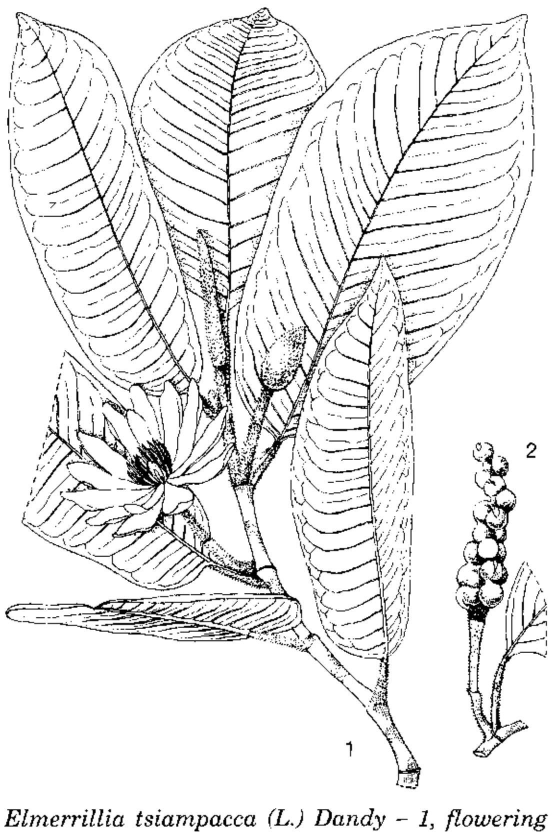
Praglowski, World pollen & spore flora 3: 5 (1974).

Synonyms *Elmerrillia celebica* (Koord.) Dandy (1927), *Elmerrillia papuana* (Schlechter) Dandy (1927), *Elmerrillia sericea* C.T. White (1929).

Vernacular names Indonesia: minjaran (Sumatra), cempaka hutan alus, wasian (Sulawesi), arimot (Biak, Irian Jaya). Malaysia: chempaka bulu (Sabah). Papua New Guinea: Wau beech.

Distribution Sumatra, Borneo, Central and North Sulawesi, the Moluccas (Ambon, Buru), New Guinea and New Britain.

Uses The wood is used as Wau beech and is superior for construction as the camphor-like scent repels termites and fungi. It is also used for coffins, which can remain intact in the soil for 50 years. Furthermore, it is used for furniture, cabinet work, finishing, mouldings, boat building and decking, canoes and veneer.



Elmerrillia tsiampacca (L.) Dandy – 1, flowering twig; 2, twig with young infructescence.

Observations A medium-sized to very large tree up to 60 m tall, bole straight or somewhat crooked, branchless for up to 20 m, up to 200 cm in diameter, sometimes with low buttresses; twigs, stipules and petioles ferrugineously or fulvously pubescent or tomentose when young; leaves narrowly elliptical to elliptical or rarely ovate, 10–46 cm × 4–15 cm, soon glabrescent above, hairy or rarely glabrous below; tepals (9–)12–18, white to yellow; fruiting carpels free. *E. tsiampacca* has been divided into 2 subspecies. Subsp. *tsiampacca* has 10–30 cm long leaves with hairs which do not curve towards the base below, and is found in Sulawesi, the Moluccas, New Guinea and New Britain. Subsp. *mollis* (Dandy) Nooteboom (synonym: *Elmerrillia mollis* Dandy) has 16–46 cm long leaves with hairs which curve towards the base below, and occurs in Sumatra and Borneo. *E. tsiampacca* is locally common and gregarious in lowland to submontane forest on fertile soils, up to 1800 m altitude; occasionally in secondary forest. The density of the wood of subsp. *tsiampacca* is 430–560 kg/m^3 and of subsp. *mollis* 300–530 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 12, 60, 99, 145, 162, 166, 216, 234, 289, 337, 397, 471, 474, 482, 612, 718, 719.

I. Soerianegara (general part),
S.I. Wiselius (properties),
S. Sudo (wood anatomy),
M.S.M. Sosef (selection of species)

Fagraea Thunb.

Kongl. Vetensk. Acad. Nya Handl. 3: 132, t. 4 (1782).

LOGANIACEAE

$x = 6$; *F. ceilanica*: $2n = 66$, *F. fragrans*: $2n = 12$

Trade groups Tembesu: medium-weight to heavy hardwood, e.g. *Fagraea crenulata* Maingay ex C.B. Clarke, *F. elliptica* Roxb., *F. fragrans* Roxb.

Vernacular names Tembesu: Burma yellowheart (En). Brunei: pedang. Indonesia: tamosu (Sumatra), kolaki, nosu (Sulawesi). Malaysia: tembusu (Peninsular), temasuk (Sabah), pedang

(Sarawak). Philippines: urung (general), dolo, teca. Burma (Myanmar): anan, ananma. Cambodia: tatrao. Laos: man pa. Thailand: tam sao (peninsular), kankrao (central), man pla (northern). Vietnam: trai.

Origin and geographic distribution *Fagraea* consists of about 35 species which occur in Sri Lanka and India through Burma (Myanmar), Indo-China, Thailand, southern China and Taiwan towards the Malesian area, northern Australia and the Pacific. The centre of diversity lies in the Malesian area with 31 species which are distributed as follows: Peninsular Malaysia 15 species, Sumatra 10, Borneo 14, the Philippines 7, Java 7, the Lesser Sunda Islands 2, Sulawesi 7, the Moluccas 5 and New Guinea 13. Several species are planted within their natural area of distribution and *F. fragrans* also in trial plantations in South America.

Uses Tembesu is a timber used in applications where strength and durability are required (heavy constructions) and can be used in exposed conditions and in contact with the ground. It is used for house posts, bridges, boats, railway sleepers, piles, poles, fence posts, door and window sills, heavy-duty flooring, barrels, chopping blocks and coffins, and it is considered a first-class turnery timber. It is also used for furniture, cabinet making and carving, although it is not a particularly ornamental wood. Moreover, it makes high-quality firewood and charcoal.

Some species are planted as ornamental trees along roads and avenues, because of their handsome, slender appearance and their fragrant or large flowers. *F. racemosa* is planted as a live fence. Planting for shade has also been observed.

Decoctions of roots, bark, twigs, leaves and flowers are used for medicinal purposes, amongst others to cure malaria or dysentery. The wood tar of one species is used to blacken teeth. Fruits are sometimes pickled and eaten. The latex under the epidermis of the fruits is widely used as a glue and locally used as a fly trap. In Malaysia the leaves are fed to livestock.

Production and international trade Tembesu timber is mainly used locally, and the amounts exported are insignificant. In 1987, approximately 210 m^3 of logs were exported from Sabah, with a value of US$ 13 000 (US$ 62/m^3).

Properties *Fagraea* yields a medium-weight to heavy hardwood. The heartwood is pale yellow or yellow, darkening upon exposure to deep golden-brown, orange-brown or pale brown, not clearly demarcated from the paler sapwood. The density is (440–)510–1060(–1130) kg/m^3 at 15% moisture content, the timber of *F. crenulata* being considerably lighter (440–660 kg/m^3) than that of the other species. The grain is straight, occasionally slightly wavy to moderately interlocked, rarely deeply interlocked, texture fine to moderately fine and even. The timber has an unpleasant smell when freshly cut, disappearing on drying, and has no distinct taste. A defect in *F. fragrans* timber is the frequent occurrence of knots due to the persistence of branches.

In tests of samples from Indonesia and Malaysia the following mechanical properties at 15% moisture content were determined: the modulus of rupture 73.5–107 N/mm^2, modulus of elasticity 12 360–14 100 N/mm^2, compression parallel to grain 52–62.5 N/mm^2, compression perpendicular to grain 8–9 N/mm^2, shear 6–14 N/mm^2, cleavage 37–49.5 N/mm radial and 40–54 N/mm tangential, Janka side hardness 5445–6970 N and Janka end hardness c. 5450 N.

The rates of shrinkage are moderate: from green to 15% moisture content 1.1% radial and 1.6% tangential and from green to oven dry 3.4% radial and 6.6% tangential. Tembesu dries extremely slowly, usually without much degrade, and must be stacked properly. In Indonesia it takes 3 months to season 20 mm thick boards of *F. fragrans* from 40% to 14% moisture content, whereas 13 mm thick boards have been reported to require 4–6 months in Malaysia to air dry. The recommended kiln schedule is a temperature of 35°C to 65°C with a corresponding relative humidity of 70% to 30%. Sapwood tends to stain in drying, and surface checking may occur, particularly in backsawn material.

Tembesu is easy to saw and works well. Wood of *F. gracilipes*, however, is very difficult to saw and blunts tools. Where the grain is interlocked, picking up may occur when planing radial surfaces; hence a 20° cutting angle is recommended. The wood finishes and polishes well, and the surface becomes glossy when sharp tools are used. The wood can be shaped, bored, mortised, turned and sanded with good results. *F. fragrans* is considered to yield a first-class turnery timber. The nailing properties are good. Wood of *F. fragrans* can be peeled into 1.5 mm thick veneer at a 90° peeling angle without pretreatment with good results. The gluing properties using urea-formaldehyde are good, although *F. gracilipes* wood is rated as moderately difficult to glue.

Tembesu is rated as durable to very durable. The resistance to marine borers is variable, but the wood is resistant to dry-wood termites, other insects and fungi; it is liable to pinhole borer attack. *F. fragrans* is generally not attacked by ambrosia beetles, but debarked logs may be infested. Apparently, the thick, tough bark protects the sapwood effectively. The heartwood is very difficult to impregnate satisfactorily, even by pressure processes; the sapwood is permeable (*F. fragrans*) or variably permeable (*F. gracilipes*) to preservatives.

Wood of *F. crenulata* contains 70% holocellulose, 44% α-cellulose, 25% lignin, 13% pentosan and 0.7% ash, and wood of *F. fragrans* contains 63% holocellulose, 46–47% α-cellulose, 24–29% lignin, 11–13% pentosan, 0.1–0.7% ash and 0.3% silica. The solubility of wood of *F. crenulata* is 6.3% in alcohol-benzene, 10.1% in hot water and 15.9% in a 1% NaOH solution, and the solubility of *F. fragrans* wood is 1.8–2.5% in alcohol-benzene, 2.4% in cold water, 4.9–6.9% in hot water and 13.1–13.5% in a 1% NaOH solution.

Description Small to fairly large, evergreen, glabrous trees, up to 40(–55) m tall (non-timber species may be lianas, and terrestrial or epiphytic shrubs); bole straight, cylindrical, branchless for up to 25 m, up to 150(–250) cm in diameter, sometimes with short buttresses or fluted; bark surface smooth or more often variously fissured, greyish to dark brown, inner bark pale yellow to brown. Leaves opposite, simple, entire or rarely crenulate, base decurrent or sometimes auricled, pinnately veined, petioled or sometimes sessile; stipules connate into an ocrea usually early splitting into 2 scales free to connate to the petiole. Flowers solitary or in a few- to many-flowered, usually terminal cyme, bisexual, actinomorphic, 5-merous; bracts and bracteoles present; sepals fleshy to leathery or even woody, united at base, lobes imbricate; petals united into a tube divided into a thinner-walled lower and thicker-walled upper part, creamy-white, lobes contorted, shorter than the tube; stamens inserted on the tube, filaments geniculate just above the base, anthers basifixed, deeply to shallowly bifid at base, dehiscing lengthwise; ovary superior, ellipsoid, 1–2-celled, with many ovules, style as long as the corolla tube or exserted. Fruit a berry or sometimes 4-valved, with sticky latex below the epidermis, many-seeded. Seeds irregularly angular, minutely warty, brown. Seedling with epigeal germination; all leaves decussate.

Wood anatomy

– Macroscopic characters:

Heartwood yellowish-brown to pale brown, sometimes pinkish-buff, not clearly demarcated from the pale yellow sapwood. Grain usually straight, sometimes slightly wavy or interlocked. Texture fine to moderately fine and even; zig-zag figure present on tangential surface; wood rather glossy. Growth rings indistinct or absent; vessels visible to the naked eye, many blocked by tyloses; rays visible with a hand lens; ripple marks absent.

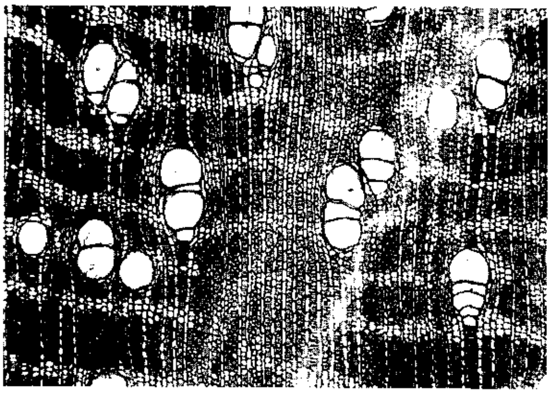
– Microscopic characters:

Growth rings, when present, marked by tangential bands of denser fibrous tissue (*F. fragrans*). Vessels diffuse, (2–)6–20/mm², occasionally solitary, often in radial multiples of 2–5(–8), sometimes in clusters, oval in outline, average tangential diameter 100–200 μm; perforations simple; intervessel pits alternate, vestured, round to oval, 8–10 μm; vessel-ray pits oval to linear elliptical, large (up to 25 μm); helical thickenings absent; tyloses generally very abundant. Fibres 900–1800 μm long, non-septate, thin-walled to very thick-walled, usually thick-walled, with simple or minutely bordered pits mainly confined to the radial walls. Parenchyma paratracheal and apotracheal; paratracheal parenchyma relatively sparse, forming narrow 1–2-seriate complete or incomplete sheaths to the vessels; apotracheal parenchyma abundant, in continuous, sometimes interrupted wavy bands of (1–)2–4(–6) cells wide, in 2–4-celled strands. Rays 15–17/mm, mostly or almost exclusively uniseriate, 0.7–1.4 mm high, heterocellular and composed of upright and square cells. Crystals, silica and intercellular canals absent. All elements non-storied.

Species studied: *F. ceilanica* Thunb., *F. elliptica*, *F. fragrans*.

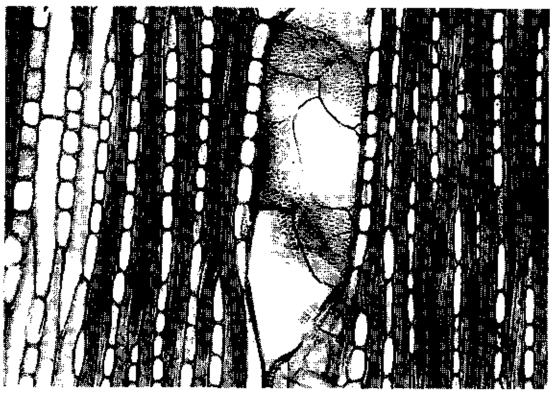
Growth and development The mean annual diameter increment of a well managed trial plantation of *F. fragrans* of 37 years old in West Java is 0.8 cm; it is 0.6 cm in a 20-year-old plantation in Sabah on a podzolic soil. In Peninsular Malaysia, mean annual diameter increments of 0.7 cm and 0.8 cm were achieved in trial plots of 38 years and 29 years old, respectively. *F. crenulata* achieved a mean annual diameter increment of 1.0 cm on fertile soil in Peninsular Malaysia 25 years after planting.

The development of *F. fragrans* trees is according to Aubréville's architectural model ('pagoda habit' or 'Terminalia branching') the growth being determined by a monopodial trunk with rhythmic growth, bearing whorled branch tiers, with branches plagiotropic by apposition, and branch modules indeterminate due to lateral flowering. *F. crenulata* corresponds to the architectural tree model of Fagerlind, differing from Aubréville's



transverse section (×25)

radial section (×75)



tangential section (×75)

Fagraea fragrans

model solely by the growth of the branch modules which is determinate by terminal flowering; it also exhibits the pagoda habit. *F. racemosa* develops according to the architectural tree model of Roux, having a monopodial orthotropic trunk with continuous growth and plagiotropic branches, but never by apposition.

Tembesu flowers and fruits almost every year. Pollination is by insects, especially by bees of the genus *Xylocopa*, and by butterflies and nocturnal moths. Fruiting of *F. fragrans* is 3–4(–7.5) months after anthesis. Seed dispersal is mainly by birds, not rarely by bats, and apparently also by ants.

Other botanical information Several species of *Fagraea* are myrmecophilous and possess extrafloral nectaries on leaves and calyces.

Ecology Tembesu occurs in open or occasionally dense primary and secondary forest, but also along forest edges or even as a pioneer in shrub vegetation or grassy locations. It occurs in perhumid to seasonal climates and from sea-level up to 1500(–2850) m altitude. It thrives in well-drained to swampy, periodically inundated habitats, occasionally even on permanently inundated localities, often along rivers or creeks. Several species are found along the shore or in or behind the mangrove belt. Most species grow on comparatively poor sandy soils, but tembesu is also found on poorly aerated clay soils and on limestone.

Propagation and planting One kg contains about 5 million seeds of *F. fragrans*. Seeds can be stored for 6 months, but they lose their viability very soon when kept inside the fruit. Fresh seed has a viability of 65–80% and germinates in 15 days to over 2 months. *F. fragrans* seed with an initial viability of 80% still had 65% viability after being stored for 3 months in air-tight containers. Fruits should be macerated by hand to extract the seeds, which should then be washed and dried. Allowing the seed to ripen for 1 month after collection is reported, but immediate sowing also gives good results. The whole berry can also be sown, but then seedlings do not appear until after 6 weeks. The very fine seed should be mixed with fine sand and sown under light shade and needs protection from ants. Watering should be done by spraying. The seedlings can be transplanted to open nursery beds or containers after 2 months, when 5–7 cm high, and they can be planted out in the field when 30–45 cm high with adhering soil clump.

Stumps of *F. fragrans* have been used, but these show a strong tendency to produce multiple shoots, leading to trees with up to five stems. Cut-

tings with several internodes taken from the branches of mature trees failed to root, but when taken from coppice shoots they rooted successfully. In-vitro propagation proved possible from rooted cuttings, but failed using explants from 10-year-old trees.
Plantations of *F. fragrans* in Java were established with a spacing of 2.5–3 m × 1 m. As it is a light demander, forming a very light canopy, it is necessary to mix these plantations with shade-tolerant species to control weed growth. Mixing with *Schima wallichii* (DC.) Korth. subsp. *bancana* (Miq.) Bloembergen has been very successful. In a trial plantation of *F. crenulata* in Peninsular Malaysia growth was very irregular, but individuals on drier sites displayed good growth, with annual diameter increment of 1 cm. In Indonesia, tembesu is planted in areas with a perhumid to slightly seasonal climate and up to 500 m altitude; here, growth on rather poor and eroded soils is still satisfactory.

Silviculture and management *F. fragrans* is considered a useful plantation species, as it is adaptable and hardy. It can be planted on poor or degraded but well-drained soils and even in lalang (*Imperata cylindrica* (L.) Raeuschel) grasslands, where it suppresses this noxious grass. The corky bark of *F. fragrans* gives it some resistance to fire; an 8-year-old plantation in lalang grassland suffered no damage from a passing fire.
Double stems should be removed. Thinning in cycles of 5 years up to the age of 30 years is appropriate for plantations; thereafter every 10 years. The lower branches are very persistent and pruning these promotes height growth. *F. fragrans* and *F. racemosa* reproduce easily by means of root suckers and coppice freely; locally, trees may be often pollarded for poles. A rotation of 15 years for *F. fragrans* planted in lalang fields is expected to yield good poles; plantations have an estimated rotation of 100 years for sawn-timber production for house and bridge construction. Natural regeneration is best in more or less open locations.

Harvesting Large trees are frequently hollow. A defect in *F. fragrans* wood is the frequent occurrence of knots. In the early 20th Century, *F. fragrans* and *Eusideroxylon zwageri* Teijsm. & Binnend. were both exploited as 'ironwood' in much the same way in South Sumatra and resources were then already qualified as being depleted. Logs of *F. racemosa* should be handled carefully, as the bark possesses fine irritant hairs.

Yield The mean annual volume increment of timber in *F. fragrans* plantations in Java is 6.1 m^3/ha. The percentage of good-quality sawn timber which can be obtained from *F. fragrans* stems is relatively high, as the stem form of this species is very good. The mean timber volume of *F. fragrans* in some natural forest areas in Indonesia is 1.3 m^3/ha.

Handling after harvest The timber should be treated with anti-stain chemicals immediately after sawing; the sapwood is especially liable to staining.

Genetic resources Early this century, *F. fragrans* resources in South Sumatra were already dwindling. In general, however, *Fagraea* spp. are probably not endangered because their area of distribution is fairly large and because they often behave like pioneers. Decline of primary forest does not seriously affect them.

Prospects *F. fragrans* is a useful tree in plantations and fire breaks due to its hardiness, fire resistance, light-demanding nature and tolerance of a wide variety of soils. It is able to suppress lalang grass, and plantations can be established in grassland without undue difficulty, whereas growth is satisfactory on poor and eroded soils.

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Selection of species

Fagraea berteriana A. Gray ex Benth.

Journ. Linn. Soc. Bot. 1: 98 (1856).

Synonyms *Fagraea sair* Gilg & Gilg-Ben. (1921), *Fagraea affinis* S. Moore (1923), *Fagraea novae-guineae* Cammerl. (1924).

Distribution New Guinea and widely distributed in the Pacific islands.

Uses The wood is locally used as tembesu, e.g. for house posts, tool handles and general construction. In many Pacific islands, the highly fragrant flowers are appreciated for decoration and perfumes. In New Caledonia, the boiled leaves are used medicinally against rash and skin irritation. In the Solomon Islands, the exocarp of the fruit is removed exposing the sticky interior which operates as a fly trap.

Observations A small or rarely medium-sized tree up to 15(–30) m tall, sometimes an epiphytic or terrestrial shrub, bole up to 50 cm in diameter; leaves elliptical to oblong, sometimes slightly ovate or obovate, 9-16 cm × 4.5–12 cm, apex rounded, secondary veins indistinct below, petiole 1.5–4 cm long, stipules partly adnate to the petiole, boat-shaped and 2-lobed at the apex; inflorescence terminal, pedicel without bracteoles; corolla tube tubular, 3–8(–15) cm long, stigma distinctly 2-lobed; fruit ellipsoid to globular, 3–5.5 cm long, orange to red when ripe. *F. berteriana* occurs in open to dense primary or sometimes secondary, wet to dry forest, mainly along forest edges, rivers and creeks, or even along the beach or in mangrove vegetation, from sea-level up to 500(–1600) m altitude.

Selected sources 162.

Fagraea bodenii Wernham

Trans. Linn. Soc. Bot. 9: 111 (1916).

Synonyms *Fagraea ampla* S. Moore (1923), *Fagraea suaveolens* Cammerl. (1924), *Fagraea papuana* Merr. & Perry (1942).

Distribution New Guinea.

Uses The wood is reputed to be used as tembesu. The leaves are chewed with traditional salt to cure an enlarged spleen caused by malaria and also as a stimulant.

Observations A medium-sized tree up to 30 m tall, sometimes a shrub, bole up to 50 cm in diameter; leaves elliptical-obovate to oblong, 5–15 cm × 2.5–7.5 cm, apex obtuse to rounded and often obtusely apiculate, secondary veins obscure below, petiole 0.7–3 cm long, stipules adnate to the petiole, rounded or obtuse; inflorescence terminal, pedicel with bracteoles about halfway; corolla tube tubular to narrowly obconical, 1.5–4 cm long, stigma distinctly 2-lobed; fruit broadly ellipsoid to subglobose and prominently beaked, c. 4 cm long, orange. *F. bodenii* is found in forest on slopes, also on limestone hills, sometimes as a shrub at a higher elevation, at 80–2850 m altitude. The density of the wood is 730–1050 kg/m^3 at 15% moisture content.

Selected sources 162, 474, 727.

Fagraea crenulata Maingay ex C.B. Clarke

Hook.f., Fl. Brit. India 4: 83 (1883).

Vernacular names Cabbage tree (En). Indonesia: malabira, bebira (Sumatra), kayu bulan (Kalimantan). Malaysia: malabera (Peninsular). Thailand: niam ruesee, lumpang (peninsular).

Distribution Southern Vietnam, peninsular Thailand, Peninsular Malaysia, Sumatra and southern and south-western Borneo.

Uses The wood is used as tembesu. It is very valuable for piling and resists borers when used without removing the bark; it has also been applied as firewood. The tree is planted locally as an ornamental and is confusingly similar to *Terminalia catappa* L.

Observations A medium-sized tree up to 25 m tall, bole up to 70 cm in diameter, crown flat-topped and with spreading branches reminiscent of *Terminalia* spp., bark surface deeply and coarsely ridged and fissured, pale grey to yellowish-grey, inner bark pale, young trunk and twigs with simple or split prickles; leaves large, broadly obovate, 17–45 cm × 12.5–25 cm, apex broadly rounded to slightly truncate, secondary veins prominent below, petiole absent or very short, stipules adnate to the petiole or midrib, narrow and acute; inflorescence terminal, pedicel with bracteoles about halfway; corolla tube funnel-shaped, 1.7–2 cm long, stigma peltate and faintly 2-lobed; fruit ellipsoid, 2–3 cm long. *F. crenulata* is found in permanent or periodic swamps behind the mangrove belt or along tidal rivers. The density of the tough wood is 440–640 kg/m^3 at 15%

moisture content. The wood is usually distinguishable from that of other *Fagraea* spp. by the absence of tyloses.

Selected sources 162, 163, 175, 216, 294, 474, 574, 705.

Fagraea elliptica Roxb.

Fl. Ind. 2: 32 (1824).

Synonyms *Fagraea speciosa* (Blume) Blume (1838), *Fagraea sumatrana* Miq. (1857), *Fagraea javanensis* (Blume) Bakh.f. (1948).

Vernacular names Brunei: temasok. Indonesia: ki tandu (Sundanese), tembesu ketam (Sumatra), tonki tonki (Ambon). Malaysia: tembasu (Peninsular), perapat padang (Iban, Sarawak).

Distribution Peninsular Malaysia, Sumatra, western Java, Borneo, Sulawesi, the Moluccas and New Guinea.

Uses *F. elliptica* is an important source of tembesu timber; the wood is used e.g. for house and bridge building and rice pounders. The leaves are probably used medicinally against stomach-ache.

Observations A medium-sized to large tree up to 45 m tall, bole up to 150 cm in diameter, occasionally with buttresses up to 1 m high, bark surface smooth becoming scaly, pale green to grey, inner bark yellow; leaves lanceolate or oblong to obovate or sometimes broadly obovate, 7.5–24 (–32) cm × 1.7–15 cm, apex usually acuminate, rarely obtuse or rounded to slightly retuse, secondary veins prominent or indistinct in thick leaves, petiole 1–4 cm long, stipules connate in a ring around the stem; inflorescence terminal and axillary, pedicel with bracteoles halfway or slightly less than halfway; corolla tube narrow and cylindrical, 3.5–6(–8) mm long, stigma capitate and obscurely 2-lobed; fruit globose, 0.5–0.8 cm across, orange to brick-red. *F. elliptica* occurs in a wide variety of habitats, from well-drained or even dry locations on sandy soils to marshy or temporarily inundated sites, usually in forest but also as a shrub in open grassy locations or on hill tops, up to 1800 m altitude. The density of the wood is 920–1130 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 162, 393, 394, 474, 705.

Fagraea fragrans Roxb.

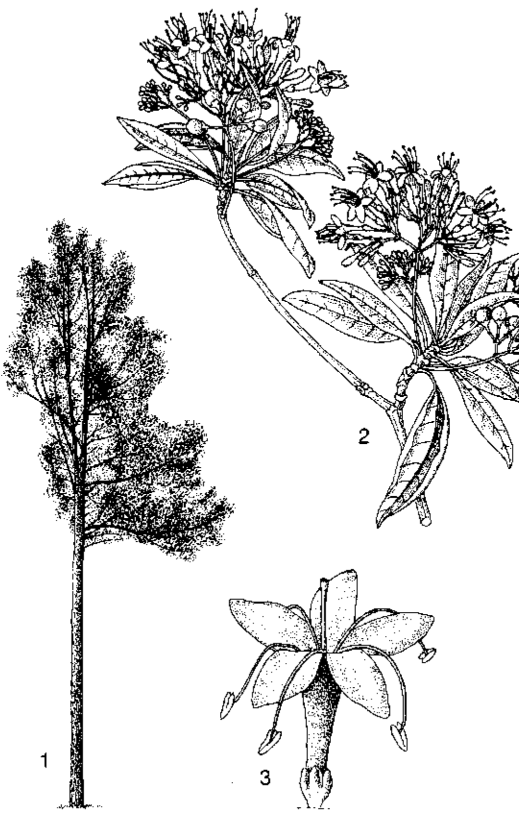
Fl. Ind. 2: 32 (1824).

Synonyms *Fagraea wallichiana* Benth. (1856), *Fagraea cochinchinensis* A. Chev. (1919), *Fagraea sororia* J.J. Smith (1923), *Fagraea gigantea* Ridley (1927).

Vernacular names Ironwood (En). Indonesia: ki badak (Sundanese), kayu tammusu (Sumatra), ambinaton (Kalimantan). Malaysia: tembusu hutan (general), tembusu padang, tembusu tembaga (Peninsular). Philippines: urung (general), dolo (Tagbanua), susulin (Tagalog). Burma (Myanmar): anan, ahnyim. Cambodia: tatraou. Laos: man pa. Thailand: kankrao (central), man pla (northern), thamsao (peninsular). Vietnam: trai.

Distribution India (Bengal), Burma (Myanmar), the Andaman Islands, Indo-China, Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo, Sulawesi, the south-western Philippines and Yapen Island (Irian Jaya); naturalized in West Java.

Uses *F. fragrans* is the main source of tembesu timber. The valuable and durable timber is used both as sawn wood as well as roundwood for posts and piles in the construction of houses, bridges and ships, and for railway sleepers, posts for electric and telephone lines, barrels, chopping blocks, furniture, cabinet work, door and window sills and wood carvings. Besides, the wood yields a very



Fagraea fragrans Roxb. – 1, tree habit; 2, twig with flowers and fruits; 3, flower.

high-quality fuelwood and charcoal. The tree is planted as a shade and ornamental tree in parks and along roads, and for reforestation purposes. A decoction of the bark is used as a febrifuge, and a decoction of twigs and leaves is used to control dysentery.

Observations A medium-sized or occasionally large tree up to 25(–55) m tall, bole up to 135(–250) cm in diameter, occasionally fluted or with buttresses up to 2.5 m high, bark surface deeply irregularly fissured, dark brown, inner bark brown to yellow; leaves oblong-lanceolate to obovate-oblong, 4–15 cm × 1.5–6 cm, apex usually short to long broadly acuminate, secondary veins slightly prominent to indistinct below, petiole 1–2.5 cm long, stipules rounded and partly free from the petiole; inflorescence axillary, pedicel with bracteoles at or below the middle; flowers fragrant, corolla tube narrowly funnel-shaped, 0.7–2.3 cm long, stigma capitate, faintly 2-lobed; fruit broadly ellipsoid, 0.7–1 cm long, orange or red. *F. fragrans* is highly variable. Some botanists do not agree with the broad concept of the species and split off *F. gigantea* (a large canopy tree with more regularly fissured bark and leaves with an undulating margin and only 5 or 6, not c. 8, pairs of secondary veins) and *F. wallichiana* (with broader leaves, larger flowers and larger more ellipsoid fruits) as distinct species. *F. fragrans* occurs in light primary and secondary forest in humid or seasonally inundated locations, but it avoids stagnant water. It grows well on poorly aerated, compact clay soils, and on poor sandy or shallow sandstone soils. In freshwater-swamp forest it is found in association with *Melaleuca* spp. It also occurs naturally as a pioneer in burnt-over areas and lalang grasslands. The density of the wood is 510–930 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 20, 26, 31, 50, 69, 77, 99, 104, 115, 137, 153, 162, 163, 177, 216, 240, 289, 294, 360, 371, 393, 394, 404, 444, 462, 464, 465, 466, 474, 526, 527, 648, 657, 705, 720.

Fagraea gracilipes A. Gray

Proc. Amer. Acad. Arts 4: 323 (1859).

Synonyms *Fagraea cambagei* Domin (1929), *Fagraea elata* Merr. & Perry (1942), *Fagraea obtusifolia* Merr. & Perry (1942).

Vernacular names Mulgrave plum (En).

Distribution The Aru Islands, New Guinea, Australia (north-eastern Queensland), the Solomon Islands, the Santa Cruz Islands and Fiji.

Uses The wood is used as tembesu, e.g. for heavy construction, survey marks, turnery, house posts, canoes and combs. The fruits are occasionally pickled and eaten.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 45 cm in diameter; leaves broadly elliptical to elliptical-obovate or elliptical, (6–)9–17(–23) cm × (2.5–)4.5–8.5(–10) cm, apex usually short, blunt and broadly acute, secondary veins obscure to invisible below, petiole 1–4 cm long, stipules adnate along half the length to the entire length of the petiole, blunt to rounded; inflorescence terminal, bracteoles inserted halfway or higher up the pedicel; corolla tube funnel-shaped, 2.2–5 cm long, stigma slightly 2-lobed to entire; fruit broadly ellipsoid-obovoid to broadly ellipsoid-ovoid, distinctly beaked, 3–4 cm long, orange or red. *F. gracilipes* occurs in and along primary or secondary rain forest, on both dry and swampy or periodically inundated locations, also in mossy oak forest, up to 1500(–2000) m altitude. The density of the wood is 1050–1060 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 61, 162, 289, 474.

Fagraea racemosa Jack ex Wallich

Roxb., Fl. Ind. 2: 35 (1824).

Synonyms *Fagraea morindaefolia* (Reinw.) Blume (1838), *Fagraea subreticulata* Blume (1850), *Fagraea maingayi* C.B. Clarke (1883).

Vernacular names False coffee tree (En). Indonesia: ki cankuda (Sundanese), melingu (Javanese), kayu si markopi-kopi (Sumatra). Malaysia: membera gading, setebal (Peninsular), engkudu hutan (Sarawak). Philippines: balatbuaya (Filipino), kukodmon (Bikol). Cambodia: han tuk (Koh Kong), nho pre (Kampot), prahout tuk (Kandal, Kompong Thom). Thailand: thum bok, phawa nam, waa nam (peninsular).

Distribution Southern Burma (Myanmar), Thailand, Cambodia, Vietnam, the Andaman and Nicobar Islands, throughout the Malesian area, except for the eastern half of Java and the Lesser Sunda Islands, to the Solomon Islands and northern Australia.

Uses The wood is used as tembesu, but the timber is often only available in small dimensions. It is used for general construction, live fence posts and combs; it is also applied as firewood. A decoction of leaves, bark, roots and flowers is used for medicinal purposes, mainly as a tonic after fever and for pains in the loins, but in the Philippines also as an antidote against snake bites. Wood-tar is used to blacken teeth. In Papua New Guinea,

Fagraea racemosa Jack ex Wallich – 1, tree habit; 2, flowering twig; 3, corolla with stamens; 4, fruit.

the leaves are used for sealing stone ovens and for wrapping food.

Observations A shrub or small to medium-sized tree up to 25(–40) m tall, bole up to 30 cm in diameter, without buttresses, bark surface smooth but becoming narrowly and deeply fissured, pale grey to dark grey-brown, inner bark yellow-brown; leaves very variable, from broadly ovate via elliptical to obovate-oblong, lanceolate or rarely even linear, 5–50 cm × 1–23 cm, apex rounded to acute and often short- to long-acuminate, secondary veins distinctly prominent below, petiole 0.2–5 cm long, stipules connate into an ocrea surrounding the stem; inflorescence terminal and usually drooping, pedicel with bracteoles at the base; corolla tube funnel-shaped, 2–4 cm long, stigma faintly 2-lobed; fruit subglobose to ellipsoid-ovoid, apiculate, bluish or greenish or red when ripe. *F. racemosa* is highly variable and several forms have been distinguished. It is found in light to dense primary but more often secondary forest on swampy to dry soil, along rivers but also on podzolized sands, in savannas and lalang grassland vegetation. Locally, it is a conspicuous element of early secondary forest on waste lands and poor soils. The density of the wood is 700–870 kg/m^3 at 15% moisture content.

Selected sources 26, 69, 78, 99, 140, 162, 163, 216, 229, 368, 527, 574.

J.W. Hildebrand (general part),
E. Boer (general part),
A. Martawijaya (properties),
J.M. Fundter (wood anatomy),
M.S.M. Sosef (selection of species)

Falcatifolium de Laubenf.

Journ. Arn. Arb. 50: 308 (1969).
PODOCARPACEAE
x = unknown

Trade groups Sempilor: lightweight softwood, e.g. *Falcatifolium falciforme* (Parl.) de Laubenf. The timber is traded as sempilor together with that of *Dacrydium* and *Phyllocladus*.

Vernacular names Sempilor. Indonesia: melur (general), kayu alau (Kalimantan). Malaysia: ekor sabit (Peninsular), kayu china (Lahad Datu, Sabah), iguh gawah (Iban, Sarawak). Philippines: binaton (general).

Origin and geographic distribution *Falcatifolium* consists of 5 species, 4 of which occur within the Malesian area; the fifth is found on New Caledonia. Within Malesia, species occur in Peninsular Malaysia, the Riau-Lingga Archipelago, Borneo, the Philippines, Sulawesi, the Moluccas (Obi) and New Guinea.

Uses The wood of *Falcatifolium* is used as timber of the sempilor trade group for light construction, furniture, joinery, mouldings, light traffic flooring, door and window frames, masts, interior finish, novelties, veneers and crates.

Production and international trade There is no doubt that, *Falcatifolium* timber is sometimes traded as sempilor together with the timber of *Dacrydium* and *Phyllocladus*. However, as the species are generally uncommon and the trees usually do not reach a large size, the contribution of *Falcatifolium* to the trade group is probably small.

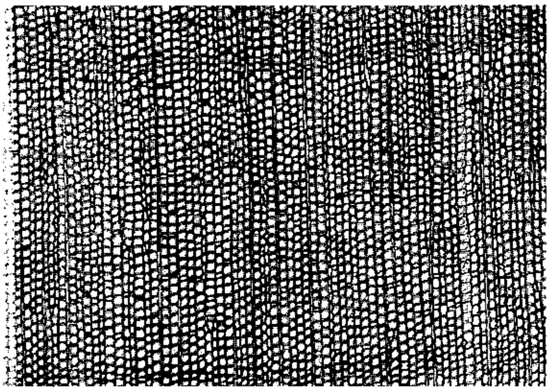
Properties *Falcatifolium* yields a lightweight softwood. The heartwood is pale yellowish-brown to golden-brown and not clearly demarcated from the paler sapwood. The grain is straight, texture fine and even.

Data on physical and mechanical properties are

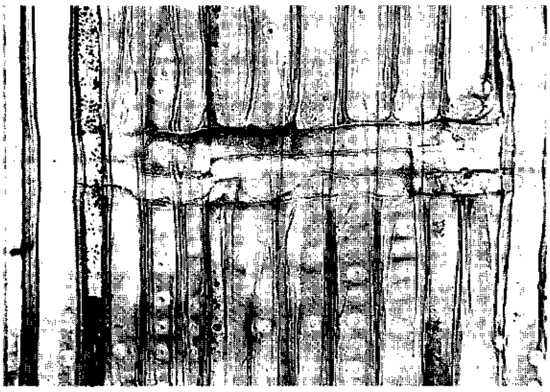
not available, but these are probably comparable to *Dacrydium* and *Phyllocladus*. The wood is easy to work. It is not durable and should not be used exposed to the weather or in contact with the ground unless it has been treated with preservatives; it is probably easy to impregnate.
The mean fibre length of *F. gruezoi* is 3625 µm.

Description Dioecious, fairly large trees up to 36 m tall, but usually much less, rarely shrubs; bole cylindrical; bark thin, more or less smooth, brownish or purple-brown with scattered lenticels, occasionally flaking in larger specimens, inner bark reddish; branching loose and irregular. Juvenile and adult leaves arranged spirally or falcately curved away from the branch into one plane (distichous), alternating with elongated appressed scales, flattened, acute, with a single vein. Fertile structures on short scaly, axillary or terminal shoots. Pollen cones solitary or clustered, cylindrical; microsporophyll a small acuminate spur above the two pollen sacs. Seed-bearing structures solitary, consisting of up to about a dozen large acuminate scales which become swollen, fleshy and red when mature; 1 subapical scale fertile; the inverted ovule turning upwards at maturity, seed exposed; mature seed nearly erect, ovoid, with 2 lateral weak ridges along its wider sides.

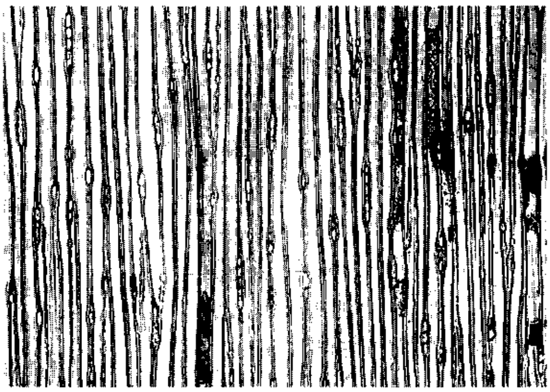
Wood anatomy
- Macroscopic characters:
Heartwood pale yellowish-brown to golden-brown, not clearly demarcated from the paler sapwood. Grain straight, texture fine and even; wood with little or no figure. Growth rings indistinct; diffuse parenchyma present but sometimes not evident to the naked eye; rays very fine, invisible to the naked eye.
- Microscopic characters:
Tracheids polygonal, square, rounded to irregular in cross-section, radially aligned, tangential diameter approximately 40–50 µm, 3–6 mm long; intertracheid pits mainly in radial walls, in single (rarely double) rows, rounded, rarely flattened, 14–18 µm in diameter, crassulae occasionally present; pits in tangential walls rare and smaller; parenchyma moderately abundant, with smooth end walls. Rays 6–9/mm, predominantly uniseriate, biseriate rays rare, (1–)4–8(–12) cells high; ray cells with smooth end walls; ray-tracheid pits mainly cupressoid to sometimes piceoid, larger in marginal cells, 1–2(–3) per crossfield, 8–12 µm in diameter. Reddish-brown extraneous material present in parenchyma cells.
Species studied: *F. falciforme*, *F. papuanum*.
Wood of *Agathis*, *Nageia*, *Phyllocladus*, *Podocar-*



transverse section (×25)



radial section (×150)



tangential section (×75)

Falcatifolium falciforme (transverse & tangential section)
Falcatifolium papuanum (radial section)

pus and *Prumnopitys* is similar to that of *Falcatifolium*. *Agathis* differs by having alternate intertracheid pits. In *Phyllocladus* and *Prumnopitys* parenchyma is absent. However, *Nageia* and *Podocarpus* are very similar.

Other botanical information The species accommodated within *Falcatifolium* were formerly treated as belonging to *Dacrydium*. They are distinct from the latter genus by their bilaterally flattened leaves, by their fertile structures being positioned on short scaly shoots and by the exposed base of the seed.

Ecology *Falcatifolium* is locally common along ridges, often in comparatively exposed locations or in the subcanopy of primary rain forest and sometimes also in kerangas forest. Occasionally, the trees occur as emergents on deeper fertile soils. In Papua New Guinea, *Falcatifolium* is a locally common element of the montane *Nothofagus* forest. The altitudinal range lies between 400 and 2400 m.

Silviculture and management Natural regeneration of *F. falciforme* is sparse in kerangas forest in Borneo, abundant in half-open stands and absent in open sites. In mountainous Fagaceous forest and in cloud forest more natural regeneration is observed in open forest stands.

Genetic resources No efforts are being made to preserve the genetic variability of *Falcatifolium*. *F. falciforme*, *F. gruezoi* and *F. papuanum* are probably not in direct danger of genetic erosion, as they occur in mountainous areas and are not subjected to extensive logging because the trees are often small. The fourth Malesian species, *F. angustum* de Laubenf., is known from only 2 collections in lowland forest near the coast in Sarawak and might be endangered.

Prospects As the timber quality of *Falcatifolium* is as good as that of other genera in the sempilor trade group (*Dacrydium* and *Phyllocladus*), it may be increasingly used and traded in the near future.

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Selection of species

Falcatifolium falciforme (Parl.) de Laubenf.

Journ. Arn. Arb. 50: 309 (1969).

Synonyms *Podocarpus falciformis* Parl. (1868), *Dacrydium falciforme* (Parl.) Pilger (1903).

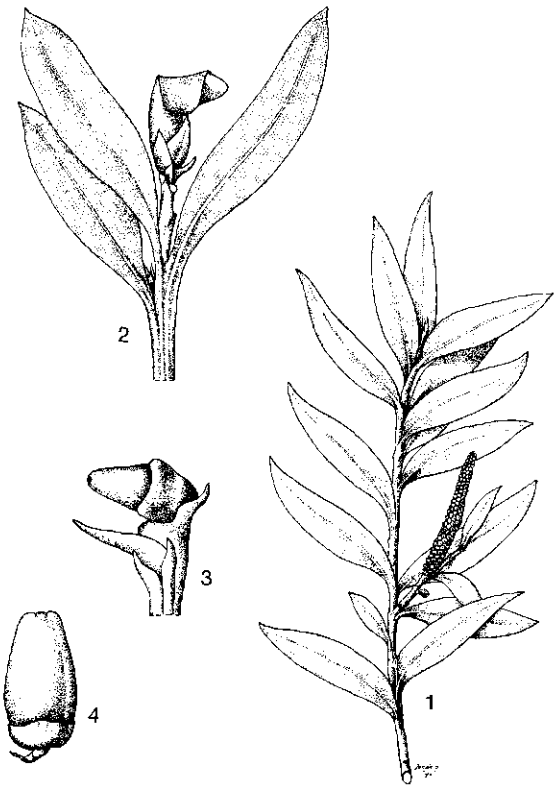
Vernacular names Malaysia: ekor sabit (Peninsular), iguh gawah (Iban, Sarawak).

Distribution Peninsular Malaysia, the Riau-Lingga Archipelago and Borneo (mainly Sarawak and Sabah, locally in Kalimantan).

Uses The wood is used as sempilor.

Observations A large shrub or medium-sized to fairly large tree up to 36 m tall (but ususally much less), crown dome-shaped; adult leaves linear-lanceolate, 20–40(–70) mm × 5–7(–9) mm; pollen cone 20–40 mm × 2.5–3.5 mm. *F. falciforme* occurs locally commonly as a bushy tree or in the subcanopy of primary rain forest along ridges, often on podzolic soils, but occasionally as a large forest tree on more fertile soils, at 400–2100 m altitude. Generally it is found in mixed Fagaceous forest and in cloud forest.

Selected sources 69, 104, 117, 127, 162, 189, 597, 705.



Falcatifolium falciforme (Parl.) de Laubenf. – 1, twig with male cone; 2, twig with young seed-bearing structure; 3, young seed-bearing structure; 4, mature seed.

Falcatifolium gruezoi de Laubenf.

Fl. Malesiana, ser. I, 10: 373 (1988).

Synonyms *Dacrydium falciforme* auct. non (Parl.) Pilger.

Vernacular names Philippines: binaton (general).

Distribution The Philippines, northern and central Sulawesi and the Moluccas (Obi).

Uses The wood is sporadically used as sempilor.

Observations A small tree up to 12 m tall; adult leaves lanceolate, 13–20(–35) mm × 3.5–6(–7) mm; pollen cone 17–60 mm × 1.5–3 mm. *F. gruezoi* occurs in exposed locations along ridges or in forest fringes at (700–)1200–2200 m altitude.

Selected sources 7, 127, 129, 162, 189.

Falcatifolium papuanum de Laubenf.

Journ. Arn. Arb. 50: 312, fig. 6 (1969).

Synonyms *Dacrydium falciforme* auct. non (Parl.) Pilger.

Distribution New Guinea.

Uses The wood is reputed to be used as sempilor.

Observations A medium-sized tree up to 22 m tall, bole up to 50 cm in diameter; adult leaves falcate, 10–20 mm × 2–4 mm, abruptly apiculate; pollen cone 5–13 mm × 2–2.5 mm. *F. papuanum* is locally common in mid-montane forest, and is often associated with *Nothofagus*, *Myrtaceae* and other *Podocarpaceae*, at 1500–2400 m altitude.

Selected sources 127, 162, 268.

E. Boer (general part, properties),
M.S.M. Sosef (general part, selection of species),
J. Ilic (wood anatomy)

Gluta L.

Mant. pl. 2: 293 (1771).
ANACARDIACEAE
x = unknown

Trade groups Rengas: medium-weight hardwood, e.g. *Gluta curtisii* (Oliver) Ding Hou, *G. papuana* Ding Hou, *G. renghas* L., *G. wallichii* (Hook.f.) Ding Hou.
Timber of *Melanochyla* spp. is also traded as rengas.

Vernacular names Rengas. Indonesia: rengas tembaga. Malaysia: rengas kerbau jalang. Papua New Guinea: hekakoro. Burma (Myanmar): thayet-thitsi. Cambodia: kroeul. Thailand: rakban. Vietnam: s[ow]n.

Origin and geographic distribution *Gluta* contains about 30 species which are distributed in Madagascar (1 species), India, Burma (Myanmar), the Andaman Islands, Indo-China, southern China, Thailand, and throughout Malesia except the Philippines and the Lesser Sunda Islands. Peninsular Malaysia is richest in species (15 species, 3 of which are endemic), followed by Borneo (11 species, 5 endemic), Sumatra (9 species, 1 endemic) and Java (2 species). One species occurs in Sulawesi and the Moluccas, and one other species (endemic) in New Guinea. The species with the largest areas of distribution are *G. renghas* (from Peninsular Malaysia to Sulawesi and once found in the Moluccas), *G. velutina* (from Burma (Myanmar) to Borneo and once in Java), and *G. aptera* and *G. wallichii* (both Peninsular Malaysia, Sumatra and Borneo).

Uses The beautiful reddish and streaked heartwood is used for high-class joinery and furniture, and other decorative purposes such as panelling, flooring, rotary veneer, plywood, fancy articles and turnery; the timber is also used for columns and beams in house and bridge construction, corbels, railway sleepers, shipbuilding (keels) and mouldings. The poisonous sap, however, greatly reduces the utilization of rengas. The wood also yields good charcoal.

The resin is collected for varnish manufacture. Roasted seeds are eaten. One species yields a dye.

Production and international trade The export from Peninsular Malaysia varied considerably in the 1980s. The greatest amount of sawn rengas timber was 3000 m^3 exported in 1984, and the smallest amount 26 m^3 exported in 1989. In 1992, the export of sawn timber from Peninsular Malaysia was 2000 m^3, with a value of US$ 240 000 (US$ 120/m^3). In 1987, Sabah exported 7800 m^3 of rengas logs with a value of US$ 475 000, and in 1992 6700 m^3 of logs and 600 m^3 of sawn timber, with a total value of US$ 570 000 (US$ 71/m^3 for logs and US$ 154 for sawn timber). In Papua New Guinea, *Gluta* timber is classified in MEP (Minimum Export Price) group 2, and fetched a minimum export price of US$ 60/m^3 for saw logs in 1992. Japan imports small amounts of rengas, mainly from Sabah.

Properties Rengas is a medium-weight hardwood. The heartwood is red or blood-red becoming dark red or dark reddish-brown upon exposure, and distinctly demarcated from the greyish, yellowish or pinkish-brown sapwood; the wood is often streaked with darker coloured zones. The sapwood is often very wide, up to 18 cm, which is unfavourable as only the heartwood is in demand. The density is (560–)590–870(–960) kg/m^3 at 15% moisture content. The grain is interlocked, texture moderately fine to moderately coarse. Planed surfaces are lustrous.

At 15% moisture content, the modulus of rupture is 70.5–111 N/mm^2, modulus of elasticity 10 975–14 900 N/mm^2, compression parallel to grain 43–49.5 N/mm^2, compression perpendicular to grain c. 7.5 N/mm^2, shear 3.5–13 N/mm^2, cleavage 38–57 N/mm radial and 49–67 N/mm tangential, and Janka side hardness 2970–6190 N.

The rates of shrinkage are fairly low to moderate: from green to 15% moisture content c. 1.0% radial and 1.8% tangential, and from green to oven dry 2.3% radial and 4.3% tangential. Rengas timber air dries at an average rate with little degrade; only slight twisting, springing and insect attack have been observed during drying. Boards 15 mm thick require 2–3 months to air dry, boards 40 mm thick 3.5–5 months. In Malaysia kiln schedule E is recommended for kiln drying.

The green timber is easy to slightly difficult to rip-saw and easy to cross cut and plane with a moderately smooth surface; boring is slightly difficult with moderately rough finish. Air-dry timber is more difficult to saw, cross cut and plane with a moderately smooth surface; boring and turning are slightly difficult with rough surfaces. The resistance to splitting when nailed is rated as excellent. Good veneers of 1.5 mm thick can be produced at a peeling angle of 91°. The veneers can be glued with urea-formaldehyde to produce plywood complying with the Japanese standard. While working with rengas, care should be taken to avoid the poisonous sap which causes painful irritation on contact; contact with the sap can result in severe dermatitis. The sawdust also causes irritation which can be relieved somewhat by applying cream of lead acetate, hydrosulphite of soda or zinc sulphate, or by generous application of soap and washing with water.

Rengas is classified as non-durable to moderately durable. In a graveyard test in Malaysia, *G. torquata* wood had an average service life in contact with the ground of only 1.8 years. In Indonesia, *G. wallichii* wood is rated as resistant to dry-wood termites. In Papua New Guinea, *G. papuana* wood is classified as susceptible to powder-post beetle attack. Rengas wood is easy to treat with preservatives. The average absorption of *G. torquata* wood was 271 kg/m^3 in a test in Malaysia, using an open tank treatment and 100% creosote. However, the heartwood of *G. papuana* is reported as difficult to treat.

Wood of *G. renghas* contains 51% cellulose, 28% lignin, 12.5% pentosan, 0.4% ash and 0.1% silica. The solubility is 3.8% in alcohol-benzene, 2.0% in cold water, 5.4% in hot water and 12.7% in a 1% NaOH solution. The energy value is 19 500 kJ/kg.

The poisonous constituent of the resinous sap is volatile and will gradually disappear. Usually, drying the timber for several years makes it harmless, but lacquered articles or furniture made from dried timber may still be toxic to persons who are especially susceptible. Even sheltering under rengas trees during heavy rain, or smoke from burned rengas wood may cause irritation.

Description Medium-sized to large trees, sometimes small trees or rarely large shrubs, up to 45(–50) m tall; bole usually cylindrical, sometimes slightly fluted at base, occasionally multiple-stemmed, up to 90(–125) cm in diameter, often with buttresses up to 4 m high, sometimes with stilt roots; bark surface fissured, scaly or dippled, rarely smooth, orange-red, reddish-brown, reddish-grey or greyish-brown, often with blotches of tar-like exudation, inner bark pinkish or reddish, with pale or dark-coloured exudate drying blackish; crown dense or spreading, often dome-like and with massive branches. Leaves arranged spirally, sometimes in pseudo-whorls, simple and entire, leathery, petioled (rarely subsessile), lacking stipules. Inflorescence axillary, paniculate; bracts and bracteoles ovate to lanceolate, caducous. Flowers bisexual; pedicels sometimes jointed; calyx cup-like, circumscissile or bursting irregularly at anthesis, caducous; petals (4–)5(–8), imbricate or contorted in bud (rarely valvate), caducous or persistent and enlarged in fruit; stamens (4–)5 (–7), 10 or many, inserted on an elongated floral axis (torus), filaments filiform, glabrous or hairy, anthers dorsifixed; disk absent; ovary superior, sessile or with stipe between insertion of stamens and ovary, 1-celled, glabrous or hairy, style 1, filiform, terminal or lateral, with indistinct stigma. Fruit a 1-celled drupe, sometimes stalked and sometimes supported by much-enlarged wing-like petals, smooth and shiny or powdery hairy. Seed with testa adherent to endocarp, embryo usually straight, cotyledons free or partly fused. Seedling with hypogeal germination, cotyledons non-emergent, hypocotyl not elongated; all leaves arranged spirally, first leaves scale-like, leaves produced intermittently in flushes.

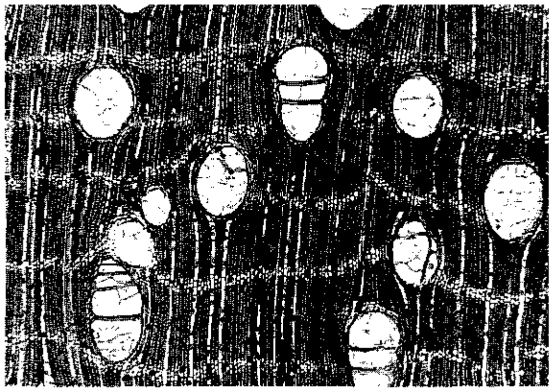
Wood anatomy

– Macroscopic characters:

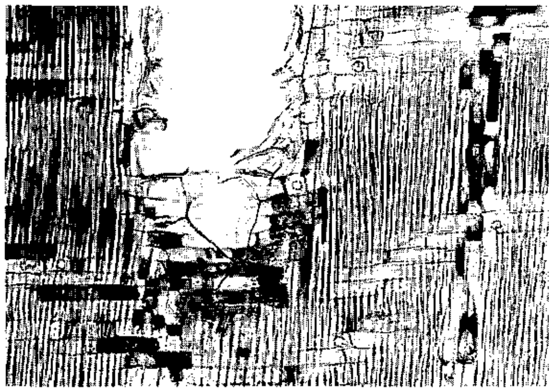
Heartwood medium to dark reddish-brown, occasionally with dark bands, often distinctly demarcated from the greyish to pinkish or yellowish-brown sapwood. Grain finely interlocked. Texture moderately fine to moderately coarse; wood weakly to distinctly lustrous. Growth rings usually distinct, delineated by compact fibrous tissue and a closer spacing of axial parenchyma bands; vessels visible to the naked eye, tyloses abundant; parenchyma distinct in latewood, in tangential bands, especially thick terminally; rays almost invisible to the naked eye; ripple marks absent.

– Microscopic characters:

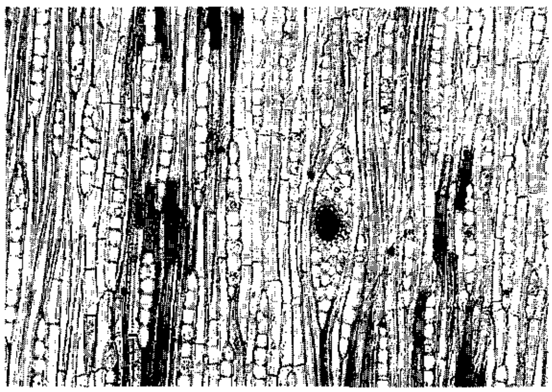
Growth rings present, defined by the closer spacing of marginal parenchyma bands. Vessels diffuse, 2–4/mm^2, solitary (35–50%) or in multiples of 2–5, generally oval, average tangential diameter 115–210 μm; perforation plates simple; intervessel pits dense, alternate, with a pit border diameter of 10–12 μm; vessel-ray pits 10–13 μm in diameter and with strongly reduced borders or simple; tyloses abundant. Fibres 600–1200 μm long, non-



transverse section (×25)



radial section (×75)



tangential section (×75)

Gluta renghas

septate, thin-walled, with sparse minutely bordered pits mainly confined to the radial walls; occasionally fibres with coloured deposits present in broad tangential bands in earlywood of growth rings. Axial parenchyma paratracheal, vasicentric; apotracheal parenchyma banded and marginal (irregularly zonate), bands 2–6(–8) cells wide, in 3–4(–8)-celled strands. Rays 4–12(–20)/mm, uniseriate or multiseriate with horizontal canals surrounded by epithelial cells, mostly less than 0.4 mm high, homocellular. Silica bodies abundant in ray cells. Horizontal intercellular canals present, mostly one in each multiseriate ray, 20–65 μm in diameter; axial intercellular canals absent.
Species studied: *G. macrocarpa*, *G. renghas*, *G. travancorica* Bedd., *G. usitata* (Wallich) Ding Hou.

Growth and development The growth of young rengas trees is reported as fairly rapid under favourable circumstances. Diameter increments of up to 2.2 cm/year have been reported in *G. wallichii* trees. The average height increment of *G. renghas* is 0.5 m/year in favourable conditions.
Most species are evergreen, but some are deciduous or semi-deciduous. *G. pubescens* sheds its leaves in Malaysia at the beginning of the rainy season, and then flowers on the bare twigs before new leaves unfold. In trees of *G. renghas* it was observed that separate limbs flowered and subsequently bore fruit at different times of the year, so two generations of fruits can be present on different branches. Fruits of *G. renghas* take 7 months to mature and fall after about 11 months.
Fruits of some species growing in swampy areas or along rivers are dispersed by water. Fruits with wing-like petals, present in several species, turn upside-down when they fall from the tree and rotate in the air. Rengas fruits are reported to be eaten by monkeys and squirrels, in spite of their irritant sap. Fruits of *G. renghas* are eaten by giant squirrels. They are reportedly also dispersed by fruit-eating bats.

Other botanical information *Gluta* belongs to the tribe *Anacardieae* together with the genera *Anacardium*, *Androtium*, *Bouea*, *Buchanania*, *Mangifera* and *Swintonia*. *Gluta* can be distinguished by its calyptriform calyx.
Several characters are extremely variable in *Gluta*: the calyx falls off in one piece or bursts irregularly or splits on one side at anthesis, the stamens vary in number from 5 to 10 or numerous, the style is either terminal or excentric, the petals are enlarged and may or may not be wing-like in fruits, the cotyledons may be free or partly fused. This variability has resulted in two genera being distinguised: *Gluta* and *Melanorrhoea* which are considered to differ particularly in the number of stamens, the length of the elongated floral axis, the presence or absence of wing-like petals in the fruit and the opening of the calyx. However, several species show intermediate characters and at present *Melanorrhoea* is considered to be a synonym for *Gluta*. The species show reticulate relationships and cannot be separated satisfactorily into groups.
The wood of *G. usitata* (well known as the source of Burmese lacquer) and *G. travancorica* is valued in India and Burma (Myanmar).

Ecology Rengas trees usually occur scattered in primary lowland rain forest, from mixed dryland to peat-swamp forest, but species of swamp and riverine forest (e.g. *G. renghas*, *G. velutina*) may occur gregariously or even co-dominant. They rarely reach 1200 m altitude. Several species occur particularly on ridges.

Propagation and planting Rengas can be propagated by seed in nurseries or by direct sowing. Per kg *G. renghas* has about 34 dry fruits and *G. wallichii* about 3200 dry seeds without wings. Fruits of *G. aptera* had 20% germination 2.5 months after sowing and fruits of *G. elegans* 95% germination in 0.5–4 months.
Rengas seedlings may be planted as stumps, as bare-root stock or as containerized seedlings; a usual spacing is 3 m × 2 m. Direct sowing of *G. renghas* was very successful in teak (*Tectona grandis* L.f.) plantations.

Silviculture and management Rengas seedlings and saplings seem to tolerate shade to a certain extent. In an experiment in Penang, Peninsular Malaysia, *G. curtisii* could not profit from increased light levels, as did *Shorea curtisii* Dyer ex King and *Shorea macroptera* Dyer, and seedling growth was slower. Natural regeneration is especially noticeable along rivers. *G. renghas* is suitable for underplanting in teak plantations after the teak has been thinned. Here, it develops into a dense vegetation layer under the teak, reducing weed development. In these plantations *G. renghas* resprouts after fire.

Harvesting Logs are usually sound, although old trees may be hollow or suffer from heart shakes. Fellers and sawyers should be provided with antidotes to the poisonous sap and the irritating sawdust. To minimize the chance of coming into contact with the sap, trees can be girdled and left to die, which takes 6–12 months. Felled trees may also be left in the forest to allow the sapwood decay; the heartwood, which is not attacked by termites, remains. It is unclear whether these two techniques are still in use, but it is possible that they are still practised by the local population.

Yield In many regions, the availability of rengas in natural forest is still fairly good. In lowland forest in Sarawak, on average about 1 large tree per 2.5 ha has been reported, but locally more than 2.5 trees/ha may be found. In natural forest in East Kalimantan, the volume of exploitable rengas timber was 5.9 m^3/ha. A tree of *G. renghas* with a clear bole of 18 m and a diameter of 87 cm can yield a timber volume of 9.2 m^3.

Genetic resources Most *Gluta* species are widespread and, at least locally, common. In many regions they have been avoided because of the poisonous sap and do not seem to be in serious danger of genetic erosion. However, a few species are rare or only very locally common, and need protection, e.g. *G. capituliflora* Ding Hou and *G. lanceolata* Ridley in Peninsular Malaysia. Rengas trees have not been planted, except in some botanical gardens.

Prospects The trade and use of rengas wood have been hampered by the poisonous or irritating sap and by the fact that the logs often have very wide sapwood. This limits its usefulness as a plantation tree for timber production. However, the heartwood is in demand for decorative purposes, and research on methods of sustainable management of natural stands of rengas seems profitable. Long cutting cycles are probably needed to obtain economically sufficient amounts of heartwood.

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Selection of species

Gluta aptera (King) Ding Hou

Blumea 24: 12 (1978).

Synonyms *Melanorrhoea aptera* King (1896), *Melanorrhoea inappendiculata* King (1896), *Melanorrhoea tricolor* Ridley (1933).

Vernacular names Indonesia: ungan (Dayak, Kalimantan). Malaysia: rengas kerbau jalang, rengas paya (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as rengas.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole up to 90 cm in diameter, buttresses absent or small, sometimes up to 3 m high, bark surface rather smooth to scaly, brown, inner bark coarsely fibrous, reddish; leaves obovate to obovate-oblong or elliptical, 4–29(–37.5) cm × 2.5–10.5(–15.5) cm, blunt, rounded or emarginate at apex, usually glabrous, with 10–23(–28) pairs of secondary veins, petiole up to 2.5 cm long, often faintly winged; flowers with circumscissile calyx, petals 11–16 mm long, white changing to red, torus broadly ovoid, 1.5–2 mm in diameter, stamens numerous, ovary glabrous; fruit subglobose, 2.5–3.5 cm in diameter, smooth, with a c. 5 mm long stalk, usually without enlarged petals; cotyledons free. *G. aptera* is widely distributed and locally common in lowland dryland and peat-swamp forest, also in secondary growth, up to 1200 m altitude. The density of the heartwood is 865–915 kg/m^3 at 15% moisture content, and the density of the sapwood 510–720 kg/m^3.

Selected sources 77, 78, 140, 162, 246, 576, 705.

Gluta beccarii (Engl.) Ding Hou

Blumea 24: 13 (1978).

Synonyms *Melanorrhoea beccarii* Engl. (1880).

Vernacular names Malaysia: rengas kerangas, rengas paya (Sarawak).

Distribution Peninsular Malaysia (rare) and Borneo (Sarawak, Brunei).

Uses The wood is used as rengas.

Observations A medium-sized to fairly large tree up to 36 m tall, with bole up to 80(–110) cm in diameter, buttresses small, up to 1.3 m high, bark surface rather smooth to shaggy scaly, pale brown, greyish, reddish or dark brown; leaves obovate or elliptical, 6–13 cm × 2.5–6 cm, obtuse or emarginate at apex, sometimes slightly acute, usually glabrous, with 9–18 pairs of secondary veins, petiole up to 2.5 cm long; flowers with circumscissile calyx, petals 12–14 mm long, white changing to dark pink, torus subglobose, c. 1.5 mm in diameter, stamens numerous, ovary glabrous; fruit subglobose, c. 1.5 cm in diameter, smooth, bright purplish-red, with a c. 10 mm long stalk, with enlarged petals up to 6 cm long; cotyledons free. *G. beccarii* occurs locally frequently in peat-swamp forest and kerangas forest in Sarawak, also in dryland forest up to 100 m altitude, in Peninsular Malaysia on steep granitic ridges at 600 m altitude. The density of the wood is 495–705 kg/m^3 at 15% moisture content.

Selected sources 77, 162, 246, 576, 705.

Gluta curtisii (Oliver) Ding Hou

Blumea 24: 13 (1978).

Synonyms *Melanorrhoea curtisii* Oliver (1886).

Vernacular names Malaysia: rengas, rengas marah keluang (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as rengas.

Observations A medium-sized tree up to 30(–34) m tall, with bole up to 70(–80) cm in diameter, buttresses usually small or absent, sometimes up to 2.5 m high, bark surface scaly, sometimes also dippled, usually orange-red, inner bark reddish; leaves elliptical-oblong or oblanceolate, 5–14 cm × 2.5–5 cm, rounded, obtuse or shortly acuminate at apex (rarely emarginate), glabrous, with 6–14(–18) pairs of secondary veins, petiole up to 2.5 cm long; flowers with circumscissile calyx, petals 4.5–6 mm long, white or pale lilac, torus subglobose, c. 1 mm in diameter, stamens (8–)10, ovary glabrous; fruit subglobose, c. 1 cm in diameter, with a c. 10 mm long stalk, with enlarged petals up to 9 cm long; cotyledons free. *G. curtisii* occurs locally frequently in lowland mixed rain forest up to 1200 m altitude, most commonly on ridges at 300–700 m. The density of the wood is 620–945 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 140, 162, 246, 651, 705.

Gluta elegans (Wallich) Hook.f.

Fl. Brit. India 2: 22 (1876).

Vernacular names Malaysia: rengas (Peninsular). Thailand: rak (Satun).

Distribution Burma (Myanmar), peninsular Thailand and Peninsular Malaysia.

Uses The wood is used as rengas for furniture. The wood can also be used to dye orange to blackish, depending on the mordants used.

Observations A medium-sized tree up to 27 m tall, with bole up to 70 cm in diameter, buttresses small or absent, or bole slightly fluted, bark surface smooth to scaly, reddish-grey, inner bark reddish; leaves elliptical to oblanceolate, 6–17.5 cm × 2–6.5 cm, acuminate or blunt at apex, glabrous, with 7–14 pairs of secondary veins, petiole up to 4(–6.5) cm long; flowers with irregularly bursting calyx, petals 11–15 mm long, white, torus cylindrical, 5–6 mm long, stamens 5, ovary glabrous; fruit obliquely ovoid or broadly ellipsoid, up to 5.5 cm long, shiny black, with a c. 7.5 mm long stalk, without enlarged petals; cotyledons incompletely fused. *G. elegans* occurs locally frequently in lowland rain forest up to 300 m altitude. The density of the wood is 570–880 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 162, 463, 465, 705.

Gluta laxiflora Ridley

Kew Bull.: 196 (1933).

Vernacular names Brunei: rengas. Malaysia: rengas (Sarawak).

Distribution Borneo (Sarawak and Brunei).

Uses The wood is reputed to be used as rengas.

Observations A medium-sized tree up to 24 m tall, with bole up to 60 cm in diameter, buttresses small or absent, bark surface flaky, rusty brown and pale grey mottled; leaves elliptical-lanceolate, rarely oblanceolate, 9–28 cm × 3–9 cm, acuminate at apex, glabrous, with 11–17 pairs of secondary veins, petiole up to 5 cm long; flowers with irregularly bursting calyx, petals 8–9 mm long, torus cylindrical, 2–3 mm long, stamens 5(–6), ovary puberulous; fruit obliquely ellipsoid or broadly ellipsoid, up to 9 cm long, brownish and scurfy, with an obscure stalk, without enlarged petals; cotyledons incompletely fused. *G. laxiflora* occurs in lowland primary mixed dipterocarp forest. It is frequent to abundant on clay soils in Brunei.

Selected sources 162, 576.

Gluta macrocarpa (Engl.) Ding Hou

Blumea 24: 14 (1978).

Synonyms *Melanorrhoea macrocarpa* Engl. (1883).

Vernacular names Malaysia: rengas (Peninsular).

Distribution Peninsular Malaysia and Borneo (Sarawak, Sabah and East Kalimantan).

Uses The wood is reputed to be used as rengas.

Observations A medium-sized to large tree up to 45 m tall, with bole up to 80 cm in diameter, buttresses occasionally present, up to 6 m high, bark surface smooth or scaly, reddish-grey; leaves elliptical-oblong to elliptical-lanceolate or obovate-oblong, 8–19 cm × 3–8.5 cm, rounded to shortly acuminate at apex, glabrous, with 10–15 pairs of secondary veins, petiole up to 3 cm long; flowers with circumscissile calyx, petals 4–7 mm long, white, yellow at base, torus subglobose, c. 1 mm in diameter, stamens (15–)20(–28), ovary glabrous; fruit subglobose, up to 4 cm in diameter, brownish to purplish-black, smooth, with stalk up to 3 mm long, enlarged petals sometimes present, up to 15(–30) mm long; cotyledons free. *G. macrocarpa* occurs in primary mixed dipterocarp forest up to 1200 m altitude, often on ridges, also on limestone and sandy soils.

Selected sources 162, 246, 705.

Gluta malayana (Corner) Ding Hou

Blumea 24: 14 (1978).

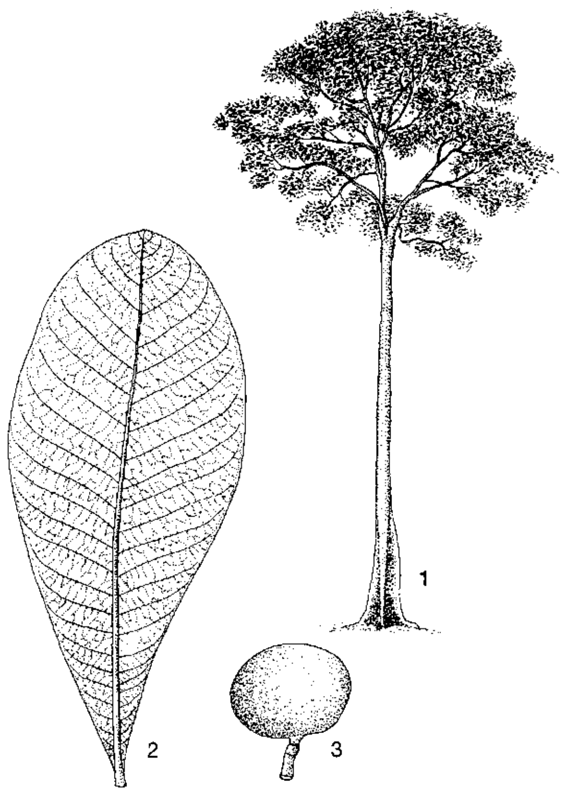
Synonyms *Melanorrhoea pilosa* Ridley (1931) non Lecomte, *Melanorrhoea malayana* Corner (1939).

Vernacular names Indonesia: kilakap (Bengkalis, Sumatra). Malaysia: rengas kerbau jalang (Peninsular).

Distribution Peninsular Malaysia and Sumatra.

Uses The wood is reputed to be used as rengas.

Observations A large deciduous tree up to 45 m tall, with bole up to 125 cm in diameter, buttresses steep and rather narrow, up to 6 m high, bark surface very closely shallowly fissured to dippled and scaly, pinkish-grey to greyish-brown, inner bark pinkish; leaves obovate-oblong to elliptical-lanceolate, 16.5–32 cm × 7–15 cm, rounded, obtuse to emarginate at apex, pubescent when young but usually glabrescent, with 17–27 pairs of secondary veins, petiole obscure or very short, up to 3 mm long; flowers with circumscissile calyx, petals 3–5 mm long, torus cylindrical, c. 1 mm long, stamens 5, ovary glabrous; fruit subglobose or depressed-globose, c. 3 cm in diameter, brown to dark brown, smooth, with stalk up to 15 mm long, enlarged petals sometimes present, up to 20 mm long; cotyledons free. *G. malayana* occurs in lowland forest in swampy or undulating country and is locally very common. The density of the wood is 580–770 kg/m^3 at 15% moisture content.



Gluta malayana (Corner) Ding Hou – 1, tree habit; 2, leaf; 3, fruit.

Selected sources 104, 140, 162, 246, 705.

Gluta oba (Merr.) Ding Hou

Blumea 24: 14 (1978).

Synonyms *Melanorrhoea oba* Merr. (1917).

Vernacular names Malaysia: oba, rengas (Sarawak, Sabah).

Distribution Borneo (Sarawak and Sabah).

Uses The wood is reputed to be used as rengas.

Observations A medium-sized tree up to 30 m tall, with bole up to 60 cm in diameter, buttresses up to 1.2 m high, bark surface scaly, grey or brownish; leaves elliptical, broadly elliptical or obovate, 5–14 cm × 2–8 cm, obtuse at apex, sometimes slightly acute, glabrous, with 9–11 pairs of secondary veins, petiole up to 15 mm long; flowers with circumscissile calyx, petals 6–7 mm long, white, torus ellipsoid, c. 2 mm long, stamens 10, ovary glabrous; fruit subglobose, up to 4 cm in diameter, dark brown, smooth, with stalk up to 18 mm long, without enlarged petals; cotyledons free.

G. oba occurs in lowland mixed dipterocarp forest and is locally common.

Selected sources 162, 246, 576.

Gluta papuana Ding Hou

Blumea 24: 14 (1978).

Vernacular names Papua New Guinea: hekakoro.

Distribution New Guinea.

Uses The timber has been especially used for the keels of canoes and for carving and is also used for light construction, furniture, interior finish, corbels, sleepers and mouldings.

Observations A medium-sized tree up to 31 m tall, with bole up to 50 cm in diameter, buttresses occasionally present and then steep and up to 3 m high, bark surface smooth and scaly, greyish-brown to dark red; leaves elliptical, broadly elliptical or obovate-oblong, 7–20.5 cm × 3–10.5 cm, rounded to slightly emarginate at apex, rarely cuspidate, glabrous, with 12–17 pairs of secondary veins, petiole up to 25 mm long; flowers with irregularly bursting calyx, petals 6.5–7.5 mm long, white, torus cylindrical, c. 1 mm long, stamens 5(–6), ovary glabrous; fruit subreniform, up to 8 cm × 5 cm, pale to dark brown or bluish-black, smooth, with an obscure stalk, without enlarged petals; cotyledons incompletely fused. *G. papuana* occurs in the lowland, in seasonally inundated forest along rivers, in freshwater swamps, but also in forest on well-drained soils, and secondary forest. The heartwood is thin and reddish-brown; the density is about 520 kg/m^3 at 12% moisture content.

Selected sources 145, 162, 166, 246, 660.

Gluta pubescens (Ridley) Ding Hou

Blumea 24: 15 (1978).

Synonyms *Melanorrhoea pubescens* Ridley (1922).

Vernacular names Malaysia: rengas, sisek tenggiling, sumpah biawak (Peninsular).

Distribution Peninsular Malaysia and Sumatra (Tapanuli).

Uses The wood is reputed to be used as rengas.

Observations A medium-sized to fairly large deciduous tree up to 40(–45) m tall, with bole up to 110 cm in diameter, sometimes fluted at base, buttresses occasionally present, up to 2 m high, bark surface very flaky or scaly, with loose overlapping scales, brown, inner bark reddish; leaves elliptical or obovate, 9–17 cm × 3.5–8.5 cm, rounded or emarginate at apex, pubescent below especially on the veins, with 11–18 pairs of secondary veins, petiole up to 3.5 cm long; flowers with circumscissile calyx, petals 9–13 mm long, white, torus subglobose, c. 2 mm in diameter, stamens numerous, ovary sparsely hairy; fruit transverse-oblong, up to 2.5 cm × 4.5 cm, smooth, with a stalk up to 15 mm long, usually without enlarged petals; cotyledons free. *G. pubescens* is locally common in lowland forest, in swamps and in dryland forest, especially on ridges.

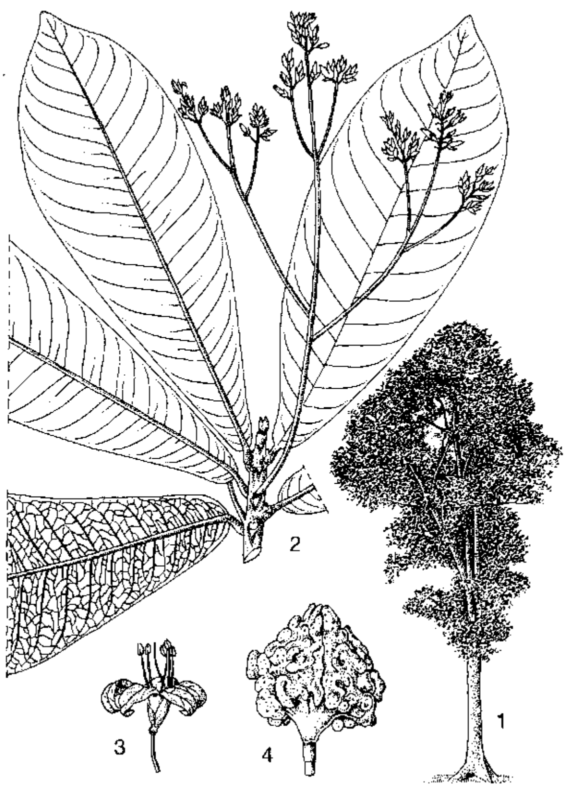
Selected sources 78, 104, 162, 246, 705.

Gluta renghas L.

Mant. pl. 2: 293 (1771).

Vernacular names Indonesia: kayu rengas suloh (Sumatra), rengas burung (Sumatra, Kalimantan), rengas tembaga (Java). Malaysia: rengas ayer, rengas jitong (Peninsular). Burma (Myanmar): thayet-thitsi. Thailand: rak baan (Songkhla), rak khao (Ranong).

Distribution Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi and once found in the Moluccas; possibly also in Burma (Myanmar) and southern Thailand.



Gluta renghas L. – 1, tree habit; 2, flowering twig; 3, flower; 4, fruit.

Uses The timber is used for columns and beams in house and bridge construction, railway sleepers, shipbuilding (keels) and turnery and is very suitable for furniture, panels, floors and veneer. The resin is collected for varnish manufacture. Roasted seeds are eaten.

Observations A medium-sized to large tree up to 50 m tall, with bole up to 115 cm in diameter, often multiple-stemmed and conically thickened at base, buttresses often present, bark surface dippled and scaly, pale brown to greyish; leaves elliptical-oblong to oblanceolate or obovate, 8–28(–36) cm × 4–8(–9) cm, obtuse at apex, glabrous, with 17–30 pairs of secondary veins, petiole up to 3 cm long; flowers with irregularly bursting calyx, petals 7.5–13 mm long, white, torus cylindrical, 2–3 mm long, stamens 5, ovary glabrous; fruit subglobose, up to 5 cm in diameter, with short or indistinct stalk up to 5 mm long, pinkish-brown scurfy and with irregular crests and protuberances, without enlarged petals; cotyledons incompletely fused. *G. renghas* occurs locally gregariously along river banks in freshwater tidal reaches and in swamp forest without peat formation. The density of the heartwood is 590–840 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 36, 78, 143, 162, 218, 234, 403, 410, 474, 526, 595, 705.

Gluta rostrata Ding Hou

Blumea 24: 15 (1978).

Vernacular names Indonesia: rengas, rengai, renge (Sumatra).

Distribution Sumatra.

Uses The wood is reputed to be used as rengas.

Observations A medium-sized tree up to 20 m tall, with bole up to 65 cm in diameter, buttresses up to 2 m high, bark surface rough, greyish red-brown; leaves obovate-oblong to oblanceolate, sometimes elliptical, 7.5–16 cm × 2.5–6.5 cm, obtuse, rounded or emarginate at apex, glabrous, with 9–14 pairs of secondary veins, petiole up to 17.5 mm long; flowers with circumscissile calyx, petals 7–12 mm long, torus subglobose, c. 1.5 mm in diameter, stamens numerous, ovary glabrous; fruit globose, up to 4 cm in diameter, sessile, brown and densely lenticellate, without enlarged petals; cotyledons free. *G. rostrata* occurs in lowland forest up to 60 m altitude, often on marshy places.

Selected sources 162, 246.

Gluta rugulosa Ding Hou

Blumea 24: 16 (1978).

Vernacular names Indonesia: hemboja, umpoh (Kalimantan).

Distribution Borneo.

Uses The wood is reputed to be used as rengas.

Observations A medium-sized tree up to 30 m tall; leaves obovate to oblanceolate, 6–27.5 cm × 4.5–10.5 cm, rounded or sometimes slightly emarginate at apex, glabrous, with 11–21 pairs of secondary veins, petiole absent or up to 1 cm long; flowers with circumscissile calyx, petals 7.5–9 mm long, torus subglobose, c. 1.5 mm in diameter, stamens numerous, ovary scurfy; fruit globose, up to 3.5 cm in diameter, sessile, brown and densely lenticellate, with enlarged petals up to 30 mm long; cotyledons free. *G. rugulosa* occurs in lowland forest up to 150 m altitude.

Selected sources 162, 246.

Gluta sabahana Ding Hou

Blumea 24: 16 (1978).

Vernacular names Malaysia: rengas, rengas mangga (Sabah).

Distribution Borneo (Sabah).

Uses The wood is reputed to be used as rengas.

Observations A medium-sized tree up to 30 m tall, with bole up to 60 cm in diameter, buttresses occasionally present but very small, up to 0.5 m high, bark surface smooth, dark brown; leaves oblanceolate, obovate-oblong, elliptical-lanceolate to narrowly elliptical, 13–23 cm × 3–8 cm, acuminate or sometimes acute at apex, glabrous, with 9–15 pairs of secondary veins, petiole very short, up to 7.5(–15) mm long; flowers with irregularly bursting calyx, petals 5–7.5 mm long, whitish or pale yellow, torus cylindrical, c. 1 mm long, stamens 5(–7), ovary puberulous; fruit obliquely broadly ellipsoid, up to 9 cm long, with obscure stalk, brownish scurfy, without enlarged petals; cotyledons incompletely fused. *G. sabahana* occurs in lowland forest up to 100 m altitude, sometimes in swampy places.

Selected sources 162, 246.

Gluta speciosa (Ridley) Ding Hou

Blumea 24: 21 (1978).

Synonyms *Melanorrhoea speciosa* Ridley (1933).

Vernacular names Malaysia: rengas bulu (Sarawak).

Distribution Borneo (Sarawak and Brunei).

Uses The wood is reputed to be used as rengas.

Observations A fairly large tree up to 40 m tall, with bole up to 80 cm in diameter, buttresses up to 1.5 m high, bark surface irregularly fissured, dark brown; leaves obovate, 5–17.5 cm × 3–9 cm, rounded or emarginate at apex, pubescent below, with 10–22 pairs of secondary veins, petiole up to 2 cm long; flowers with circumscissile calyx, petals 10–15 mm long, white but reddish at base, torus subglobose, c. 1.5 mm in diameter, stamens numerous, ovary densely hairy; fruit subglobose, up to 3 cm in diameter, with a short, c. 5 mm long stalk, smooth, without enlarged petals; cotyledons free. *G. speciosa* occurs in the lowland, both in dryland mixed dipterocarp forest on loamy soils and in peat-swamp forest.

Selected sources 162, 246, 576.

Gluta torquata (King) Tard.

Adansonia 1: 195, t. 1, fig. 15 (1961).

Synonyms *Melanorrhoea torquata* King (1896).

Vernacular names Indonesia: sitorngom horbojalang (Sumatra). Malaysia: rengas kerbau jalang (Peninsular).

Distribution Peninsular Malaysia and Sumatra (Tapanuli).

Uses The wood is used as rengas.

Observations A medium-sized tree up to 30 m tall, with bole up to 80(–125) cm in diameter, buttresses steep, up to 3 m high, bark surface smooth to finely dippled, pale brown; leaves obovate, sometimes obovate-oblong or broadly elliptical, 15–24(–35) cm × 9–13.5(–18) cm, rounded or slightly emarginate at apex, usually glabrous, with 16–29 pairs of secondary veins, petiole up to 2 cm long; flowers with irregularly bursting calyx, withering and twisting round the pedicel like a loose collar, petals 5–6 mm long, white, densely puberulous, torus cylindrical, c. 1.5 mm long, stamens 5, ovary hairy; fruit subglobose or depressed-globose, up to 4 cm in diameter, with a c. 10 mm long stalk, smooth, brown, without enlarged petals; cotyledons free. *G. torquata* is uncommon and occurs in lowland forest. The density of the wood is 625–750 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 78, 140, 162, 206, 364, 389, 705.

Gluta velutina Blume

Mus. Bot. Lugd.-Bat. 1: 183 (1850).

Synonyms *Gluta coarctata* (Griffith) Hook.f. (1876).

Vernacular names Indonesia: rengas pendek (Sumatra). Malaysia: rengas ayer, rengas pantai (Peninsular). Thailand: rak nam (Surat Thani). Vietnam: c[aa]y s[ow]n dai.

Distribution Burma (Myanmar), Thailand, Vietnam, Peninsular Malaysia, Sumatra, western Java (collected only once) and Borneo.

Uses The wood is used as rengas, but the timber is only available in small dimensions. The seeds and leaves are reportedly edible, but this needs confirmation, as other parts of the plant contain irritant or even poisonous substances (especially the bark). The exudate is sometimes used as lacquer.

Observations A large shrub or small to medium-sized tree up to 20 m tall, with often gnarled bole up to 50 cm in diameter, often with branched stilt roots and short, sharp buttresses, bark surface smooth to minutely scaly, pinkish-brown; leaves elliptical-oblong to oblanceolate, 12–32 cm × 5–8 cm, obtuse to acuminate at apex, glabrous, with 16–32 pairs of secondary veins, petiole very short, up to 1 cm long; flowers with irregularly bursting calyx, petals 7–9 mm long, whitish or pinkish, torus cylindrical, 1.5–2 mm long, stamens 5, ovary glabrous; fruit subglobose, up to 7.5 cm in diameter, with a short, c. 5 mm long stalk, pale brown scurfy with irregularly tuberculate ridges especially towards the base, without enlarged petals; cotyledons free. *G. velutina* is common along edges of tidal rivers on submerged mudbanks in the freshwater or slightly brackish zone, together with *Barringtonia conoidea* Griffith and *Pandanus helicopus* Griffith. The density of the sapwood is only about 320 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 104, 162, 163, 474, 576, 595, 705.

Gluta wallichii (Hook.f.) Ding Hou

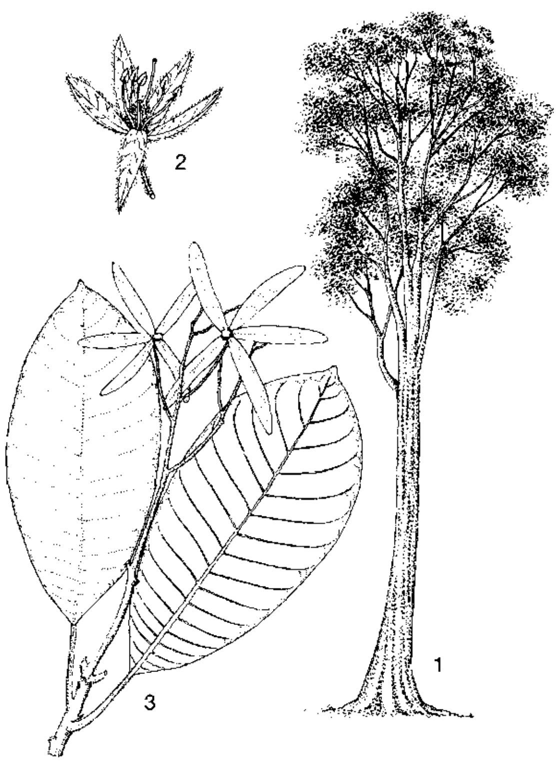
Blumea 24: 21 (1978).

Synonyms *Melanorrhoea wallichii* Hook.f. (1876), *Melanorrhoea maingayi* Hook.f. (1876), *Melanorrhoea woodsiana* Scort. ex King (1896).

Vernacular names Indonesia: rengas tjujung (East Kalimantan). Malaysia: rengas kerbau jalang, rengas burung, rengas sumpah biawak (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses *G. wallichii* is an important source of rengas timber; the wood is especially valued for furniture but is also used for columns and beams in house and bridge construction, railway sleepers, shipbuilding (keels), turnery, panels, floors and veneer. The fruits have been mixed into dart poison. Roots and leaves have been applied in local medicine.



Gluta wallichii (Hook.f.) Ding Hou – 1, tree habit; 2, flower; 3, fruiting twig.

Observations A large evergreen tree up to 45 m tall, with bole up to 90 cm in diameter, buttresses up to 4 m high, bark surface usually deeply fissured, greyish-brown, inner bark pinkish; leaves obovate-oblong to elliptical or elliptical-lanceolate, 8.5–34.5 cm × 4–14 cm, obtuse to acuminate at apex, sometimes slightly emarginate, glabrous or velvety hairy below, with 9–24 pairs of secondary veins, petiole up to 6 cm long; flowers with irregularly bursting calyx, petals 4–7 mm long, white, densely hairy, torus pulvinate, c. 1.5 mm in diameter, stamens 5, ovary hairy; fruit ovoid or ellipsoid, up to 1.5 cm long, with an obscure stalk, smooth, brownish, with enlarged petals up to 8 cm long; cotyledons free. *G. wallichii* is widely distributed in mixed dipterocarp forest and swamp forest up to 1000 m altitude. In Peninsular Malaysia, it is common on hillsides, in Sumatra locally co-dominant in peat-swamp forest. It can be found on clayey soils as well as limestone. The density of the wood is 470–980 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 104, 140, 162, 234, 246, 403, 474, 572, 576, 595, 705.

Gluta wrayi King

Journ. As. Soc. Beng. 65(2): 482 (1896).

Synonyms *Gluta virosa* Ridley (1917).

Vernacular names Malaysia: rengas ayer, rengas kerbau jalang (Peninsular). Thailand: rak (Trat), rak bai nui (Satun). Vietnam: c[aa]y s[ow]n qu[ar].

Distribution Southern Vietnam, Thailand and Peninsular Malaysia.

Uses The wood is used especially for furniture.

Observations A medium-sized tree up to 30 m tall, with bole up to 85 cm in diameter, buttresses rather stout, up to 3 m high, bark surface smooth to shallowly dippled, greyish-brown, greenish-brown or orange-brown, inner bark yellowish-brown; leaves elliptical to elliptical-lanceolate, (6–)10–26 cm × (2–)3.5–9 cm, acuminate at apex, glabrous, with 9–15 pairs of secondary veins, petiole up to 4.5 cm long; flowers with irregularly bursting calyx, petals 10–13 mm long, white, torus cylindrical, 1.5–4 mm long, stamens 5(–6), ovary densely puberulous; fruit ellipsoid, up to 7 cm long, with an obscure stalk, brownish scurfy, without enlarged petals; cotyledons incompletely fused. *G. wrayi* occurs in lowland forest up to 800 m altitude, sometimes on granite ridges. The heartwood is a beautiful deep red with dark bands.

Selected sources 78, 162, 163, 705.

E. Boer (general part)
R.H.M.J. Lemmens (general part, selection of species),
W.C. Wong (properties),
S. Noshiro (wood anatomy)

Gymnacranthera (A.DC.) Warb.

Ber. Pharm. Ges. 2: 227 (1892).

MYRISTICACEAE

x = unknown; *G. farquhariana* var. *zippeliana*: $n = 21$

Trade groups Penarahan: lightweight to medium-weight hardwood, e.g. *Gymnacranthera bancana* (Miq.) Sinclair, *G. farquhariana* (Wallich ex Hook.f. & Thomson) Warb., *G. forbesii* (King) Warb.

Penarahan timber represents the wood of all genera of the family *Myristicaceae*, hence as well as *Gymnacranthera* also *Horsfieldia, Knema* and *Myristica*. In the Philippines, penarahan is traded mixed with red meranti or as mixed second-class timber.

Vernacular names Penarahan. Indonesia: siamang, biawak (Sumatra). Malaysia: darah darah (Sabah), kumpang (Sarawak). Papua New Guinea: nutmeg. Philippines: anuping.

Origin and geographic distribution *Gymnacranthera* consists of 7 species, one of which occurs in southern India. The other 6 species are distributed in southernmost Thailand, Peninsular Malaysia, Sumatra, Borneo, Sulawesi, the Moluccas, the Philippines (not yet recorded in Palawan), New Guinea and the Bismarck Archipelago. The greatest species diversity is found in Borneo.

Uses The timber of *Gymnacranthera* is used for the same purposes as that of other genera in the family of *Myristicaceae*. It is reported to be used for rotary veneer, pattern making, tool handles, cabinet work, shelving, moulding and light construction. The wood may be of local importance for construction and firewood. The Indian species *G. canarica* (King) Warb. yields a vegetable oil or fat. The bark of *G. farquhariana* is mixed with lime to cure the skins of birds.

Production and international trade *Gymnacranthera* timber is traded together with the timber of other *Myristicaceae* genera, so no separate production and trade figures are available. In 1983, 2800 m^3 of penarahan saw logs was exported from Peninsular Malaysia (2200 m^3 to Singapore and 600 m^3 to South Korea) with a value of US$ 95 000, and in 1984 1050 m^3 (mainly to Singapore and a small amount of 50 m^3 to Taiwan) with a value of US$ 42 000 (US$ 40/m^3). The export of penarahan saw logs from Sabah was 10 000 m^3 in 1987 with a value of US$ 610 000, and the export of timber in 1992 7000 m^3 (97% as logs, 3% as sawn timber) with a total value of US$ 510 000 (US$ 71/m^3 for logs, US$ 140/m^3 for sawn timber). Probably, the contributions of *Gymnacranthera* timber in these total amounts are minor.

Properties *Gymnacranthera* wood is lightweight to medium-weight. The heartwood is pale brown to brown with an orange-red tinge and is clearly to indistinctly demarcated from the sapwood which is pale brown with a yellow-pink tinge. The density is 590–890 kg/m^3 at 15% moisture content. The grain is straight, texture fine to moderately coarse and even. The wood is more or less lustrous.

No test results on mechanical properties, or specific data on drying and working characteristics are available. However, the properties are expected to be broadly similar to *Myristica* wood. Consequently, the rates of shrinkage are probably fairly high, and the timber is expected to dry slowly, but with only slight seasoning defects.

The wood is rated as easy to saw, cross-cut, plane, bore and turn, giving a smooth finish. The resistance to splitting when nailed is good. The wood is easy to peel and the veneer dries easily with very little degrade; the gluability of the veneer is good. The wood is non-durable, but the sapwood readily absorbs preservatives.

Description Dioecious, evergreen shrubs or trees, up to 30(–45) m tall; bole cylindrical, 50 cm or more in diameter, small buttresses sometimes present, stilt roots rarely present; bark surface smooth or finely fissured, sometimes minutely flaky, reddish-brown or grey-brown, inner bark fibrous, pinkish or orange, slowly exuding red sap; crown monopodial, often pyramidal with the limbs spreading radially; twigs often bluntly angular at the apex, with lenticellate, rugose, never striate bark. Leaves distichous, simple and entire, distinctly petiolate, the blades up to 40 cm long, often whitish and glabrescent or with persistent tomentum below; secondary veins looping and joining, tertiary venation coarsely reticulate, indistinct on both surfaces; stipules absent. Inflorescences axillary, rarely on the older wood, paniculate, the female ones more condensed or even simple; bracts small, caducous, bracteoles absent. Flowers actinomorphic, tiny, pedicelled, variously pubescent, fragrant when crushed; perianth elliptical to ovoid or pear-shaped, (2–)3–4-lobed, yellow; male flowers with an androecium with 5–13 anthers connate with their back to a central column; female flowers with a superior, almost globose, 1-celled ovary, stigma sessile, obliquely 2-lobed. Fruit ellipsoid to globose, with a thick fleshy wall, eventually splitting into 2 halves, 1-seeded. Seed ellipsoid, enclosed in a pink or red aril which is deeply laciniate to near the base; endosperm fatty, without starch; cotyledons divaricate, connate at base. Seedling with hypogeal germination.

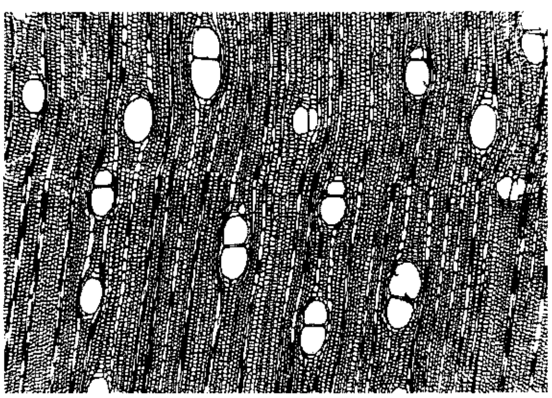
Wood anatomy

– Macroscopic characters:

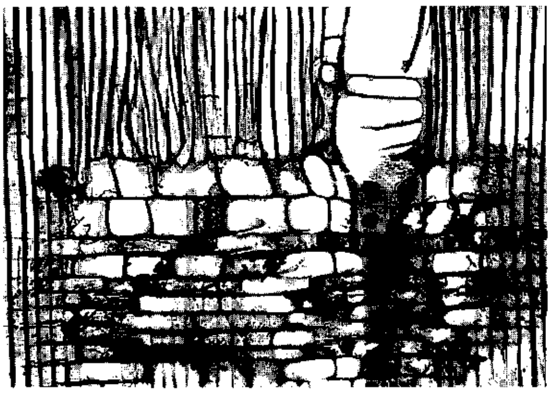
Heartwood pale brown to brown with orange-red tinge, distinctly to indistinctly demarcated from the pale brown sapwood with a yellow-pink tinge. Grain straight. Texture fine to moderately coarse, even; wood more or less lustrous. Growth rings rather faint to absent; vessels just visible to the naked eye; irregularly spaced and banded parenchyma and rays distinct with a hand lens.

– Microscopic characters:

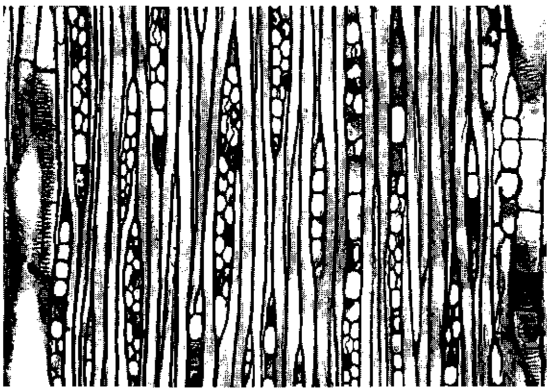
Growth rings absent to fairly distinct, and then marked by marginal parenchyma and very slight differences in fibre wall thickness. Vessels diffuse, 3–12/mm^2, solitary and in radial multiples of 2–4,



transverse section (×25)



radial section (×75)



tangential section (×75)

Gymnacranthera forbesii

round to oval or slightly angular, average tangential diameter c. 130 μm; perforations predominantly scalariform to reticulate with thick bars; intervessel pits non-vestured, scalariform to opposite; vessel-ray and vessel-parenchyma pits mainly large and simple, and horizontally elongated (scalariform) or with reduced borders; helical thickenings and deposits absent; tyloses abundant and often sclerotic. Fibres c. 1.5 mm long, non-septate, thin-walled to medium thick-walled, with minutely bordered pits mainly confined to the radial walls. Parenchyma moderately abundant, scanty paratracheal to vasicentric, and in 2–6 cells wide zonate (tangential) bands, in 4–10-celled strands. Rays 10–12/mm, 1–2 cells wide, c. 0.4 mm high, heterocellular, composed of procumbent body ray cells with 1–2 rows of square to upright marginal cells. Crystals absent. Oil cells and tanniferous tubes present in the rays.
Species studied: *G. farquhariana*.

Growth and development Germination has never been studied in *Gymnacranthera*, but it is probably identical to other Asian *Myristicaceae* genera, i.e. the *Horsfieldia* seedling development type. The testa remains around the cotyledons and is shed together with them. The taproot, hypocotyl and plumule are pushed free from the testa by elongation of the cotyledonary petioles; the hypocotyl is short and subterranean. The erect main stem of the seedling grows in flushes, according to the growing seasons, with dispersed leaves, and develops cataphylls early in the growing season. The leaves produced at the end of the growing season are the largest and are placed close together forming a pseudo-whorl. The shoot ends in a usually 'open' terminal bud from which the orthotropic growth proceeds in the next season. Branching occurs from the axils of the pseudo-whorled leaves, causing pseudo-verticillate branching from the main stem. The branches are usually more or less horizontal or somewhat drooping; they ramify to various degrees, and twigs in the periphery of the crown may carry inflorescences. The phyllotaxis of the branches is distichous. The general growth form of *Myristicaceae* is according to Massart's architectural model. Strong erect-growing renewal shoots may be produced after severe damage of the crown, showing dispersed phyllotaxis.

In disturbed forest in East Kalimantan, the annual diameter increment of *G. farquhariana* was 0.2–0.6 cm, while that of *G. forbesii* was 0.1–0.9 (–2.9) cm.

In Peninsular Malaysia, *G. farquhariana* flowers in March–April and fruits ripen from August–October; no periodic leaf fall has been observed. The yellow flowers, sometimes smelling sweet or spicy when crushed, are probably pollinated by insects. Seed dispersal is supposedly by birds such as wood pigeons, but hornbills are also reported to disperse the seeds. The birds swallow the seed whole.

Other botanical information Within the family *Myristicaceae* the genus *Gymnacranthera* is characterized by the pubescent perianth, the form of the androecium, and by the laciniate aril of the seed. Vegetative diagnostic features are the smooth or finely fissured lenticellate bark of the twigs, and the usually whitish lower surface, distinctly looping and joining lateral veins, and indistinct, laxly reticulate tertiary venation of the leaves.

Ecology The species of *Gymnacranthera* occur scattered in evergreen primary rain forest, and often in secondary growth. They are most frequent in well-drained forest, sometimes in marshy locations, mostly at low altitudes, but ascending up to 1200 m. They are middle-storey trees, but form elements of the canopy layer in less tall peat forest and kerangas.

Propagation and planting Very little is known about the propagation and planting of *Gymnacranthera*. Tests on viability and germination period of seed have been done for two species in Malaysia: *G. farquhariana* seed without aril had 90% germination in 1–2.5 months and seed of *G. forbesii* had 35% germination in 1–1.5 months.

Silviculture and management In silvicultural operations in natural forest *Gymnacranthera* species are regarded as economically unimportant and are not given special attention. There are no reports of planting *Gymnacranthera* species.

Genetic resources Some species are widespread in the Malesian area (e.g. *G. farquhariana*), but others have a local distribution or are restricted to isolated areas (e.g. *G. bancana* in southern Peninsular Malaysia, Sumatra, Sarawak and Brunei, *G. contracta* Warb. in Sarawak, Brunei and western Sabah, and *G. maliliensis* R. Schouten in central Sulawesi); for these, deforestation in their respective areas of distribution may easily endanger their genetic diversity.

Prospects Very little is known about *Gymnacranthera* except on its botany. Much more information on silvicultural aspects, regeneration, and propagation and planting is needed to determine the possible future value for timber production.

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Selection of species

Gymnacranthera bancana (Miq.) Sinclair

Gard. Bull. Sing. 16: 436, fig. 53, pl. 13A (1958).

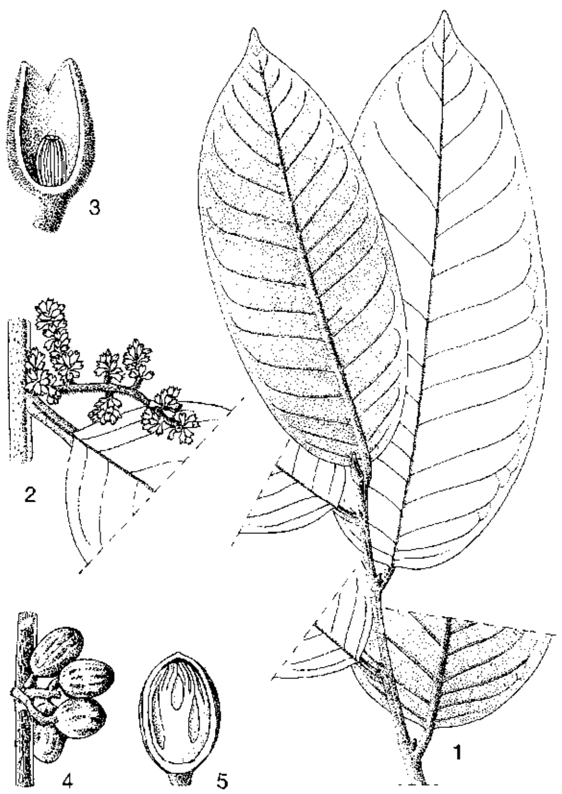
Synonyms *Myristica bancana* Miq. (1861), *Gymnacranthera murtonii* (Hook.f.) Warb. (1897), *Myristica amplifolia* Warb. (1897).

Vernacular names Indonesia: medang simpai, perang (Sumatra), balo (Bangka). Malaysia: penarahan (general), dara kerbau, mendarah (Peninsular).

Distribution Southern Peninsular Malaysia, Singapore, Sumatra, Bangka, and Borneo (Sarawak and Brunei).

Uses The wood is used as penarahan.

Observations A medium-sized to fairly large tree, up to 40 m tall, young twigs, inflorescence and lower leaf surfaces with woolly tomentum; leaves elliptical to lanceolate, 18–42 cm long, midrib flush in fresh leaves, sunken in dried ones; male flowers 4–6 mm long, the androecium much



Gymnacranthera bancana (Miq.) Sinclair – 1, twig with leaves; 2, twig with male inflorescence; 3, sectioned male flower; 4, branchlet with infructescence; 5, sectioned fruit with seed and aril.

shorter than the perianth tube; fruit ellipsoid, 2.2–3.5 cm long, rusty tomentose. *G. bancana* grows in primary and secondary dryland forest, sometimes in swamp forest, on hillsides and ridges, on granite rock, on sand or sandy loam soil, up to 250 m altitude. Flowering occurs throughout the year. The density of the wood is 710–810 kg/m^3 at 15% moisture content.

Selected sources 77, 305, 436, 474, 550, 567, 568, 595, 705.

Gymnacranthera farquhariana (Wallich ex Hook.f. & Thomson) Warb.

Mon. Myrist.: 365, t. 20 (1897).

Vernacular names Indonesia: kayu banitang rodang (Sumatra), mandarahan (Kalimantan), lahu (Moluccas). Malaysia: penarahan (general), kumpang, sengayen (Iban, Sarawak). Philippines: anuping (Filipino), magolumog (Bagobo), dahaan (Samar-Leyte Bisaya).

Distribution From southernmost peninsular Thailand, through Malesia towards the Bismarck Archipelago, but not in Java and the Lesser Sunda Islands.

Uses The wood is used as penarahan. In Irian Jaya the bark, together with lime, is used to cure the skins of birds.

Observations A medium-sized, sometimes large tree, up to 30(–45) m tall, bark greyish to medium brown, twigs, lower leaf surfaces and inflorescences glabrescent or short tomentose; leaves elliptical to lanceolate, 5–27 cm long, midrib flat or sunken above, tertiary venation usually prominent below; male flowers 2.5–4 mm long, androecium about as long as the perianth tube; fruit usually subglobose to ellipsoid, 1.8–2.8 cm long, glabrescent or inconspicuously pubescent. *G. farquhariana* is highly variable and has been divided into 4 varieties. Var. *farquhariana* (synonyms: *Myristica farquhariana* Wallich ex Hook.f. & Thomson, *Gymnacranthera farquhariana* var. *griffithii* (Hook.f.) Warb., *Gymnacranthera eugeniifolia* (A.DC.) Sinclair var. *griffithii* (Hook.f.) Sinclair) has coriaceous leaves of 6–17 cm long and with a revolute margin, and is found in Peninsular Malaysia, Sumatra and Borneo. Var. *eugeniifolia* (A.DC.) R. Schouten (synonyms: *Gymnacranthera eugeniifolia* (A.DC.) Sinclair var. *eugeniifolia*, *Gymnacranthera apiculata* Warb.) has chartaceous to coriaceous leaves of 5–13.5 cm long with veins that are sometimes slightly raised below, and short ellipsoid to globose fruits, and occurs in Peninsular Malaysia, Sumatra and Borneo. Var. *paniculata* (A.DC.) R. Schouten (synonyms: *Gymnacranthera paniculata* (A.DC.) Warb., *Gymnacranthera acuminata* Merr., *Gymnacranthera macrobotrys* Merr.) has chartaceous oblong-lanceolate to oblanceolate leaves of 9–21 cm long, and is found only in the Philippines. Var. *zippeliana* (Miq.) R. Schouten (synonyms: *Gymnacranthera zippeliana* (Miq.) Warb., *Gymnacranthera paniculata* (A.DC.) Warb. var. *zippeliana* (Miq.) Sinclair, *Gymnacranthera suluensis* Warb.) has thickly membranous to subcoriaceous leaves of 7.5–27 cm long and ellipsoid to oblong fruits on 4–8 mm long stalks, and occurs throughout the range of the species. *G. farquhariana* occurs in primary and secondary forest, in peat swamp or along rivers, or in well-drained forest on hills and ridges, sometimes in kerangas forest on sandy soils or on limestone, up to 1300 m altitude. The density of the wood is 620–890 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 305, 436, 465, 474, 527, 544, 550, 567, 568, 705, 718.

Gymnacranthera forbesii (King) Warb.
Mon. Myrist.: 363, t. 20, fig. 1–2 (1897).

Vernacular names Malaysia: penarahan (general), medang kuning (Peninsular), kumpang semah (Iban, Sarawak).

Distribution Southernmost peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses The wood is used as penarahan.

Observations A medium-sized to fairly large tree up to 35 m tall, without buttresses, twigs and lower leaf surface glabrescent, inflorescence tomentose; leaves elliptical to oblong-lanceolate, 14–33 cm long, midrib slightly sunken above, secondary veins prominent below; male flowers 2.5–4 mm long, androecium about as long as the perianth tube; fruit ellipsoid-oblong, 1.8–2.4 cm long, glabrescent or short pubescent. *G. forbesii* occurs in primary and secondary forest on hills, river banks, and swampy locations, on sandy to loamy soils or soils on limestone, up to 1250 m altitude. The species has been divided into 2 varieties. Var. *forbesii* (synonym: *Myristica forbesii* King) is found throughout the range of the species. Var. *crassinervis* (Warb.) Sinclair (synonym: *Gymnacranthera crassinervis* Warb.) has more prominent and wider secondary veins on the lower leaf surface and more conspicuously branched infructescences, and is found in Borneo only. The density of the wood is 605–695 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 305, 436, 550, 567, 568, 705.

W.J.J.O. de Wilde (general part, selection of species),
W.C. Wong (properties),
A. Aglua (wood anatomy)

Hevea Aublet

Hist. pl. Guiane: 871, t. 335 (1775).
EUPHORBIACEAE
x = unknown; *H. brasiliensis*: $2n$ = 36, 72, 144

Trade groups Rubberwood: lightweight to medium-weight hardwood, a single species, *Hevea brasiliensis* (Willd. ex A.L. Juss.) Muell.-Arg., Linnaea 34: 204 (1865), synonym: *Siphonia brasiliensis* Willd. ex A.L. Juss. (1824).

Vernacular names Rubberwood: para rubber tree, hevea (En). Caoutchouc, caoutchouc de para, hévéa (Fr). Brunei: kayu getah, pokok getah para. Indonesia: kayu karet, kayu getah, pokok getah para. Malaysia: kayu getah, pokok getah para. Burma (Myanmar): kyetpaung. Cambodia: kausuu. Laos: jaang. Thailand: yang phara (general), katoh (Malay, peninsular). Vietnam: cao su.

Origin and geographic distribution *Hevea* consists of 10 species which occur in tropical America. *H. brasiliensis* occurs naturally from Brazil to Venezuela, and from Colombia to Peru and Bolivia. It is now cultivated in most parts of the lowland humid tropics. It was introduced into South-East Asia (Sri Lanka, Singapore, and Bogor, Indonesia) in 1876, and into Peninsular Malaysia in 1877. It is now widely cultivated in South-East Asia, with Peninsular Malaysia as the most important production area.

Uses The most important product of *Hevea* is the latex produced in the bark and made into natural rubber. Rubberwood was formerly regarded as a by-product of the rubber plantations and used for the production of charcoal or as fuelwood, for brick making, tobacco drying and rubber drying. Nowadays, the importance of the timber from the rubber plantations is fully recognized, and locally it is planted exclusively for timber production. Most of the timber is used to manufacture furniture. Other uses include interior finish, moulding for e.g. wall panelling, picture frames, drawer guides, cabinet handles and others, parquet flooring, many household implements, blockboard cores, pallets, crates, coffins, veneers, and glue-laminated timber for e.g. staircases and door and window components. Since the timber is only moderately durable when exposed to the weather, it should not be used for exterior purposes. Offcuts and other rubberwood residues have been used successfully in Malaysia for the production of particle board, wood-cement board, and medium density fibreboard (MDF). Rubberwood waste is an excellent medium for the growing of mushrooms, especially oyster mushrooms (*Pleurotus* spp.).

Seeds contain 40–50% of an oil which dries well and is suitable for use as food and for technical purposes.

Production and international trade In the 1970s rubberwood was considered a by-product of the rubber plantations. It used to be converted to chips and exported from Malaysia to Japan. Commercial utilization of the timber began in the late 1970s. In 1979, only 900 m^3 of rubberwood, valued at US$ 55 000 was exported from Peninsular Malaysia, but the total export of sawn rubberwood from Peninsular Malaysia was 178 000 m^3 in 1986 and 259 000 m^3 (with a value of US$ 39 million) in

1987, constituting some 10% of the total sawn timber exports. Exports from Peninsular Malaysia dropped sharply after the imposition of an export levy to promote value-added processing to 103 000 m^3 in 1990 and further to 39 000 m^3 (with a value of US$ 9.3 million, i.e. US$ 239/m^3) in 1992. Rubberwood furniture has been estimated to make up over 70% of the exported furniture from Peninsular Malaysia in the years 1983–1993. It is estimated that the value of exported rubberwood furniture was about US$ 1.3 billion in the period 1986–1990. The total export of sawn rubberwood plus rubberwood products is still increasing in Peninsular Malaysia.

The export of sawn rubberwood from Sabah was 750 m^3 in 1992, with a value of US$ 190 000 (US$ 253/m^3).

In Thailand, the rubberwood industry is currently experiencing very rapid growth, although exports are still insignificant in comparison with Peninsular Malaysia. The export of sawn rubberwood in 1984 was only 1700 m^3 worth US$ 175 000, but it increased to 26 000 m^3 worth US$ 5.9 million by 1988. The export value of rubberwood furniture increased from US$ 20.6 million in 1986 to US$ 57.9 million in 1988.

In Indonesia, until very recently, very little attention was given to the development of rubberwood processing because of the buoyant timber trade in indigenous species. As well as traditional uses of the wood, there are now two particle board plants and a limited number of saw mills processing rubberwood in Indonesia. Since 1991, large rubberwood plantations have been established (e.g. in East Kalimantan).

Properties Rubberwood is a lightweight to medium-weight hardwood. The heartwood is pale cream-coloured, often with a pink tinge, weathering to pale straw-coloured or pale brown, not distinctly demarcated from the sapwood. The density is 560–640 kg/m^3 at 15% moisture content. The grain is straight to shallowly interlocked, texture moderately coarse and even.

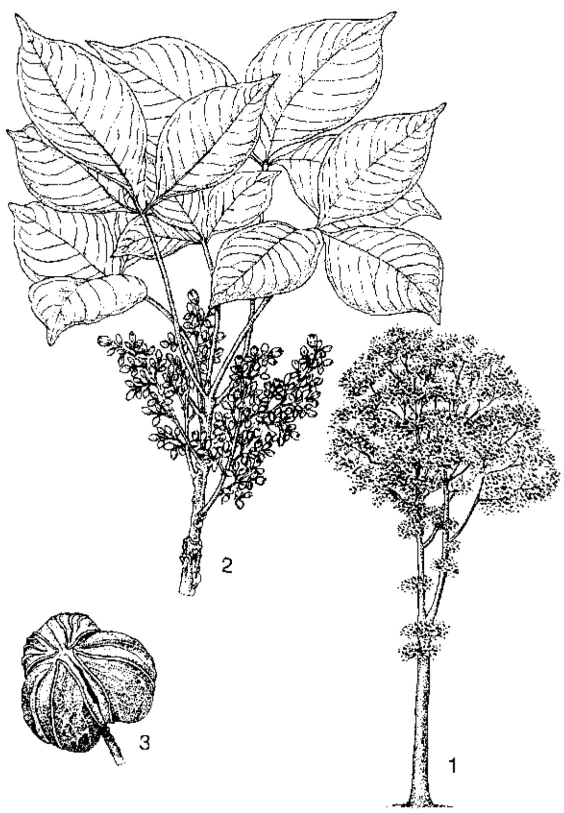
At 12% moisture content, the modulus of rupture is 59–74 N/mm^2, modulus of elasticity 6070–9240 N/mm^2, compression parallel to grain 33–36.5 N/mm^2, compression perpendicular to grain c. 10 N/mm^2, shear 10.5–11 N/mm^2, cleavage c. 54 N/mm radial and 72 N/mm tangential (at 17% moisture content), Janka side hardness 5270–6810 N and Janka end hardness 6145–7320 N. See also the table on wood properties.

The rates of shrinkage are rather low: from green to 12% moisture content c. 1.2% radial and 2.5% tangential and from green to oven dry 2.5–3.1% radial and 4.8–6.5% tangential. Rubberwood air dries fairly rapidly with bowing and springing as the main defects. Boards 25 mm thick take about 2.5 months to air dry and boards 40 mm thick 3.5 months. For kiln drying, kiln schedule E is recommended in Malaysia.

Rubberwood is easy to saw and cross-cut, although latex may clog the saw teeth. It is easy to plane and the finish is smooth. The nailing and gluing properties are rated as good. The wood is suitable for veneer and plywood production. It is successfully used in Malaysia for the commercial manufacture of particle board, medium density fibreboard, blockboard and wood-cement board.

In Malaysia, rubberwood is classified as moderately durable. Untreated stakes (50 mm × 50 mm × 600 mm) lasted 2 years in contact with the ground. It is very susceptible to attack from fungi (both sap-staining and wood-rotting) and borers. Therefore, the logs and sawn timber should be treated with preservatives if they are not processed immediately. Rubberwood is easy to treat with preservatives, either by dip diffusion or vacuum pressure impregnation.

Description A deciduous, monoecious, medium-sized to fairly large tree up to 40 m tall, but usually up to 25 m in cultivation; root system with a well-developed taproot and far spreading laterals; bole usually straight but tapered, branchless for 10 m or more, up to at least 50 cm in diameter, without buttresses; bark surface smooth, hoop marked, grey to pale brown, inner bark pale brown, with abundant white latex; crown conical, branching pattern highly variable, stem leader dominant or soon divided into several heavy branches. Leaves arranged spirally, trifoliolate; petiole long with apical glands; stipules deciduous; leaflets entire, elliptical to obovate, 4–50 cm × 1.5–15 cm, acuminate, pinnately veined. Inflorescence a many-flowered, axillary, short-pubescent panicle on the basal part of a new flush; male and female flowers in the same panicle, small, without petals, female flowers less numerous and distributed at the apex of main and lateral branches; male flowers with a bell-shaped, 5-lobed perianth, yellow; stamens united into a column with 10 sessile anthers in 2 rows; female flowers with a green disk at base, ovary superior, 3-celled, terminated by 3 sessile white stigmas. Fruit an exploding, 3-lobed capsule, 3–5 cm across, pale brown when mature, with a thin rind and bony inner wall breaking into 6 pieces, each lobe with 1 seed. Seeds ovoid, about 2–3.5 cm long, testa waxy, with



Hevea brasiliensis (Willd. ex A.L. Juss.) Muell.-Arg. – 1, tree habit; 2, flowering twig; 3, fruit.

very numerous small dark brown spots and a variable number of irregularly shaped patches; endosperm abundant, almost completely enveloping the straight embryo. Seedling with hypogeal germination; hypocotyl elongating; cotyledons thin, leaf-like, green with pink or purple tinge.

Wood anatomy

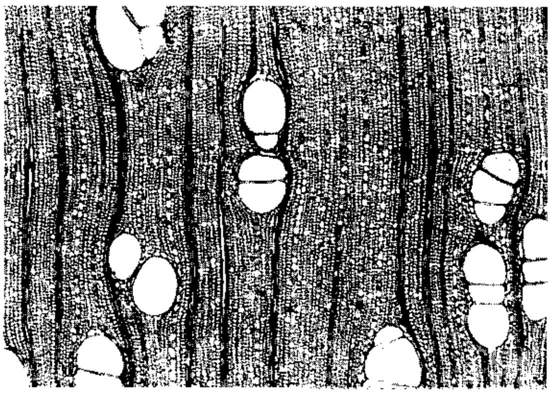
– Macroscopic characters:

Heartwood pale cream, often with a pink tinge when fresh, darkening on exposure to pale straw-coloured or pale brown, not clearly demarcated from the sapwood. Grain straight to shallowly interlocked. Texture moderately coarse but even; sawn rubberwood often shows black stripes with the inclusion of a thin layer of bark material, being the result of poor tapping practices with damaged or removed cambium; in freshly sawn wood a characteristic and distinct smell of latex is present. Growth rings indistinct, but tangential surfaces may have a structure resembling growth rings due to the banded parenchyma; vessels moderately large to large, visible to the naked eye, vessel lines conspicuous on longitudinal surfaces, tyloses sparse to abundant; parenchyma in narrow and closely but irregularly spaced bands joining the rays to form a net-like pattern; rays moderately fine and not visible to the naked eye; ripple marks absent.

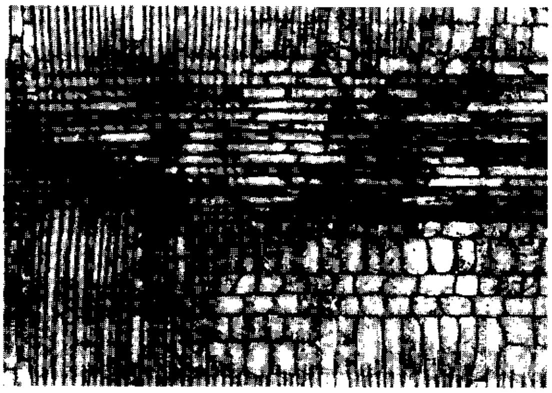
– Microscopic characters:

Growth rings indistinct or absent. Vessels diffuse, 3–4/mm^2, solitary and in radial groups of 2–4, rarely 5–8, clusters fairly common, generally round to oval, average tangential diameter 150–250 μm; perforation plates simple; intervessel pits 10–13 μm in diameter, sometimes coalescent; vessel-ray and vessel-parenchyma pits round to oval, simple or with reduced borders; helical thickenings absent; tyloses present. Fibres 1200–1650 μm long, non-septate, thin-walled to moderately thick-walled, with simple to minutely bordered pits mainly confined to the radial walls. Parenchyma apotracheal diffuse, diffuse-in-aggregates and in narrow discontinuous lines up to 3 cells wide, often containing chambered crystals, in 3–7(–9)-celled strands; paratracheal parenchyma comparatively sparse, confined to the immediate vicinity of the vessels, in 3–9-celled strands. Rays 7–10/mm, mostly (1–)2–3(–4)-seriate, 0.6(–1.8) mm high, heterocellular with 1–3(–4) rows of square to upright marginal cells (Kribs type heterogeneous II and III), uniseriate rays few and short. Prismatic crystals in tyloses, chambered axial parenchyma and ray cells. Silica bodies absent.

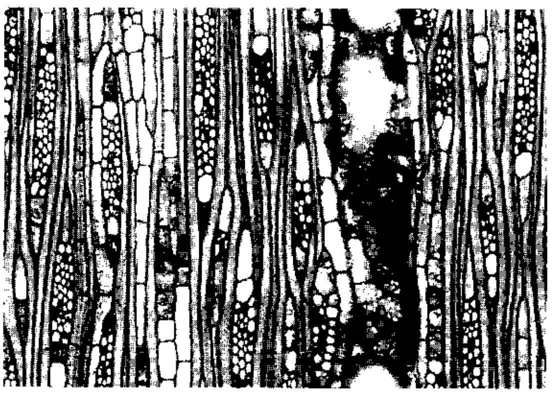
Growth and development Initially, seedlings develop a leafless green axis emerging from the soil. When it stops growing, the first leaves appear. The epicotyledonary axis remains unbranched for more than a year and shows successive increments distinguished morphologically by series of scale leaves (and later their scars). Each growth increment consists of a basal series of scale leaves, separated by increasingly long internodes, followed by a series of trifoliolate leaves which show a progressive reduction in petiole length within each series. The axis therefore consists of a series of leaf clusters separated by leafless parts. When the growth of the leaves ceases, they are initially still soft and drooping and their colour changes from reddish to pale green. The next stage is the raising of the leaves to a horizontal position, and then they assume a darker colour. Leaves persist for about a year before they are shed. In saplings the rhythmic growth produces about 6 flushes per year. The growth rate is about 30 cm per month during the first year after the preliminary period of about 2 months when



transverse section (×25)



radial section (×75)



tangential section (×75)

Hevea brasiliensis

the plant is becoming established. A healthy seedling can reach a diameter of 2.5 cm in one year.

Branching is from the axils of leaves with average-sized petioles and begins after about 9 flushes; the branches are distinctly tiered. After the first year of growth, the plants then go through a phase of rapid vegetative growth for the next 4 years before they start flowering and fruiting. However, trees have been reported to flower already when 20 months old and to fruit in just over 3 years. Inflorescences appear in the axil of scale leaves towards the base of flushes on high-level branches of older trees. The development of flowers does not affect the growth of the shoot. The tree consequently has Rauh's architectural growth model, determined by a monopodial trunk which grows rhythmically, thus developing tiers of branches. 'Lampbrush' is a modification without ramification and with continuous growth according to Corner's architectural model. It can be induced by eliminating about one-third of each maturing leaf.

The trees grow rapidly and attain a height of about 18 m in 8 years. Girth development decreases when trees are tapped for latex.

Rubberwood is briefly deciduous in Peninsular Malaysia at the beginning of the year, and there is often a second complete or partial leaf-change in August-September. The intensity of leaf shedding depends on climatic conditions and varies with clone. A dry period of one month or longer causes partial or complete leaf fall. Old leaves turn vivid orange or red, sometimes bright yellow before they fall.

Both self- and cross-pollination is carried out by small insects. Natural pollination is poor and leads to only 1–4% of the female flowers setting fruit. Even with hand pollination no more than 5% of the pollinated female flowers develop into mature fruit. Fruits ripen in about 5 months. Seeds are actively dispersed for 10 m or more by the exploding capsules.

Other botanical information Another *Hevea* species, *H. spruceana* Muell.-Arg., was introduced to Indonesia in 1913 for breeding purposes, without any positive results. It easily hybridizes with *H. brasiliensis* and therefore seeds collected from areas containing *H. spruceana* progeny might constitute a danger to the established *H. brasiliensis* plantations as both *H. spruceana* and its hybrid with *H. brasiliensis* yield only small amounts of rubber of poor quality. *H. spruceana* differs from *H. brasiliensis* e.g. in the veins on the lower leaf surface being hairy, the flowering shoots being situated at the end of strong twigs, the larger flowers which are tinged with red or mauve, and the fruit being pear-shaped.

Ecology Rubber is successfully cultivated under humid lowland tropical conditions, roughly between 15°N and 10°S (main production areas between 6°N and 6°S), with comparatively little variation in temperature. The optimum day temperature is 26–28°C. Rubber will thrive best up to an altitude of 300 m, and planting above 400–500 m is not recommended, because the trees then tend to be smaller, with less vigorous growth, and reduced production of both latex and timber. The annual rainfall requirement ranges from 2000–3000(–4000) mm with 170–220 rainy days. A well-distributed annual rainfall of 1500 mm is considered to be the lower limit for commercial production. In high rainfall areas good internal drainage of the soil is important. In some areas rubber can tolerate a 2–3 month period of drought. Owing to its deep and extensive root system, rubber prefers a moist, well-drained stiff loamy soil, but will also thrive on clay, alluvial soils, or even on hard gravelly soils, and young volcanic soils, and peat (provided the peat layer is not too deep). Rubber tolerates soils with a pH of 4–8, but the optimum lies at 5–6. It does not tolerate salt or brackish water. It thrives best on fertile soils, but in this respect is less demanding than other crops like oil palm and cocoa. The occurrence of strong winds is also an important factor, as these may snap trunks and branches; however, more wind-resistant clones do exist. Furthermore, overheating of the soil surface, roots becoming exposed due to soil erosion and periodic lack of water are inimical, and may cause poor development or abnormal symptoms in young trees.

Propagation and planting Propagation and planting of rubber was until recently solely aimed at the production of latex. Information on the establishment of plantations with the primary objective of timber production is still very limited, although a start has been made. An account is given here for rubber propagation and planting for latex production.

Rubber can be propagated by seed. Direct seeding is also possible for plantation establishment, but generally improved vegetatively propagated planting stock is used. This is easily produced by bud grafting rootstock. Seed from vigorous high-yielding parents is used to produce rootstock. Seeds remain viable for a very short time and are classified as being recalcitrant. Drying below 20% moisture content and lack of oxygen seem to harm the seeds. Moist storage under ambient conditions gave 74% germination after 2.5 months and 30% after 4 months.

Seeds germinate in 10–14 days in shaded beds and are then transferred to polybags or nursery beds. Budwood is grown in special nurseries in which trees budded with the desired clones are closely spaced. The rootstock is bud grafted with the scions 4–5 cm above the soil level. After bud grafting, the plants are raised in polybags or in beds to obtain bare-root planting stock. In Indonesia and Malaysia, seedlings from 'clonal' seeds may also be used. Clonal seed is obtained from monoclonal or polyclonal plantings which are known to produce high-yielding trees.

Plants are ready for planting when they have two whorls of leaves. Recommended spacing for planting has varied over the years either in squares of 5 m × 5 m or in lines with a spacing of 8–10 m between the rows and 2–3 m between the seedlings. High planting densities (500–600 trees/ha) give the highest yields/ha and are adopted by smallholders. Lower planting densities (400–450 trees/ha) lead to an earlier tappable size and higher yields per tree and per tapper, hence higher net financial results, and are adopted by estates. Cover crop establishment is standard practice in both new plantings and when replanting on estates and is done just before planting. The species most commonly used are *Pueraria phaseoloides* (Roxb.) Benth., *Centrosema pubescens* Benth. and *Calopogonium mucunoides* Desv. In smallholdings, temporary intercropping during the first 1–3 years with food crops is a common practice.

Silviculture and management Maintenance includes weeding, manuring, pruning and sometimes mulching. Fertilizers are applied in small quantities and frequently in the nursery and the first few years after planting. Subsequently, fertilizers are applied twice a year until the trees are mature and thereafter only once a year. The economic life cycle of a rubber plantation is 30–35 years and after this cycle replanting is necessary.

Diseases and pests The most important fungi in South-East Asia causing root disease in rubber are in order of significance *Rigidoporus lignosus*, *Ganoderma pseudoferreum* and *Phellinus noxius*, giving rise to white, red and brown root diseases, respectively. They cause much destruction and mortality in new plantings as well as in replanted areas. Pre-planting control is accomplished by removing all infected inoculum sources, and post-planting control is achieved by regular inspection and treating of the affected plants with calixin. Early establishment of cover crops is also effective in controlling root diseases. *Colletotrichum gloeosporoides*, *Corynespora* and *Phytophthora* cause important fungal leaf diseases. *Oidium heveae*, powdery mildew, affects flowers and leaves under conditions of high relative humidity and causes secondary leaf fall and poor seed set. Attack can be controlled by a protective dusting with sulphur. Bird's eye spot disease caused by *Helminthosporium heveae* is also common but is confined to the nursery. The most damaging and most feared leaf disease is the South American Leaf Blight (SALB) caused by *Microcyclus ulei*. So far the disease is confined to South and Central America thanks to stringent phytosanitary regulations. Infected trees lose their leaves after every new flush resulting in dieback and ultimately the death of the tree. Pink disease caused by *Corticium salmonicolor* attacks the stem and branches, but can be easily controlled by calixin or bordeaux mixture.

Pests include termites (*Coptotermes curvignathus*), larvae of certain *Melolonthis* beetles, and (commonly found in nurseries) the yellow tea mite (*Hemitarsonemus latus*) and thrips (*Scirtothrips dorsalis*).

Harvesting After 30–35 years the rubber plantation needs to be replanted to ensure economic latex production. In Malaysia, this is often done after 20–25 years. At this age trees have a diameter ranging from 25–45 cm. Trees of over 25 years may reach larger dimensions. A clear bole of 10 m is usual at this age, although tree boles of relatively new rubber clones are shorter and of smaller diameter. Boles of seedling trees are usually strongly tapered. Logs from smallholdings usually have a greater variation in size and quality, and also a higher percentage of 'bark pocket' in the wood probably due to bad tapping practices. Logs from large plantations generally give wood of better and more uniform quality.

Extraction is usually rather easy as plantations are generally easily accessible. After felling, the logs are bucked into lengths of 1.5–1.8 m and recovery of the sawn timber is 46–62%. Portable sawmilling and valuation of stands instead of harvested wood ('on the stump') can increase the efficiency of rubberwood extraction.

Yield Some yield figures are available from Malaysia. A rubber plantation of 25 years old has an estimated volume of wood including branches over 10 cm diameter of 260 m^3/ha and when only wood over 15 cm diameter is considered the volume is 180 m^3/ha. The total extractable bole volume ranges from 52–163 m^3/ha.

The total land area planted with rubber in South-East Asia is estimated to be 6.4 million ha: in Indonesia 2.8 million ha (2.0 million ha in Sumatra, 0.5 million ha in Kalimantan, the remainder elsewhere), in Malaysia 1.9 million ha (1.6 million ha in Peninsular Malaysia, 200 000 ha in Sarawak and almost 100 000 ha in Sabah), and in Thailand 1.7 million ha. Based on a conservative estimate of 100 m^3 of rubberwood/ha, the total standing stock is more than 600 million m^3.

Handling after harvest Rubberwood is readily attacked by sapstain, mould and decay-causing fungi. A deep penetrating blue stain is caused by the fungus *Botryodiplodia theobromae*. Fresh rubberwood is heavily infected by the sap-staining organism within a few days of exposure. Therefore, transport after felling and processing need to be planned extremely well. If there is a delay in converting the logs to sawn timber, an anti blue-stain end coating containing fungicides must be applied to the cut ends and any part where the bark is damaged. In addition, insecticides have to be sprayed on the logs to prevent borer attacks.

Genetic resources The surviving seedlings from the first introduction in South-East Asia in 1876 provide only a narrow genetic base. Subsequent introductions into Indonesia and Malaysia were added as genetic resources but have not have much impact on breeding progress. A small introduction of various *Hevea* species was made to Malaysia in 1966. Further augmentation of genetic resources in the South-East Asian region was implemented through the introduction of large numbers of wild *Hevea* germplasm from Brazil in 1981. Germplasm collections are maintained in Malaysia and Ivory Coast.

Breeding Breeding activities generally used to be directed towards rubber yield increases. Present-day breeders now recognize that emphasis should not be placed on rubber yield alone but on other desirable characteristics also, such as vigour, quality of virgin and renewed bark, colour and stability of latex, resistance to leaf and bark diseases and to wind damage, and recently also on improved wood characteristics. Trees with superior wood quality have been selected for planting in solely timber-producing plantations in East Kalimantan; such plantations are also under consideration in Peninsular Malaysia. The use of other *Hevea* species to incorporate resistance to leaf diseases (in particular South American Leaf Blight) has also been pursued in breeding.

Prospects Rubber has now been established as an important timber especially for the manufacture of furniture. It has also been widely accepted as a source of raw material for the production of chipboard, medium density fibreboard (MDF) and other composite panel products. Projected demand for rubberwood will exceed supply. However, economic studies have indicated that plantations established for wood production alone are only marginally viable. To derive the best economic returns, the plantations will have to be managed for both latex and wood production. The prospects for further development of the rubberwood industry in South-East Asia look bright because the supply of timber from natural forest is dwindling and the costs of establishing fast-growing timber tree plantations are high, and also because of the availability of over 6 million ha of rubber plantations capable of producing about 19 million m^3 of wood annually. The sustainable supply from plantations will ensure that rubberwood is accepted as an 'eco-labelled timber' on the world market in the future.

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S.C. Lim (general part, properties, wood anatomy)

Homalium Jacq.

Enum. syst. pl.: 5, 24 (1760).
FLACOURTIACEAE
x = unknown; *H. tomentosum*: n = 11

Trade groups Malas: heavy hardwood, e.g. *Homalium foetidum* (Roxb.) Benth., *H. longifolium* Benth., *H. tomentosum* (Vent.) Benth.

Vernacular names Malas: aranga (En, Fr), Burma lancewood (En). Indonesia: gia (general), dlingsem (Javanese), melmas (Kalimantan), momala (Sulawesi). Malaysia: selimbar, petaling padang (Peninsular), takaliu, keruing rengkas, bansisian (Sabah). Philippines: aranga (general). Burma (Myanmar): myaukchaw, myaukugo. Laos: 'khên nang. Thailand: kha nang (central).

Origin and geographic distribution *Homalium* consists of over 200 species occurring throughout the tropics and sometimes in the subtropics. Within the Malesian area about 32 species are present. The largest number of species is found in the Philippines (11) and New Guinea (11), followed by Peninsular Malaysia (8), Borneo (5), Sumatra and Sulawesi (4), Java (3), the Moluccas (2) and the Lesser Sunda Islands (1). The two most important timber producing species, *H. foetidum* and *H. tomentosum* almost exclude each other in distribution, the first occurring in the wetter areas, the second in the drier ones.

Uses Malas is used in general and heavy constructions, for house building (e.g. for posts, flooring, basements), posts, wharf and bridge decking, boat building (keels), oars, dunnage (as a substitute for keruing), truck bodies, scantlings, sleepers, joinery, boxes, furniture, and tool handles. It is reported as excellent for turnery. Due to its resistance to marine borers the timber is also suitable for salt water piling. It is sometimes used for charcoal and is one of the best fuelwoods in Papua New Guinea, burning even when wet.

Production and international trade Malas timber is exported in only limited quantities. Export is mainly from Papua New Guinea; very small amounts are available from other countries. Japan is the main importing country, others are Korea, Germany and Australia. Malas accounted in 1987 for 1.3% of the total timber import from Papua New Guinea in Japan.

Properties Malas is a heavy hardwood. The heartwood is brown, reddish-brown or sometimes yellow-brown; sapwood slightly paler and not distinctly demarcated from the heartwood. The density of malas is (715–)750–1120 kg/m^3 at 15% moisture content. The grain is straight or shallowly interlocked, sometimes deeply interlocked, texture fine and even.

At 12% moisture content the modulus of rupture of *H. foetidum* wood is c. 150 N/mm^2, modulus of elasticity 19 000 N/mm^2, compression parallel to grain 84 N/mm^2, shear 19 N/mm^2, cleavage 38 N/mm radial and Janka side hardness 9900 N.

The rates of shrinkage of malas are moderate to fairly high: from green to 12% moisture content 2.5% radial and 5.0% tangential, from green to oven dry 4.1–5.2% radial and 7.5–13.2% tangential. Malas is usually difficult to season because it is particularly prone to end and surface checking, especially back-sawn material, and it has a slight tendency to twist. However, test results from various areas differ. The wood should be quarter-sawn to avoid degrade. Air drying 4 cm thick boards from green to 15% moisture content takes about 5 months. A mild kiln schedule is recommended although some checking (sometimes severe) cannot be avoided. Checks are, however, often only shallow and can readily be removed by dressing. Kiln drying from green to 12% moisture content takes 5–6 days.

The working properties of malas are good, although the wood is slightly difficult to saw because of its high density, but it has only little blunting effect on saw teeth; it is non-siliceous. The wood planes and machines to a smooth finish with slight picking up on radial faces. It sands very well and takes a good polish, and it turns well, producing a relatively smooth finish. Preboring before nailing is necessary to prevent splitting. The green wood seems suitable for bent applications in furniture. It is highly suitable for the production of plywood, particulary as face veneer.

The heartwood is moderately durable to durable and is fairly resistant to termite attack. The sapwood is not susceptible to attack by *Lyctus* borers and ambrosia beetles. The wood of some species is resistant to marine borers. The absorption of preservatives by the heartwood is only fair, the sapwood can be treated well. In an open-tank treatment using a mixture of 50% creosote and 50% fuel oil a maximum absorption of 93 kg/m^3 has been observed for heartwood of *H. longifolium*.

Freshly sawn wood has a distinct iodine-like odour that often persists through to the seasoned material. Wood of *H. foetidum* contains 59% cellulose, 35% lignin, 12% pentosan and 2.1% ash. The solubility is 11.6% in alcohol-benzene, 1.4% in cold water, 2.6% in hot water and 13.6% in a 1% NaOH solution. The energy value is about 18 150 kJ/kg.

Description Shrubs or small to medium-sized, rarely large, often slender trees up to 30(–62) m tall; bole generally straight and cylindrical, usually branchless for at least half the total height of the tree, up to 75(–140) cm in diameter, often with steep buttresses; bark surface smooth, corky, becoming variously rugose, rusty brown, outer bark c. 2 cm thick, inner bark hard, granular, cream with orange to yellow-brown flecks or mottles; crown comparatively narrow and dense. Leaves simple, alternate, entire or crenate-serrate, pinnately veined; stipules absent or minute and caducous. Inflorescence axillary or subterminal, many-flowered, consisting of spike-like racemes or panicles. Flowers solitary or in fascicles along the rachis, actinomorphic, bisexual, (4–)5–8(–12)-merous; calyx tube broadening upwards, connate with the ovary, with flat, linear or obovate-spatulate lobes; petals inserted in throat of calyx, similar to and alternating with the sepals; stamens positioned in front of and/or rarely on the base of the petals, solitary or in fascicles of 2–8(–12), anthers small, dorsifixed; disk consisting of usually tomentose glands opposite each sepal; ovary almost inferior, free only in the upper half, unilocular, with 2–6(–8) placentas, each with (1–)3–7 ovules near the apex, styles 2–5(–7), free or joined at base, stigma small. Fruit a capsule, dry and more or less coriaceous, often with a persistent calyx and corolla, indehiscent or splitting into 2–8 valves from the apex. Seeds 1 or few, tiny, without an aril; with abundant endosperm.

Wood anatomy

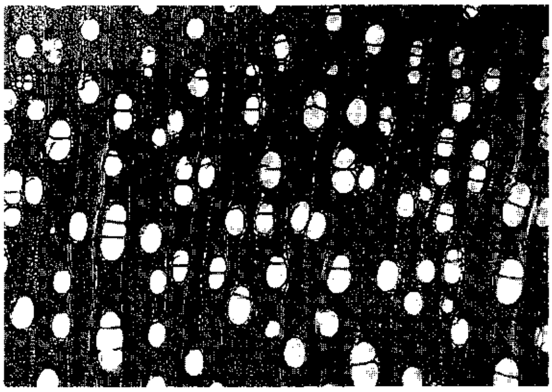
– Macroscopic characters:

Heartwood brown, reddish-brown or sometimes yellow-brown, not clearly demarcated from the paler sapwood (pale yellow-brown to pinkish-brown). Grain usually straight or sometimes interlocked. Texture fine and even; figure sometimes evident on back-sawn material from indistinct growth rings; wood dull in appearance.

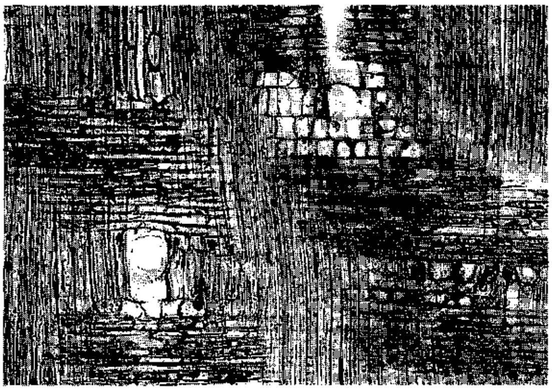
Growth rings usually indistinct; vessels small, indistinct to the naked eye, evenly distributed; parenchyma absent, rays not visible to the naked eye, although visible as darker streaks on quarter-sawn surfaces; ripple marks absent.
– Microscopic characters:
Vessels diffuse, (18–)24–30(–56)/mm^2, solitary (6–63%) and in radial multiples up to 4(–8), mostly oval, average tangential diameter 50–130(–155) µm; perforation plates simple; intervessel pits alternate, mostly polygonal sometimes rounded, non-vestured, minute, 3–4(–5) µm in diameter; vessel-ray pits half-bordered, otherwise similar to intervessel pits, often unilaterally compound; helical thickenings absent; tyloses absent. Fibres 1.1–2.1 mm long, distinctly septate, moderately thick-walled to thick-walled, with numerous indistinctly, minutely bordered pits mainly confined to the radial walls. Parenchyma absent or very sparse, paratracheal, in 2–4-celled strands. Rays 11–19/mm, uniseriate and 3–4(–5)-seriate, 0.5–1.5 mm high, markedly heterocellular, uniseriate rays composed entirely of upright cells, multiseriate rays with 4–10(–20) marginal rows of upright cells (Kribs type heterogeneous II or I); horizontal intercellular canals absent. Prismatic crystals abundant, mainly in upright ray cells, sometimes more than one crystal per chamber, strands of smaller crystals present in the septate fibres in some samples. Silica absent. Extraneous reddish-brown deposits common in ray cells of darker coloured samples.
Species studied: *H. bracteatum*, *H. foetidum*, *H. loheri* Merr., *H. oblongifolium* Merr., *H. tomentosum*.
The wood of some *Nothofagus* species may resemble malas, but it can easily be differentiated from malas by the presence of coarser intervessel pitting and large vessel-ray pits.

Growth and development The mean heights of *H. tomentosum* trees in a plantation after 2 and 5 years are 3 m and 5 m, respectively, with a mean diameter of 7 cm at the age of 5 years. *Homalium* trees planted in western Java were 11 m tall after 8 years, with a diameter of 20 cm and a clear bole of 6 m.
In Java *H. tomentosum* flowers from April to September and fruits are ripe from May to September. *H. grandiflorum* flowers only every 10–15 years. The often accrescent calyx and corolla form a parachute after anthesis. Thus seed dispersal is mainly by wind.

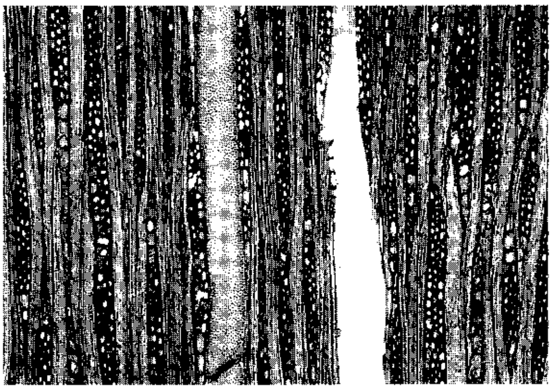
Other botanical information Several of the Malesian species of *Homalium* were formerly



transverse section (×25)



radial section (×75)



tangential section (×75)

Homalium tomentosum

placed in a separate genus called *Blakwellia*. In the field, species of *Homalium* might be confused with *Euphorbiaceae*, especially when the leaves are entire. Bark surface and slash characteristics are similar to those of *Xanthophyllum* (*Polygalaceae*).

Ecology Most of the species, at least the ones reaching timber size, occur in primary or sometimes secondary lowland rain forest up to 600(-1400) m altitude. They are locally common, although they do not occur gregariously, and sometimes grow in periodically inundated sites on sandy or clayey soils, sometimes on limestone, often along rivers. *H. tomentosum* occurs strictly on well-drained sites in climates with a pronounced dry season.

Propagation and planting There are approximately 453 000 air-dried seeds of *H. tomentosum* per kg. Seeds are reported to have a very low germination capacity, less than 5%. Germination starts 3-6 weeks after sowing. Direct sowing in the field is fairly successful for this species. Plantation establishment by means of stumps or wildlings is also satisfactory. Natural regeneration is abundant and seedlings can tolerate moderate shade.

Silviculture and management Initial growth and canopy closure of *H. tomentosum* is slow. This species is resistant to fire. It is reported to coppice well.

Harvesting Locally in Irian Jaya, *Homalium* trees have been logged selectively and classified together with timbers from *Canarium*, *Dillenia*, *Koordersiodendron*, *Palaquium*, *Syzygium* and *Vatica*. Large trees of *H. foetidum* regularly have heart rot; the logs split easily when harvested.

Yield Production of *H. tomentosum* is rather low, especially on poor sites. The standing stock volume of *H. foetidum* in natural forest of Papua New Guinea is estimated at 0.15–0.35 m^3/ha in hill forest and 0.4–0.8 m^3/ha in lowland forest. In the Bismarck Archipelago it may locally reach 6 m^3/ha.

Genetic resources There is a risk of genetic erosion of natural populations of *Homalium*; moreover, very few plantations exist. In Papua New Guinea, malas is very popular and may need conservation regulations. Some species occur only very locally or are even rare, e.g. *H. loheri* and *H. oblongifolium* in the Philippines.

Prospects As the timber of *Homalium* is of high quality and durable, it may be worthwhile to pay more attention to problems regarding its silvicultural characteristics and the management of natural forest in which it is represented. The establishment of experimental plantations should be promoted.

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Selection of species

Homalium bracteatum Benth.

Journ. Linn. Soc., Bot. 23: 213 (1885).

Synonyms *Homalium curranii* Merr. (1909).

Vernacular names Philippines: aranga (general), arangan-babae (Bikol), malakamanga (Tagalog).

Distribution The Philippines (Luzon, Samar).

Uses The wood is used as malas for general construction.

Observations A medium-sized tree; leaves ovate or mostly elliptical-oblong, 15–20 cm × 5–8 cm, rather coarsely crenate, obtuse, shining and glabrous on both surfaces; panicles thyrsoid, grey- or yellowish-tomentose; flowers solitary or rarely in pairs, 5-merous, grey-hirtellous, on a 1 mm long pedicel, stamens in fascicles of 3. *H. bracteatum* is not uncommon in primary forest at low altitude.

Selected sources 162, 330, 527.

Homalium caryophyllaceum (Zucc. & Moritzi) Benth.

Journ. Linn. Soc., Bot. 4: 38 (1860).

Synonyms *Homalium sumatranum* Miq. (1860), *Homalium frutescens* Warb. (1893), *Homalium hosei* Merr. (1916).

Vernacular names Indonesia: tangan mungit (Kalimantan), tenau (southern Sulawesi). Malaysia: anjing ayer, petaling ayer (Peninsular), tekaliu (Sabah). Cambodia: trâlak'tùk'. Thailand: neng (general), phlom kod (Trat).

Distribution Indo-China, Thailand, Peninsular Malaysia, Sumatra, West Java, Borneo and central and southern Sulawesi.

Uses The wood is sporadically used as malas for general construction and possibly for house building. In Java *H. caryophyllaceum* is used as a hedge plant.

Observations A shrub or small tree up to 15 m tall, bole cylindrical; leaves elliptical-oblong to elliptical, 7–16(–19) cm × (3–)4–7(–10) cm, entire to coarsely crenate-serrate, shortly obtusely acuminate, glabrous or sparsely pubescent beneath; racemes simple or rarely 2–3-branched near the base, sparsely pubescent; flowers subsessile, solitary or in pairs, 5–6-merous, sepals greyish appressed tomentose, petals more densely so, stamens in fascicles of 3–4. *H. caryophyllaceum* occurs in humid and dry evergreen forest or shrubby vegetation on hilly or level sites, often along rivers or on periodically inundated land, up to 150 m altitude. The wood is rather hard and heavy with a density of about 930 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 162, 163, 474, 573, 595.

Homalium celebicum Koord.

Versl. Minahasa 473, 623 (1898).

Vernacular names Indonesia: karikis, togo ulu (Manado), kombolili (Butung).

Distribution Sulawesi and Butung Island.

Uses The wood is reported to be of excellent quality and used for house building.

Observations A medium-sized or possibly large tree up to 20(–50) m tall, bark surface reddish, scaly; leaves elliptical to nearly ovate, 7–12(–17) cm × (4–)5–7(–10) cm, distantly shallowly serrate-crenate, obtusely acuminate, shiny and glabrous on both surfaces; panicles divaricate, finely greyish pubescent; flowers in fascicles of 2–3 or rarely solitary, 5-merous, on 1.5–3 mm long pedicels, sepals and petals greyish tomentulose, stamens in fascicles of 3. *H. celebicum* occurs in primary mixed rain forest on hills, on clay or limestone at 50–550 m altitude. It is frequently found together with *Kalappia celebica* Kosterm. and *Diospyros celebica* Bakh.

Selected sources 162, 661.

Homalium dictyoneurum (Hance) Warb.

Engl. & Prantl, Nat. Pflanzenfam. III, 6a: 36 (1893).

Synonyms *Pierrea dictyoneura* Hance (1877).

Distribution Indo-China and Peninsular Malaysia.

Uses The wood is used as malas. *H. dictyoneurum* and *H. grandiflorum* are the only common species in Peninsular Malaysia reaching a fair timber size.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 75 cm in diameter but usually less, with small steep buttresses, bark surface smooth or sometimes with raised lenticels, yellowish-brown to grey-brown; leaves ovate-oblong, 10–18 cm × 4–7(–9) cm, entire, obtusely acuminate, shiny and glabrous on both surfaces; racemes simple, spike-like, fulvous tomentose; flowers solitary, 9–10-merous, on 2–3 mm long pedicels, subtended by persistent bracts of 5–6 mm in diameter, sepals and petals velutinous, stamens 6, more or less in pairs, additionally 2 or 3 between each subglobose disk gland. *H. dictyoneurum* is locally common in evergreen forest on hillsides and ridges, sometimes on limestone at low elevations. The peculiar large persistent bracts are characteristic for this species. Sterile specimens cannot be distinguished from *H. grandiflorum*.

Selected sources 162, 163, 573, 705.

Homalium foetidum (Roxb.) Benth.

Journ. Linn. Soc., Bot. 4: 37 (1860).

Synonyms *Homalium luzoniense* Fernandez-Villar (1880), *Homalium platyphyllum* Merr. (1918), *Homalium novoguineense* v. Slooten (1919).

Vernacular names Ternate ironwood (En). Indonesia: gia (general), melmas (Kalimantan), momala (Sulawesi). Malaysia: petaling padang (Peninsular), keruing renkas, bansisian (Sabah). Papua New Guinea: malas (general). Philippines: aranga (general), kamagahai (Bikol), yagau (Cebu Bisaya).

Distribution Peninsular Malaysia, Sumatra, Borneo, the Philippines, Sulawesi, the Moluccas, New Guinea and the Bismarck Archipelago.

Uses *H. foetidum* is a fairly important source of malas timber; it is used amongst others for houses, bridges and for combs.

Observations A medium-sized to large or sometimes very large tree up to 45(–62) m tall, bole straight, branchless for up to 30(–55) m, up to 100(–120) cm in diameter, with steep buttresses up to 2 m high, bark surface becoming rugose with many large lenticels and horizontal raised ridges; leaves oblong to ovate-oblong, (10–)12–20(–28) cm × 5–8(–11) cm, usually coarsely crenate, abruptly acuminate, glabrous, shining above, dull beneath; panicles usually many, composed of several to many spike-like racemes, covered with a very short grey indumentum; flowers in spaced, whorled fascicles, 7–8-merous, on 1–2 mm long pedicels, sepals and petals pilose, stamens in pairs in front of each petal. *H. foetidum* occurs scattered in primary and secondary rain forest or in thickets, often along rivers, on clayey or sandy soil, sometimes on periodically inundated land, up to 200(–530) m altitude. In Papua New Guinea it is associated with *Pometia pinnata* type of lowland rain forest, where it can make up up to 15% of the gross volume. The density of the wood is 750–1060 kg/m^3 at 15% moisture content. See also the table on wood properties.

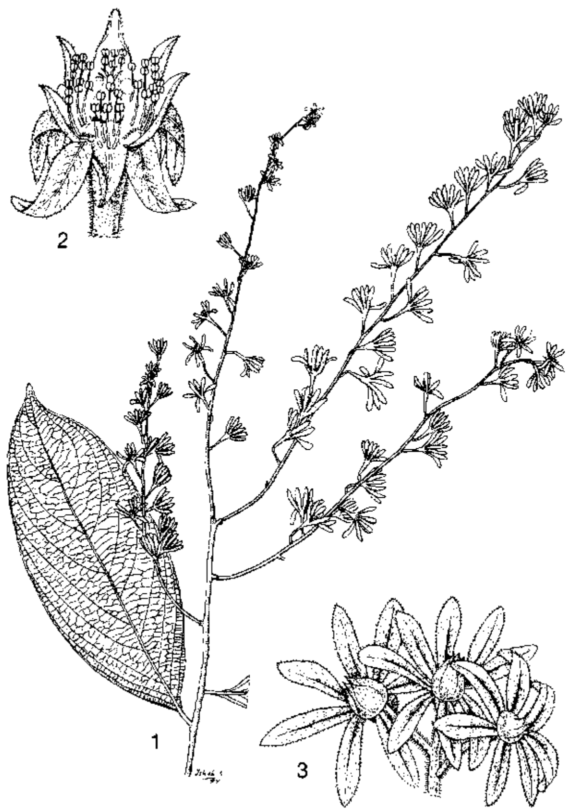
Selected sources 26, 60, 77, 99, 109, 145, 162, 180, 404, 474, 508, 527, 595, 613, 661, 705, 719.

Homalium grandiflorum Benth.

Journ. Linn. Soc., Bot. 4: 36 (1860).

Synonyms *Homalium parvifolium* Hook.f. ex Benth. (1860), *Homalium damrongianum* Craib (1915), *Homalium fallax* v. Slooten (1925), *Homalium calciphilum* Ridley (1928).

Vernacular names Indonesia: langit (Java), kayu batu (Sumatra), bajud (Kalimantan). Malaysia: kayu batu (Peninsular). Burma (Myanmar): te-bo. Thailand: taeng sang (Lampang), cha khian phueak (northern), phikun pa (central). Vietnam: ky yen.



Homalium grandiflorum Benth. – 1, fruiting twig; 2, flower; 3, fruits.

Distribution Burma (Myanmar), throughout Indo-China and Thailand towards Peninsular Malaysia, Sumatra, Borneo and Java.

Uses *H. grandiflorum* is a fairly important source of malas timber; the wood is used for house building.

Observations A small to medium-sized tree up to 30 m tall, bole with steep buttresses, bark with scattered lenticels; leaves ovate-elliptical to elliptical-oblong, (7–)10–15(–37) cm × 3–7(–15) cm, entire or nearly so, shortly obtusely acuminate, glabrous and shiny on both surfaces; racemes simple or sometimes shortly branched; flowers usually solitary, (5–)6–8(–9)-merous, with lanceolate-oblong bracts, sepals and petals glabrescent, stamens in groups of 1–3 between the disk glands, the rest in pairs inserted on the base of the petals. Within *H. grandiflorum* 2 varieties are distinguished: var. *grandiflorum* and var. *javanicum* (Koord. & Valeton) Sleumer. The latter, differing from the first by its nearly woolly, more laxly flowered inflorescence, occurs in mixed rain forest on Java. Var. *grandiflorum* is more widely distributed and occurs in lowland rain forest on hilly and sandy sites that are never inundated, up to 600 m altitude. Sterile specimens cannot be distinguished from *H. dictyoneurum*. The wood is reported as hard, difficult to work and its density is 950–990 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 99, 140, 162, 163, 386, 474, 573, 574, 595, 661, 705, 734.

Homalium longifolium Benth.

Journ. Linn. Soc., Bot. 4: 35 (1860).

Vernacular names Malaysia: petaling gajah (Selangor), selumbar (Pahang), masikang (Negeri Sembilan). Thailand: chen kiang (peninsular), pauh kijang jantan, rukam babi (Malay, peninsular).

Distribution Peninsular Thailand and Peninsular Malaysia.

Uses The wood is used as malas, e.g. in house building.

Observations A medium-sized to fairly large tree up to 42 m tall, bole rather slender, fluted, up to at least 50 cm in diameter, bark surface becoming scaly with small scales, brown to grey; leaves lanceolate to elliptical, 7–12(–17) cm × 3–5 cm, entire to shallowly crenate, shortly acuminate, glabrous, sometimes slightly shiny above; racemes solitary, rarely branched near the base, minutely white or pale yellowish tomentose; flowers in 3–4(–5)-flowered fascicles, 5–6-merous, on 1–1.5 mm long pedicels, sepals and petals minutely tomentose on their margins, stamens solitary before each petal. *H. longifolium* is locally common in evergreen forest on hills and ridges, at 50–650 m altitude. The wood is reported to be very hard and has a density of 715–985 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 140, 162, 573, 705.

Homalium minahassae Koord.

Versl. Minahasa: 474, 624 (1898).

Vernacular names Indonesia: karikis sela (Minahasa), lagumute, kationgar (Moluccas).

Distribution North Sulawesi and the Kai and Tanimbar Islands (the Moluccas).

Uses The wood is used as malas for house building.

Observations A medium-sized tree up to 35 m tall, bole up to 80 cm in diameter; leaves oblong-lanceolate to ovate-lanceolate, (10–)15–20 cm × 4–5(–8) cm, entire, gradually narrowed into the subacute apex, glabrous and shiny on both surfaces; racemes simple or branched, grey tomentose; flowers solitary, 6–7-merous, on 2–3 mm long pedicels, sepals and petals glabrescent, stamens in fascicles of 6–7(–8) before each petal, one stamen between the disk glands, the others inserted on the base of the petal. *H. minahassae* occurs in primary forest on level, sandy clay soils, up to 100 m altitude.

Selected sources 162, 234, 661.

Homalium panayanum Fernandez-Villar

Nov. app.: 94 (1880).

Synonyms *Homalium myrianthum* Baker (1896), *Homalium subscandens* Elmer (1912), *Homalium obovatum* Merr. (1925).

Vernacular names Malaysia: malaban, kaniniium (Dusun, Sabah), panawan (Bajan, Sabah). Philippines: ampupuyot (Bisaya), kandong (Iloko), puyot (Panay Bisaya).

Distribution Borneo (Sabah) and the Philippines including Palawan.

Uses The wood is used as malas, but probably only rarely, due to the general small size of the tree.

Observations A shrub or small tree; leaves elliptical-obovate to oblong-obovate, (4–)5–10(–12) cm × 3–5 cm, entire to obscurely shallowly crenate, broadly obtusely acuminate or subrotund, glabrous, shiny above, dull beneath; panicles branched from near the base, greyish pubescent; flowers solitary, 6–7-merous, on c. 2.5 mm long pedicels, sepals and petals densely covered with spreading hairs, stamens solitary, in front of each petal. *H. panayanum* occurs in forest on hills and ridges from the lowland up to 1400 m altitude. The wood is reported to be similar to that of *H. foetidum*.

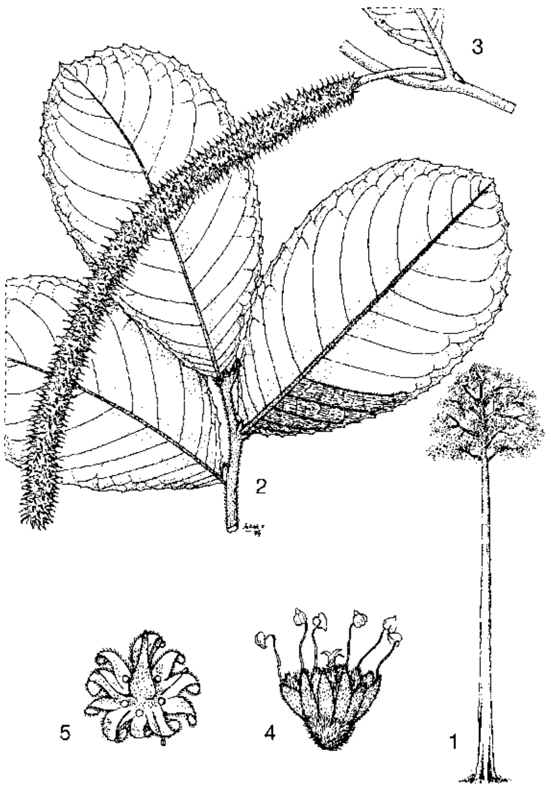
Selected sources 162, 527, 544.

Homalium tomentosum (Vent.) Benth.

Journ. Linn. Soc., Bot. 4: 34 (1860).

Vernacular names Indonesia: delingsem, gerinseng (Java), kaladdo (Flores), neku (Timor). Burma (Myanmar): myauk chaw. Cambodia: phloeuo niëng. Laos: 'khên nang. Thailand: kha nang (central), chang phuek luang (Chiang Mai), puei khang hai (Lampang).

Distribution From north-eastern India through Burma (Myanmar) and Indo-China towards central Thailand and in western Sumatra (rare), cen-



Homalium tomentosum (Vent.) Benth. – 1, tree habit; 2, twig with leaves; 3, twig with inflorescence; 4, flower; 5, young fruit.

tral and eastern Java and the Lesser Sunda Islands.

Uses The wood is used as malas and for the manufacture of matches. *H. tomentosum* might be useful for afforestation.

Observations A deciduous medium-sized tree up to 30(–40) m tall, bole well-shaped, up to 40 cm in diameter, buttressed; leaves broadly obovate to obovate-oblong, (7.5–)10–15(–25) cm × 4–7(–13) cm, shallowly glandular-crenate, obtuse to apiculate, dull, glabrescent above, tomentose below; racemes simple or rarely 1–2-partite near the base, yellowish tomentose; flowers in 2–3(–5)-flowered glomerules, 5–6-merous, sessile or nearly so, sepals and petals woolly, stamens solitary, inserted before each petal. *H. tomentosum* is locally common but not gregarious in mixed deciduous forest, sometimes with bamboo, and in teak forest. It usually occurs where the dry monsoon is well pronounced, not seldom on calcareous soil, at low elevation or rarely up to 700 m altitude. It is reported to be fairly fire-resistant and its wood is hard and heavy with a density ranging from 840–1120 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 115, 140, 162, 163, 218, 219, 331, 386, 474, 573, 574, 648.

E. Boer (general part),
M.S.M. Sosef (general part, selection of species),
W.G. Keating (properties),
J. Ilic (wood anatomy)

Kokoona Thwaites

Hook. Journ. Bot. Kew Gard. Misc. 5: 379 (1853).

CELASTRACEAE

x = unknown

Trade groups Mata ulat: heavy hardwood, e.g. *Kokoona littoralis* M.A. Lawson, *K. ochracea* (Elmer) Merr., *K. reflexa* (M.A. Lawson) Ding Hou. The timber was formerly traded together with that from the genus *Lophopetalum* as perupok.

Vernacular names Mata ulat. Brunei: bajan. Indonesia: sepalis (Sumatra). Malaysia: bajan (Sarawak), sabong api (Iban, Sarawak). Philippines: layeng (Tagalog).

Origin and geographic distribution *Kokoona* consists of 10 species: 1 species in Sri Lanka and southern India, 1 in Burma (Myanmar), and 8 in the western Malesian area, i.e. in Peninsular Malaysia (5 species), Sumatra (2 species), Borneo (6 species), and the Philippines (1 species, Palawan only).

Uses The timber is suitable for heavy construction if treated with preservatives. It is used for posts, beams, joints, rafters, heavy duty furniture including laboratory bench tops, window and door frames, railway sleepers and telegraphic and power transmission poles. The conspicuous bands of parenchyma on the tangential surfaces give the wood a very decorative figure, and it may be used for panelling, parquet flooring, strip flooring and fancy articles. The wood is difficult to split and therefore not a popular firewood.
The ochre-yellow middle bark of *Kokoona* species burns readily and is used as a tinder.

Production and international trade Mata ulat is only used locally and only very small amounts are exported if at all. No statistics are available on production and trade.

Properties Mata ulat is a heavy hardwood. The heartwood is yellowish-brown to pinkish-brown and not distinctly demarcated from the sapwood.

The density is (840–)895–1070(–1120) kg/m³ at 15% moisture content. The grain is straight to fairly interlocked, texture fine but slightly uneven due to broad parenchyma bands.

A test on wood of *K. littoralis* in green condition in Peninsular Malaysia showed the following mechanical properties: the modulus of rupture 102 N/mm², modulus of elasticity 16 300 N/mm², compression parallel to grain 53 N/mm², compression perpendicular to grain 7 N/mm², shear 10.5 N/mm², cleavage 68 N/mm radial and 73 N/mm tangential, and Janka side hardness 6800 N.

The rates of shrinkage are fairly low to moderate: from green to about 17% moisture content 1.6–2.6% radial and 2.0–3.0% tangential. During drying the timber may be prone to checking and splitting. *K. reflexa* timber is reported to be more amenable to seasoning than timber of *K. littoralis*. Boards 15 mm thick take 2–3 months to air dry, and 40 mm thick boards take 3.5–5 months. In Malaysia, kiln schedule C is recommended. Boards 25 mm thick can be kiln dried in 10 days from 50% to 10% moisture content, but rather severe surface checking and splitting have been observed.

Mata ulat wood is usually comparatively easy to resaw and cross cut in green and air-dry condition, despite its high density; however, sometimes it is difficult to saw, quickly blunting saw teeth. Planing and boring are generally also easy giving smooth surfaces (except for some picking up of grain on radial surfaces), but it is more difficult to turn air-dry wood giving rough surfaces. The wood is not suitable for plywood manufacture because of its high density and because the veneer has a tendency to tear and split.

Mata ulat is classified as moderately durable. In tests in Malaysia, stakes of *K. reflexa* showed an average service life of 4.2 years in contact with the ground. The wood is not resistant to subterranean termites, and sawn wood has also been attacked by powder-post beetles and sap-staining fungi. The heartwood is very difficult to treat with preservatives, even when using a full-cell vacuum-pressure treatment, but sapwood is more amenable to preservative treatment.

Description Small to large, evergreen trees up to 55 m tall; bole straight, cylindrical, up to 125 cm in diameter, sometimes with short buttresses; bark surface often with horizontal hoop marks, cracked or fissured, with large lenticels, grey to chocolate brown, middle bark ochre to orange, inner bark fibrous, pinkish to yellowish; twigs flattened at the nodes, drying black or pale. Leaves decussate or rarely subopposite or alternate on some branches, simple, the margin entire, wavy or toothed; stipules very small. Inflorescence axillary or terminal, paniculate or racemose. Flowers bisexual, actinomorphic, 5-merous, with an articulate pedicel; petals free, contorted, yellowish to whitish; disk fleshy, cup-shaped or rarely 5-lobed with the lobes alternating with the petals; stamens 5, inserted inside the inner edge of the disk, filaments gradually or abruptly narrowed towards the apex and often transparent at the upper end, anthers with or without a prominent connective; ovary superior, sometimes partly buried in the disk, 3-celled, ovules 6–16 in each cell, in 2 rows down the central axis, style single, short or obscure, with a short, thick, sometimes 3-lobed stigma. Fruit a 3-valved capsule, 3-angled, splitting loculicidally. Seeds overlapping, flat, with a conspicuous membranous wing at the apical end, albumen absent. Seedling with epigeal germination; cotyledons fleshy, remaining within the seed-coat and hypocotyl elongated (durian type of germination); all leaves opposite.

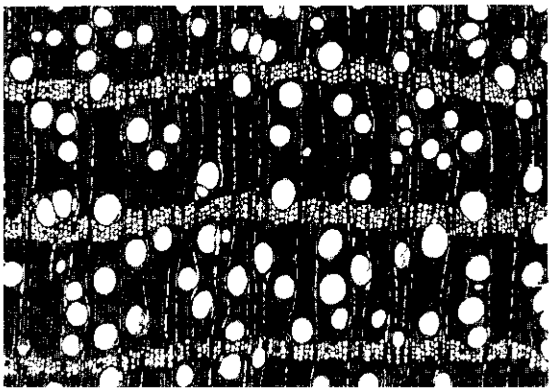
Wood anatomy

– Macroscopic characters:

Heartwood yellowish-brown with a pinkish tinge, indistinctly demarcated from the paler sapwood. Grain shallowly interlocked. Texture fine and generally even; planed surfaces fairly lustrous, with fine streaks on radial surfaces and decorative zigzag markings on tangential surfaces. Growth rings absent or indistinct, but the broad terminal bands of parenchyma are distinct and visible to the naked eye, and may simulate growth rings; vessels small, not distinct to the naked eye; rays very fine, not visible to the naked eye; ripple marks absent.

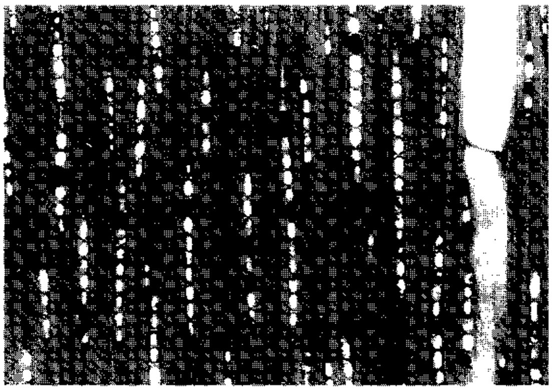
– Microscopic characters:

Growth rings absent. Vessels diffuse, 16–27(–34)/mm², solitary except for apparent pairs produced by overlapping tips of vessel elements, slightly unevenly distributed, often arranged in groups, round to oval, average tangential diameter 55–70 μm; perforation plates simple; intervessel pits alternate, c. 4 μm; vessel-ray pits similar to intervessel pits but half-bordered; white or yellow deposits sometimes present; tyloses absent. Fibres 1.1–1.6 mm long, non-septate, thick-walled, with conspicuously bordered pits. Parenchyma predominantly apotracheal, occurring as broad tangential bands of 4 or more cells wide, bands often anastomosing or ending abruptly, in 4–12-celled strands. Rays 11–15(–17)/mm, predominantly uniseriate, sometimes with biseriate parts, up to 390 μm



transverse section (×25)

radial section (×75)



tangential section (×75)

Kokoona littoralis

high, homocellular with all ray cells procumbent. Crystals occasionally present in ray cells.
Species studied: *K. littoralis*, *K. reflexa*.

Growth and development Trees of *K. reflexa* in the FRIM arboretum (Peninsular Malaysia) of 38 years old were up to 22 m tall with a clear bole of up to 7.5 m and a diameter at breast height of up to 28 cm, i.e. a mean annual diameter increment of 7.5 mm. The winged seeds are dispersed by wind.

Other botanical information *Kokoona* was formerly included in *Lophopetalum*, but differs in having contorted petals without appendages, and seeds with a unilateral wing. Wood anatomy and palynological characteristics support the separation of the two genera.

Ecology The species of mata ulat are found scattered in a wide range of habitats in the rain forest. They occur in well-drained locations in flat country or on hills and ridges, but also in freshwater or peat swamps, in kerangas, or rarely on ultrabasic soils, usually in the lowland, but ascending to montane forest up to 1500 m altitude.

Propagation and planting Seed of *K. sessilis* Ding Hou, a rare tree from Peninsular Malaysia, has 35% germination in 10–22 days, and 75% germination in 10–32 days if the wings have been removed from the seeds. Seed of *K. littoralis* has 90% germination.

Harvesting The logs are generally free from defects.

Yield The yield of mata ulat per ha is insignificant, as the trees occur scattered in the forest.

Genetic resources Mata ulat usually occurs too scattered to be of economic importance for its timber. No inventory of stands is available, but the species seem not to be particularly vulnerable to loss of genetic variation as a result of timber exploitation as they are not specifically selected for logging. Rare species with a limited area of distribution (e.g. *K. sessilis*) may easily be affected by large-scale clearance of forest.

Prospects Very little is known about mata ulat, but it is unlikely that it will have potential as a timber-producing tree of economic importance as it occurs too scattered and grows slowly in comparison with other timbers classified in Malaysia as 'medium hardwood' such as keruing (*Dipterocarpus* spp.) and kempas (*Koompassia malaccensis* Maingay ex Benth.).

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Selection of species

Kokoona littoralis M.A. Lawson

Hook.f., Fl. Brit. India 1: 617 (1875).

Synonyms *Lophopetalum dubium* M.A. Lawson (1875), *Kokoona scortechinii* King (1896), *Lophopetalum maingayi* Ridley (1922).

Vernacular names Brunei: bajan. Indonesia: sepalis (Sumatra). Malaysia: mata ulat (general), bajan (Iban, Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as mata ulat.

Observations A large tree up to 45 m tall, bole up to 100 cm in diameter, buttresses small or absent, bark surface smooth, dull grey-brown; leaves papery to leathery, margin entire or sometimes remotely and very shallowly crenate, sometimes slightly recurved, lower surface pale and dull; anthers with connective prolonged 0.5–1 mm beyond the anther cells, stigma capitate. *K. littoralis* occurs locally frequently in well-drained primary forest, on leached clay-rich soils, or in kerangas forest on podzols, rarely on ultrabasic soils, up to 600(–1500) m altitude. The density of the wood is 910–1055 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 26, 77, 99, 162, 206, 364, 463, 465, 576, 705, 721, 723.

Kokoona ochracea (Elmer) Merr.

Enum. Philipp. fl. pl. 2: 484 (1923).

Synonyms *Ardisia ochracea* Elmer (1913).

Vernacular names Brunei: ubar. Indonesia: kayu minyak, kelapatiung (East Kalimantan). Malaysia: mata ulat (general), perupok kuning (Sabah). Philippines: layeng (Tagalog), repetek (Palawan).

Distribution Peninsular Malaysia, Borneo and Palawan.

Uses The wood is used as mata ulat. The bark contains an inflammable oil and is used locally as a tinder.

Observations A fairly large tree up to 40 m tall, bole up to 65 cm in diameter, sometimes with steep buttresses up to 3 m high, bark surface smooth to rugose, hoop-marked, often with large lenticels, pale grey-brown to brown, inner bark granular, yellow or pink; leaves more or less leathery, margin shallowly toothed, drying ochre-grey below, secondary veins raised below; anthers with connective prolonged about 1.5 mm beyond the anther cells, stigma cylindrical. *K. ochracea* is uncommon and found scattered in lowland forest, up to 1000 m altitude.

Selected sources 26, 77, 99, 162, 536, 644, 705.

Kokoona ovatolanceolata Ridley

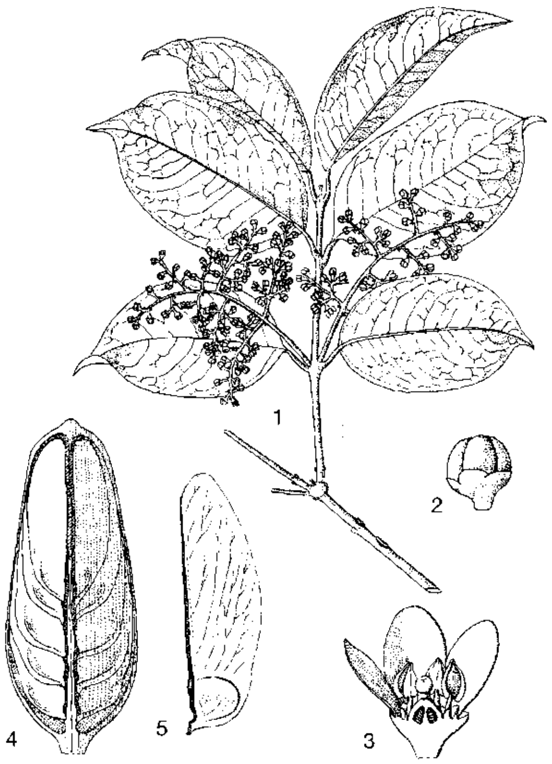
Kew Bull.: 236 (1938).

Vernacular names Brunei: kayan. Indonesia: anakan (West Kalimantan), bekumpai, kulian (South Kalimantan). Malaysia: bandung, bajan paya, dian (Sarawak).

Distribution Borneo.

Uses The wood is used as mata ulat. The bark contains an inflammable oil and is used locally as a tinder.

Observations A large tree up to 45 m tall, bole straight, cylindrical, up to 75 cm in diameter, with low buttresses, bark surface becoming irregularly cracked and powdery flaky towards the butt, hoop-marked, inner side of outer bark orange; leaves leathery, margin entire to remotely crenulate, dull below, secondary veins raised on both surfaces; anthers with connective sometimes obscurely prolonged beyond the anther cells, stigma broadly oblong. *K. ovatolanceolata* is locally com-



Kokoona ovatolanceolata Ridley – 1, flowering twig; 2, flower bud; 3, sectioned flower; 4, opened fruit; 5, seed.

mon on deep white sandy soils in kerangas, and in peat-swamp or freshwater swamp forest, at low altitudes.

Selected sources 26, 99, 162, 576.

Kokoona reflexa (M.A. Lawson) Ding Hou

Fl. Malesiana, ser. I, 6: 262 (1962).

Synonyms *Lophopetalum reflexum* M.A. Lawson (1875), *Hippocratea maingayi* M.A. Lawson (1875).

Vernacular names Indonesia: pasir (Batak, Sumatra), sepalis (Sumatra), kayu minyak (South Kalimantan). Malaysia: mata ulat (general), bajan (Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as mata ulat.

Observations A large to very large tree up to 55 m tall, bole straight, cylindrical, up to 125 cm in diameter, with steep tall buttresses, bark surface eventually minutely cracking and coming away in small powdery papery flakes, hoop-marked, dull grey-brown; leaves papery, margin wavy and usually toothed towards the apex, drying rusty brown below and blue-grey above, secondary veins very slightly prominent below; anthers with the connective not prolonged, stigma orbicular, flat. *K. reflexa* occurs only locally frequently but always scattered in lowland forest, particularly on well-drained soils along ridges, up to 750 m altitude. The density of the wood is 895–1070 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 99, 162, 206, 466, 705, 723.

K.M. Kochummen (general part, selection of species),
W.C. Wong (properties),
Ani binti Sulaiman (wood anatomy)

Koordersiodendron Engl.

Koord., Versl. Minahasa, Meded. 's-Lands Plantentuin 19: 410 (1898).

ANACARDIACEAE

x = unknown; $2n$ = unknown

Trade groups Ranggu: medium-weight hardwood, a single species, *Koordersiodendron pinnatum* (Blanco) Merr., Bull. For. Bur. 1: 33 (1903), synonyms: *Koordersiodendron celebicum* Engl. (1898), *Lannea speciosa* (Blume) Engl. ex Perk. (1904), *Koordersiodendron papuanum* Kaneh. & Hatus. (1942).

Vernacular names Ranggu. Indonesia: tabu hitam (Kalimantan), kayu bugis, bugis (Sulawesi), grepau (Irian Jaya). Philippines: amugis (general), dangila (Tagalog), karogkog (Bikol).

Origin and geographic distribution *Koordersiodendron* consists of a single species and is widely distributed throughout the Philippines, the northern part of Borneo, Sulawesi, the Moluccas and the northern part of Irian Jaya.

Uses Ranggu timber is excellent for flooring owing to its uniform dark red colour, and is also used for construction under cover (posts, beams, joists, rafters, interior finish), boat and cart construction, furniture, cabinet making and turnery. The wood is suitable for the manufacture of wood-wool board.
The gum from the bark has been used in local medicine.

Production and international trade In Sabah, ranggu was mainly used locally because it had more defects than other timber species from Sabah and the green logs, which sink in water, are difficult to transport. However, the present export is considerable: in 1987 12 500 m^3 of logs with a value of US$ 700 000, and in 1992 8000 m^3 (5% as sawn timber, 95% as logs) with a total value of US$ 580 000 (US$ 180/m^3 for sawn timber, US$ 67/m^3 for logs). Japan imports limited amounts of ranggu, mainly from Sabah and Irian Jaya.

Properties Ranggu is a medium-weight hardwood. The heartwood is pale pinkish-brown, reddish-brown to dark red-brown, often with black streaks, well demarcated from the greyish-brown or pale pinkish sapwood. The density is (410–)530–915(–1020) kg/m^3 at 15% moisture content. The grain is usually interlocked, sometimes straight, occasionally wavy or curly, texture moderately fine. The wood is glossy, and the taste and odour are not perceptible.

Tests of samples of green wood from the Philippines, Sabah and Irian Jaya showed the following mechanical properties: the modulus of rupture 66–86.5 N/mm^2, modulus of elasticity 10 625–15 300 N/mm^2, compression parallel to grain 31–47 N/mm^2, compression perpendicular to grain about 9.5 N/mm^2, shear 9–15.5 N/mm^2, cleavage about 80.5 N/mm radial and 92 N/mm tangential, Janka side hardness 3400–7120 N and Janka end hardness 3660–6300 N. A test of wood from Sabah showed the following figures at 17% moisture content: modulus of elasticity 17 030 N/mm^2, compression parallel to grain 58 N/mm^2, shear 13.5 N/mm^2, cleavage 76 N/mm radial and 87 N/mm tangential, Janka side hardness 7480 N and Janka end hardness 6865 N. See also the table on wood properties.

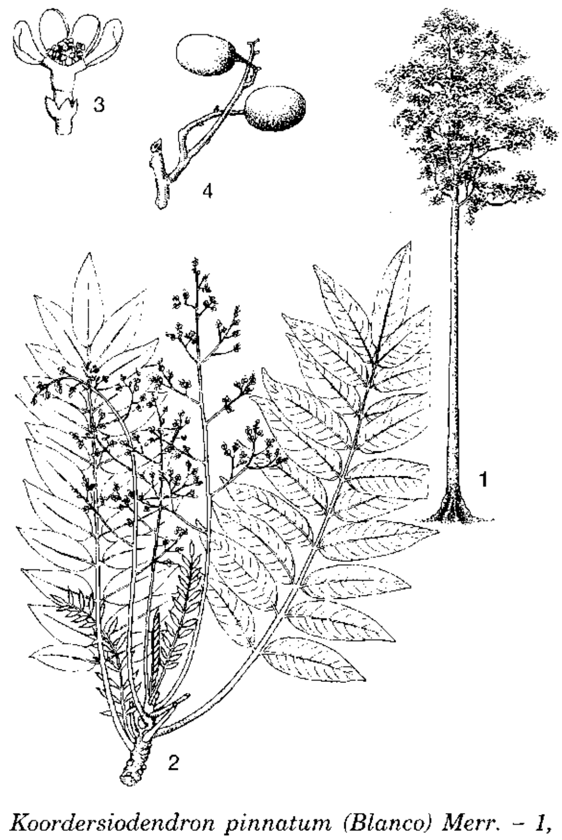
The rates of shrinkage are moderately high to high: from green to 15% moisture content 1.7% radial and 2.6% tangential, from green to 12% moisture content 3.1–5.0% radial and 5.6–8.0% tangential. Ranggu is difficult to season because of its distinct tendency to cup and warp, whereas splitting and checking are normally observed when seasoning 25 mm stock. Air drying prior to kiln drying is recommended. Material of 50 mm and thicker is stable in service when properly dried.

Ranggu is rather difficult to saw and causes circular saws to heat up. A band saw rather than a circular blade is recommended for ripping. In planing, a 30° cutting angle is suitable for back-sawn material, but 20° for quarter-sawn stock. Boring and mortising result in a good finish, but support is usually needed at the exit faces. Preboring is essential for nailing. Stock finishes and polishes well, although torn grain is common on quartered faces. The wood has a moderate blunting effect on tools. It is probably not suitable for veneer, because it is too heavy and liable to defects when peeled.

Ranggu is rated as non-durable to moderately durable. It is easily attacked by termites, pinhole borers and probably also marine borers. It is moderately susceptible to *Lyctus* beetles. Due to tyloses, the heartwood is extremely resistant and the sapwood is moderately resistant to preservative treatment. The wearing properties of ranggu are excellent.

The wood contains 49.3% cellulose, 26.9% lignin, 16.7% pentosan and 1.3% ash. The solubility in alcohol-benzene is 4.9%.

Description A large, evergreen tree up to 50 m tall; bole cylindrical, branchless for up to 25(–30) m, up to 80(–200) cm in diameter, sometimes with buttresses up to 2 m high; bark surface usually deeply fissured, dark brown or black, inner bark laminated, fibrous, pink to red, with a little colourless exudate; crown dense and dark green. Leaves arranged spirally, crowded at the end of



Koordersiodendron pinnatum (Blanco) Merr. – 1, tree habit; 2, flowering twig; 3, flower with 1 petal removed; 4, branchlet with fruits.

twigs, imparipinnate, 50–80 cm long, with (6–)10–16 pairs of leaflets, rachis hairy, exstipulate; leaflets subopposite, ovate-oblong to narrowly oblong, 3–20 cm × 1.5–5.5 cm, entire, slightly asymmetrical at base, acuminate, with 10–24 pairs of usually bright red secondary veins, glossy green above, yellowish-green below, glabrescent, with short petiolule, without domatia. Flowers in an axillary panicle up to 50 cm long, bisexual, actinomorphic, 5-merous, small, white or yellowish-green; sepals united at base, the lobes 0.7–1 mm long; petals free, imbricate, 2–3 mm long; stamens 10, glabrous, anthers subglobose, connective protruding slightly beyond the thecae; ovary superior, sessile, subglobose, deeply longitudinally 5-furrowed, densely hairy, 5-celled, usually with one fertile cell and one ovule per cell, styles 5, short; disk intrastaminal, round and flat, 10-notched. Fruit a 1(–3)-celled drupe, broadly ellipsoid, 2.5–4 cm long, obtuse at both ends, yellowish when ripe, with cartilaginous endocarp. Seed ellipsoid, with the testa free from the endocarp; cotyledons free, plano-convex. Seedling with epigeal, cryptocotylar germination; cotyledons succulent, enclosed by the persistent, dark brown, cracking and fibrous fruit wall; first 2 leaves opposite and compound, subsequent leaves arranged spirally.

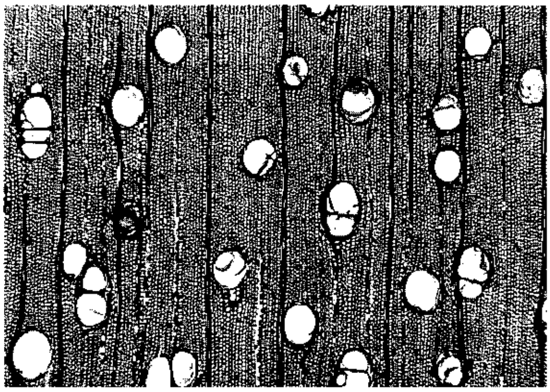
Wood anatomy

– Macroscopic characters:

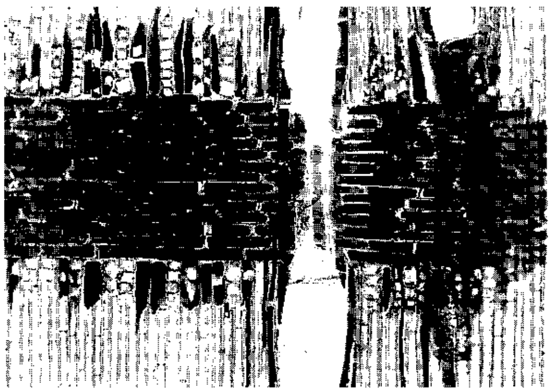
Heartwood pale pinkish-brown to dark red-brown, often with fine dark streaks, fairly distinctly demarcated from the greyish-brown or pale pinkish sapwood. Grain often slightly interlocked, sometimes straight and occasionally wavy. Texture rather fine and even; wood lustrous. Growth rings absent or indistinct, occasionally distinct; vessels indistinct to barely visible to the naked eye, tyloses abundant; vasicentric parenchyma visible with a lens, rays not distinct to the naked eye; ripple marks absent.

– Microscopic characters:

Growth rings, when present, marked by differences in fibre wall thickness. Vessels diffuse, 3–8/mm^2, solitary, occasionally in radial multiples of 2–3 or in small clusters of 3–5, round, rarely oval, tangential diameter 90–250 μm; perforations simple; intervessel pits alternate, bordered, rounded to polygonal, 10–15 μm; vessel-ray and vessel-parenchyma pits coarse and of various shapes, with strongly reduced borders to almost simple; helical thickenings absent; tyloses abundant. Fibres 620–1600 μm long, septate, thin-walled to moderately thick-walled (walls 4–6(–10) μm thick), with minutely bordered pits confined to



transverse section (×25)



radial section (×75)

tangential section (×75)

Koordersiodendron pinnatum

the radial walls. Parenchyma sparse paratracheal, vasicentric, mostly in 1–2-celled sheaths to the vessels, in 3–5-celled strands. Rays 4–12/mm, 1–3(–5)-seriate, up to 0.8 mm high, heterocellular with 1–3 rows of upright cells and/or square marginal cells (Kribs type heterogeneous II and III). Prismatic crystals rare in chambered axial parenchyma cells, common in chambered or enlarged marginal ray parenchyma cells; ray and parenchyma cells often with red or brown deposits. Silica absent. Gum ducts present in wide, fusiform rays. All elements non-storied.

Growth and development During germination the taproot and hypocotyl emerge from one pole of the fruit; the cotyledonary petioles elongated and carry the fruit away from the plumule. The taproot is long and slender. After the first two leaves have developed, a resting stage follows.
In the dry season the tree crown becomes lighter, but never loses all foliage.
In Sabah, the mean annual diameter increment of ranggu is 0.2–0.9 cm. The fruits are dispersed by animals, notably hornbills, green pigeons and primates, which feed on the pulp.

Other botanical information *Koordersiodendron* belongs to the tribe *Spondiadeae* and seems most closely related to *Pegia* or *Spondias*. The genus is characterized by the many leaflets without domatia, the 10 stamens and the 5-celled ovary with incompletely connate cells. In Sarawak, the vernacular name ranggu is also used for *Melia excelsa* Jack.

Ecology Ranggu occurs in humid evergreen lowland forest, but in the Philippines it is reported to be found mainly on the fringes of lowland forest, from near the beach up to 450(–800) m altitude. It is widespread but occurs scattered and almost nowhere abundant. It is occasionally found in inundated locations. It prefers loamy soils. On the island of Seram (the Moluccas), ranggu occurs as an emergent tree over 45 m tall, with an average of 3.3 trees over 50 cm diameter at breast height per ha in a forest type dominated by *Canarium vulgare* Leenh. In Irian Jaya, it is found on forest fringes along the beach and associated with *Celtis philippensis* Blanco, *Vitex quinata* (Lour.) F.N. Williams, *Canarium asperum* Benth. and *Trichadenia philippinensis* Merr. on well-drained soils containing gravel and boulders.

Propagation and planting Information available on propagation from seed indicates that germination in the nursery is fair. Wildlings transferred to the nursery showed 90% survival and a height increment of 34 cm during the first 6 months in the nursery. Compared with the original population from which they came from, the wildlings had a shorter taproot and more lateral roots, which make them better, more sturdy planting stock than the seedlings under the mother tree.

Diseases and pests In Sabah a longhorn beetle attacks living trees and causes serious defects of the timber.

Harvesting As the green logs sink in water (density about 1120 kg/m^3 at an estimated moisture content of 60–80%), they cannot be transported by river. Large trees are often hollow.

Yield In South Sulawesi, the estimated timber volume of a particular forest is 13.8 m^3/ha for ranggu trees over 50 cm in diameter. In the Samarinda forest in East Kalimantan, this parameter ranges from 2.0–8.8 m^3/ha. In Seram, the Moluccas, ranggu makes up 5% of the total basal area in natural forest.

Genetic resources Considering its wide distribution, ranggu does not seem in danger of genetic erosion at present.

Prospects The wood has an attractive dark-red colour, but there are some problems in converting the timber, as sawing is not very easy and the tools used are easily blunted. As extremely little is known about the silviculture of ranggu, it is doubtful whether the importance of the wood will increase in the future.

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Other selected sources 12, 69, 77, 92, 96, 112, 142, 278, 283, 290, 299, 329, 330, 367, 393, 394, 474, 526, 584, 626, 627, 675, 715.

E. Boer (general part),
J.W. Hildebrand (general part),
D.S. Alonzo (properties),
J.M. Fundter (wood anatomy)

Libocedrus Endl.

Syn. conif.: 42 (1847).

CUPRESSACEAE

x = unknown (probably 11 as in the majority of *Cupressaceae*); $2n$ = unknown

Trade groups Libocedrus: lightweight to medium-weight softwood, a single species within the Malesian area, *Libocedrus papuana* F. v. Mueller, Roy. Soc. Vict. n.s. 1: 32 (1889), synonyms: *Libocedrus torricellensis* Schlechter ex Lauterb. (1913), *Papuacedrus papuana* (F. v. Mueller) Li (1953), *Papuacedrus torricellensis* (Schlechter ex Lauterb.) Li (1953).

Vernacular names Libocedrus: papuacedrus (En). Indonesia: kasuari gunung, dauti, matu (Irian Jaya).

Origin and geographic distribution *Libocedrus* consists of 7 species which occur in southern Chile (1 species), New Zealand (2 species), New Caledonia (3 species), and the eastern Malesian area (1 species). The single Malesian species is found in the Moluccas (rare) and New Guinea. Fossil shoots and wood have been encountered in the Eocene of Patagonia and Chile.

Uses The wood is used for construction, light framing, door and window frames, furniture, cabinet-work, joinery, moulding, shingles, weatherboards and boat building. The bark is sometimes used for roofing and is highly valued locally.

Production and international trade *Libocedrus* wood attracts high prices and the export of logs is banned in Papua New Guinea; only processed wood can be exported. The amount of timber exported is small.

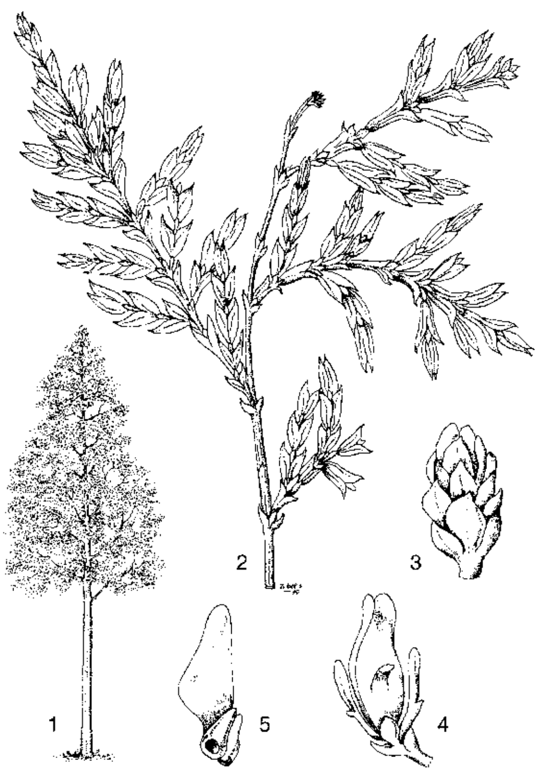
Properties *Libocedrus* produces a lightweight to medium-weight softwood. The heartwood is pale yellowish-brown, darkening to golden-brown or reddish-brown upon exposure, not distinctly demarcated from the straw-coloured sapwood. The wood has a cedar-like aromatic odour; it is sometimes slightly glossy. The density is (400–)430–680 kg/m^3 at 12% moisture content. The grain is straight, texture moderately fine. The wood is moderately hard. In Papua New Guinea, the wood is classified in the lowest strength group. No results of tests on mechanical properties are available.

The rates of shrinkage are fairly low: from green to 12% moisture content 2.0–3.0% radial and 3.5–5.0% tangential. Drying in a climate chamber from 100% to 17.5% moisture content at 40°C takes about 60 days, without serious degrade. Kiln drying from green to 12% moisture content requires about 6 days, and about 2 days after initial air drying to 25% moisture content. The recommended kiln schedule is at a dry-bulb temperature of 55–70°C. Surface checking is rare, apart from minor checking and splitting when pith material is present. Warping, in the form of slight (occasionally moderate) twist, is likely to develop as well as slight cupping of some back-sawn boards.

The wood is easy to saw and cross cut at a 20° rake angle, with a smooth surface but a high extent of loosening fibres at the edges. It is easy to plane when a 35° rake angle is used and satisfactory to mould and bore, producing smooth surfaces; the results of mortising, turning, boring and nailing are satisfactory. No difficulties arise in coating and staining, or in gluing. The wood dust may cause irritation.

The wood is moderately durable and rather easy to somewhat difficult to treat with preservatives. It is not susceptible to *Lyctus* attack.

Description A monoecious evergreen tree up to 50 m tall; bole up to at least 80 cm in diameter; bark surface smooth but fissured, peeling off in strips or flakes, brown but weathering to blackish or grey, inner bark fibrous, pink, with some resinous exudate; crown pyramidal in younger trees, flat and broad in older ones; branches spreading or slightly pendulous with age, darker above and often glaucous beneath. Leaves alternating in whorls of 3–4 but soon reduced to decussate, scale-like, acute, of 2 types, the first pair small, rhomboid, the second pair about twice as large, strongly keeled and compressed, the basal parts connate, the apical part subfalcate; stomata concentrated on the lower surface, only few on the upper. Fertile structures terminal, solitary, often on short lateral branches. Pollen cone cylindrical, 4–25 mm × 2–3 mm, composed of decussate or more or less crowded scales (microsporophylls) each with 2–4 inverted pollen sacs. Seed cone woody, composed of 2 ovate opposite fertile scales each with 2 erect ovules at their base and 2 small lateral sterile scales; fertile scale broadly lanceolate to almost elliptical, 8–12 mm × 4–6 mm; mature cone brown or blackish, often with radiating ridges. Seed 2–3 mm long, with 2 very unequal wings, larger wing twice as long as the seed and curved outward from the seed.



Libocedrus papuana F. v. Mueller – 1, habit of young tree; 2, twig with leaves; 3, pollen cone; 4, seed-bearing structure; 5, seed.

Wood anatomy

– Macroscopic characters:

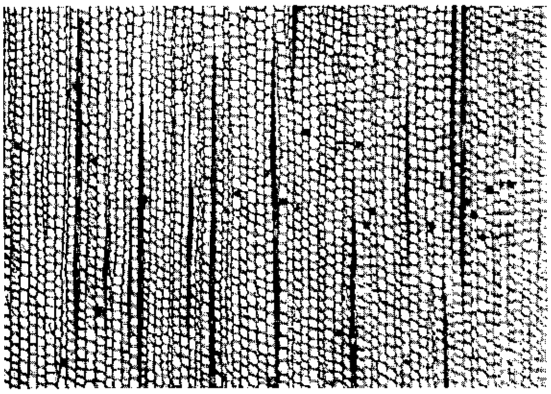
Heartwood pale yellowish-brown, sometimes with pinkish tinge, darkening to a golden-brown colour, sapwood straw-coloured. Grain straight. Texture fine and even. Growth rings indistinct; parenchyma not evident to the naked eye; rays very fine, not visible to the naked eye but moderately distinct on radial surfaces; wood slightly lustrous, with a faint cedar-like odour (like sharpened pencils), back-sawn faces generally with some figure.

– Microscopic characters:

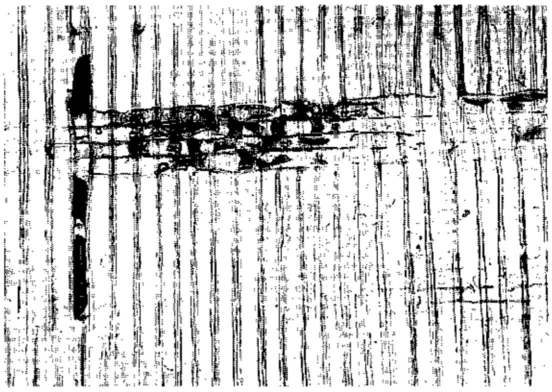
Tracheids polygonal, square to rounded in cross-section, tangential diameter approximately 35–55 μm, 4.5–6.7 mm long; intertracheid pits in 1(–2) rows, opposite when in pairs, large and rounded, 16–18 μm in diameter, crassulae evident; pits on tangential walls rare and smaller. Parenchyma diffuse, moderately abundant, end walls smooth. Rays 6–8/mm, almost exclusively uniseriate, biseriate rays rare, (1–)4–16(–25) cells high, biseriate part, when present, 1 cell high, large, end walls smooth; ray-to-axial-tracheid pits bordered, taxodioid, medium-sized, 10–14 μm in diameter, 1–2(–3) per crossfield. Resin canals and ray tracheids absent. Abundant reddish-brown extraneous material present in ray and parenchyma cells. *Podocarpus* wood can resemble that of *Libocedrus*, but *Libocedrus* wood can easily be differentiated by the faint cedar-like smell which can be enhanced by cutting or sanding the wood.

Growth and development The seedling leaves are 1-veined and linear, c. 1 cm long, whereas their shape changes abruptly on lateral branches. Both pollination and seed dispersal are strictly by wind.

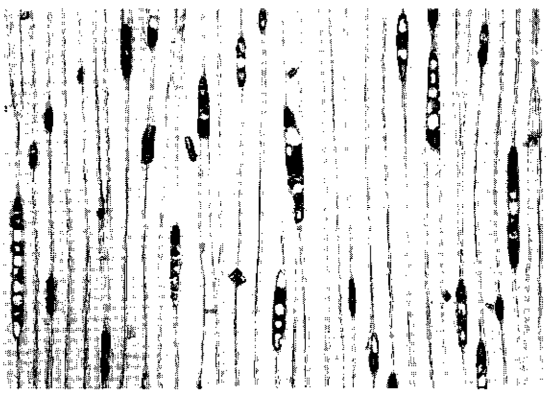
Other botanical information *Libocedrus* is the only genus of the family *Cupressaceae* occurring within the Malesian area. It is most closely related to the Holarctic *Thuja* group of genera. The Holarctic genus *Calocedrus*, which includes the well-known cultivated *C. decurrens* (Torr.) Florin, was included for a long time within *Libocedrus*. The single Malesian species has been separated from its Pacific and South-American relatives and placed in a distinct genus: *Papuacedrus*. However, the distinguishing characters proved



transverse section (×25)



radial section (×75)



tangential section (×75)

Libocedrus papuana

not to be very important and the species were re-united into one genus again.

L. papuana is divided into 2 varieties: var. *papuana* and var. *arfakensis* (Gibbs) de Laubenf. (synonyms: *Libocedrus arfakensis* Gibbs, *Papuacedrus arfakensis* (Gibbs) Li). The latter differs in the shape of the juvenile leaves only. Specimens with only adult leaves cannot be identified at the variety level.

Ecology *Libocedrus* often occurs as an emergent tree in mixed coniferous montane rain forest, especially from 1500 m up to the tree line. It may become dominant locally and is often associated with podocarps or with *Nothofagus* species. Sometimes it occurs as an emerging but stunted tree of less than 10 m tall in alpine shrub vegetation up to 3800 m altitude; occasionally as low as 620 m along the north coast of New Guinea. In New Guinea, it forms a characteristic element of the high mountain forest at around 3000 m altitude, together with other conifers.

Harvesting In the montane zones pit-saw teams convert logs of *Libocedrus* into boards and these are used to construct government buildings in these remote areas.

Genetic resources No efforts are being undertaken to preserve the genetic variability of *L. papuana*. It does not yet seem to be subject to genetic erosion, as it occurs particularly in remote mountainous areas which are often inaccessible for forest exploitation.

Prospects The montane *Podocarpaceae-Nothofagus* forest of New Guinea, in which *Libocedrus* usually occurs, is potentially of economic importance as the softwoods are of good quality and *Nothofagus* yields an excellent hardwood. The major problem until now has been the access to this forest type.

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Other selected sources 55, 280, 355, 528, 715.

E. Boer (general part),
M.S.M. Sosef (general part),
S.I. Wiselius (properties),
J. Ilic (wood anatomy)

Lithocarpus Blume

Bijdr. fl. Ned. Ind.: 526 (1826).
FAGACEAE
x = unknown; $2n$ = unknown

Trade groups Mempening: medium-weight to heavy hardwood, e.g. *Lithocarpus celebicus* (Miq.) Rehder, *L. elegans* (Blume) Hatus. ex Soepadmo, *L. sundaicus* (Blume) Rehder.
Timber of *Lithocarpus* spp. is usually traded together with that of *Quercus* spp. In Papua New Guinea, the timber of *Castanopsis* is traded together with that of *Lithocarpus*.

Vernacular names Mempening: spike oak, sunda oak (En). Indonesia: pasang (general). Philippines: oak (general). Papua New Guinea: New Guinea oak. Thailand: ko, ko muu. Vietnam: s[ox]i.

Origin and geographic distribution *Lithocarpus* consists of over 300 species and occurs from north-eastern India and Nepal to China, Taiwan and southern Japan, south to Indo-China and Thailand, and throughout the Malesian area except for eastern Java and the Lesser Sunda Islands, east towards the Louisiade Archipelago; a single species occurs in the western United States. Within the Malesian area a total of 104 species occur, the majority in the west: Peninsular Malaysia 38 species, Sumatra 29, Java 13, Borneo 50, Sulawesi 4, the Moluccas 1, the Philippines 19, and New Guinea 9.

Uses Mempening is suitable for medium to heavy construction, but preservative treatment is a prerequisite for permanent structures. It is used for house and bridge construction (beams, columns, planks), railway sleepers, fence posts, tool handles, and rice pounders, and also for furniture, flooring and decorative interior finishing like panelling, ceiling and skirting and for the production of veneers. Wood of *Lithocarpus* spp. is suitable for the preparation of pulp and paper. It is a good firewood and is suitable for making charcoal.
The nuts of several species are eaten. The bark contains tannin and is occasionally used to tan leather and also to dye rattan and cotton brown. Several species are used as bed logs in shiitake mushroom (*Lentinus edodes*) cultivation.

Production and international trade In South-East Asia, *Lithocarpus* timber is traded together with that of *Quercus*. The latter probably constitutes only a minor part of the total amount. In 1987, the export of mempening round logs from Sabah was about 650 m^3 with a value of US$ 45 000, but in 1992 the export had increased considerably to 12 750 m^3 (17% as sawn timber and 83% as logs) with a total value of US$ 1.1 million (US$ 187/m^3 for sawn timber, US$ 70/m^3 for logs). The wood, however, is mostly consumed locally. Japan imports comparatively small amounts of mempening, mainly from Sabah and Sarawak. In Papua New Guinea, *Lithocarpus* timber is traded together with that of *Castanopsis* as Papua New Guinea oak. It commands high prices and the export of logs has been banned.

Properties Wood of *Lithocarpus* is medium-weight to heavy and moderately hard to hard. The heartwood is greyish-brown to brown or brown-red to pinkish-brown, sometimes with a yellow tinge, the sapwood is brown or pale brown to straw-coloured. The density is (510–)600–1000 (–1105) kg/m^3 at 15% moisture content. The grain is straight to slightly wavy, sometimes interlocked, texture slightly coarse to coarse and uneven.
At 18% moisture content, the modulus of rupture of *L. sundaicus* wood is 115 N/mm^2, modulus of elasticity 19 400 N/mm^2, compression parallel to grain 61.5 N/mm^2, shear 13 N/mm^2, cleavage 51 N/mm radial and 77 N/mm tangential, and Janka side hardness 7830 N.
The rates of shrinkage are high: for *L. sundaicus*

wood in Malaysia from green to 15% moisture content 1.9% radial and 4.2% tangential. The timber seasons fairly slowly and must be carefully stacked to avoid serious defects. It is particularly prone to splitting and fungal staining during seasoning. Kiln drying is fairly easy as long as slow schedules are used; some warping and splitting may occur.

Lithocarpus timber is easy to slightly difficult to saw into boards while green and slightly difficult when air dry. Cross cutting is easy when green and slightly difficult when air dry. Planing and boring are easy in both lengthwise sawn and cross-cut material but sharp edges are important. Turning is difficult and yields a rough finish. Preboring is advised in nailing as the timber is prone to splitting. The wood is resistant to abrasion. The timber takes a good varnish, paint and polish and requires little filling. A test on a single log of an unidentified *Lithocarpus* species from Malaysia showed that peeling poses no difficulty as long as the speed is above 30 revolutions per minute, but as the veneer was liable to tear and the glue-bond was poor, plywood production could not be recommended. Veneer from *L. sundaicus*, however, can be glued with urea-formaldehyde and produces a plywood complying with the Japanese standard. Trials conducted with *L. ewyckii* and *L. falconeri* (Kurz) Rehder (a small tree of southern Burma (Myanmar), peninsular Thailand and Peninsular Malaysia) indicated that the wood is suitable for the preparation of pulp and paper.

Lithocarpus timber is rated as moderately durable; stake tests show an average service life in contact with the ground of 3.7 years under tropical conditions. The treatability of the sapwood with preservatives is rated as moderately resistant, heartwood is resistant to impregnation. Treatment of *L. sundaicus* with Wolman salt gives an absorption of 80–160 kg/m^3.

Lithocarpus wood contains 72.5–78% holocellulose, 47–56.5% α-cellulose, 20.5–27% lignin, 13.5–15% pentosan, 0.3–0.7% ash and c. 0.3% silica. The solubility is 0.6–2.4% in alcohol-benzene, c. 1.5% in cold water, 1.6–5.9% in hot water and 10.1–15.0% in a 1% NaOH solution. The energy value of *L. sundaicus* wood is approximately 19 200 kJ/kg.

The air-dried bark of *L. sundaicus* contains 15–22% tannin, rarely less.

Description Monoecious evergreen (in Malesia) small to large trees up to 45(–52) m tall; bole up to 100(–150) cm in diameter, occasionally with thick, often steep buttresses up to 2.5(–4) m high, or stilt-rooted; bark surface smooth to fissured, sometimes scaly, lenticellate, usually grey-brown, inner bark with broad hard rays penetrating the cambium. Leaves arranged spirally, simple, margin entire, usually leathery, glabrous to densely pubescent or tomentose at least below; petiole thickened; stipules extrapetiolar, caducous. Inflorescence male, female or mixed, spicate, rigid and erect; male inflorescence solitary in the axil of lower leaves or in paniculate clusters on lateral or subterminal shoots, simple or branched; female or mixed inflorescence solitary in the axil of higher leaves or on the upper part of the paniculate cluster; mixed inflorescence with the male flowers in the upper part and female ones in the lower part. Male flowers solitary or in clusters of 3–7(–30) along the rachis; perianth segments (4–)6(–7), connate at base; stamens (8–)12(–15), with slender filaments and dorsifixed anthers; pistillode present, hairy. Female flowers solitary or in dichasial clusters of 3–7(–15) along the rachis; perianth segments 6, connate at base; staminodes 10–12; ovary inferior, with as many cells as the styles, styles 3–6(–15), more or less connate at base, stigmas punctiform. Cupules solitary or in dichasial clusters, one below each female flower, cup- or saucer-shaped to almost globular and then enclosing almost the entire fruit, variously lamellate, squamose, tuberculate or muricate but never spiny. Fruit an indehiscent nut (acorn), 1 per cupule, round in cross-section, glabrous to densely tomentose, apex umbonate, the umbo without rings. Seed 1, exalbuminous; cotyledons flat-convex. Seedling with hypogeal germination; leaves arranged spirally or sometimes the first 2 opposite, usually open and flat rather than conduplicate, usually replaced by scales at the first few nodes.

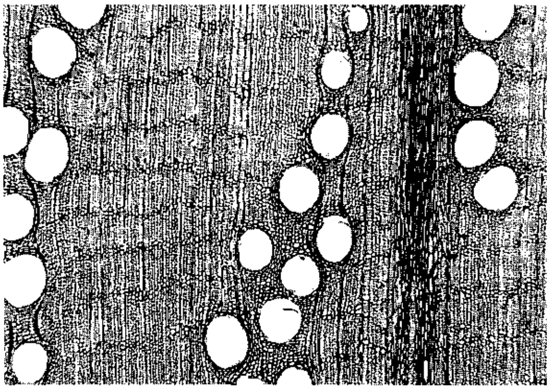
Wood anatomy

– Macroscopic characters:

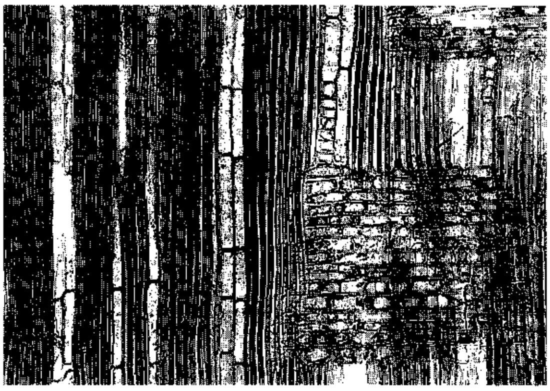
Heartwood greyish-brown to brown or brown-red to pinkish-brown, sometimes with a yellow tinge, indistinctly to distinctly demarcated from the brown or pale brown to straw-coloured sapwood. Grain straight to slightly wavy, sometimes interlocked. Texture slightly coarse to coarse; wood moderately lustrous. Growth rings usually indistinct; vessels visible to the naked eye; parenchyma usually visible without a lens; rays of 2 distinct sizes, the smaller ones visible only with a lens; ripple marks absent.

– Microscopic characters:

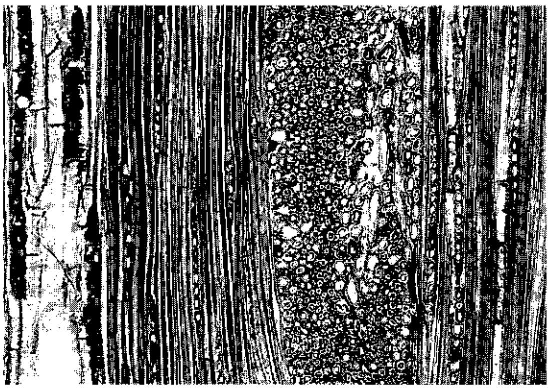
Growth rings often indistinct, in some species distinct and wavy, marked by differences in fibre



transverse section (×25)



radial section (×75)



tangential section (×75)

Lithocarpus solerianus

wall thickness. Vessels diffuse, in a diagonal to radial pattern, (6–)10(–16)/mm^2, almost exclusively solitary, round to oval, tangential diameter (60–)150(–250) μm; perforations simple; intervessel pits non-vestured, opposite to alternate, round to oval, 5–8 μm; vessel-ray and vessel-parenchyma pits large and simple and often elongated; helical thickenings and deposits absent; tyloses usually present. Vasicentric tracheids common. Fibres c. 1580 μm long, non-septate, medium thick-walled to very thick-walled (variable within and between species), with simple to minutely bordered pits mainly confined to the radial walls. Parenchyma apotracheal, rather abundant, in narrow wavy bands of 1 cell wide, in (5–)8(–11)-celled strands. Rays of 2 distinct sizes: uniseriate (to rarely biseriate) rays c. 8/mm and c. 0.4 mm high, homocellular; wide rays 0.4/mm, up to 13–15(–40)-seriate and up to 8.5 mm high, homocellular. Prismatic crystals present in chambered ray and axial parenchyma cells. Silica inclusions and intercellular canals not observed.

Species studied: *L. celebicus*, *L. edulis* (Makino) Rehder, *L. neorobinsonii* A. Camus, *L. sundaicus*.

Growth and development Germination varies between the species and takes place 1–9 months after sowing. During germination, the fruit wall and testa remain persistent around the well-developed cotyledons. The taproot develops into a sturdy root system. The young leaves are open and flat, hence not conduplicate.

L. korthalsii develops according to the architectural tree model of Rauh, i.e. a monopodial trunk which grows rhythmically and develops tiers of branches, with branches morphogenetically identical to the trunk.

In montane forest of West Java, naturally regenerated mempening was 3–4 m tall 5 years after selective cutting. In an experiment with *Lithocarpus* in the Philippines, the height increment of coppice shoots was 0.8–1.4 m in 3 years.

In Borneo, *Lithocarpus* generally flowers early in the dry season which seems to maximize pollination as it coincides with the peak of the insect population. Mature fruits are found 7–8 months after flowering; for *L. sundaicus* in Peninsular Malaysia after only about 4 months. New leaves are produced in distinct flushes. Seeds are eaten by all kinds of animals. Like all *Fagaceae*, *Lithocarpus* has a symbiotic relationship with ectomycorrhizae.

Other botanical information *Lithocarpus* was formerly considered as a part of the genus *Quercus*, because of the similar cupules. This similarity is, however, due to convergent evolution. In *Quercus* a cupule develops below a 3-flowered dichasium (a dichasium cupule) but the 2 lateral flowers are atrophied, resulting in a solitary flower in the cupule. Within *Lithocarpus* a cupule develops below each female flower of the 3–7-flowered dichasium (a flower cupule). In some species the lateral flowers atrophy, resulting in a solitary flower that is very similar to, but ontogenetically different from that of *Quercus*. *Quercus* and *Lithocarpus* are currently considered as evolutionarily far apart and are assigned to different subfamilies. Apart from this, *Lithocarpus* differs from *Quercus* by its uni- or bisexual inflorescences, its erect male inflorescences, and its male flowers with usually 12 stamens and dorsifixed small anthers. *Quercus* has unisexual inflorescences, pendulous male inflorescences, and male flowers with 6 stamens and basifixed large anthers.

Ecology Within the Malesian area, the species of *Lithocarpus* occur scattered, mainly in evergreen lowland to montane rain forest at (0–)300–1500(–3000) m altitude. They are characteristic elements of the lower montane and mid-montane forest, often together with *Quercus* or, in New Guinea with *Castanopsis*. They are generally found in areas with a perhumid climate, rarely (e.g. *L. sundaicus* in Central and East Java) in regions with a slightly seasonal climate. The species occur on a wide variety of soil types including limestone, peat, podzolic soils and quartzite ridges. *Lithocarpus* species are not resistant to fire.

Propagation and planting Mempening can be propagated by seed, although seed viability is generally poor and seed cannot be stored for longer than a month. The number of dry seeds per kg is 200–450 for *L. elegans*, about 135 for *L. indutus*, about 275 for *L. pseudomoluccus*, and 185–350 for *L. sundaicus*. Germination rates are 5–20% in 1–4 months for *L. elegans*, 15–25% in 1–4 months for *L. ewyckii* and 15% in about 6 months for *L. gracilis*. Seed of *L. cyclophorus* germinates in 5–8 months, seed of *L. lucidus* in 4–9 months. Peeling the fruits may enhance germination. Seedlings should be 25–30 cm tall at the moment of planting. Direct sowing in cleared areas is also practised.

Silviculture and management Natural regeneration of mempening after selective cutting is satisfactory, but never profuse, accounting for only a minor part of the commercially interesting tree species in montane forest. The occurrence of small open areas of 300–500(–1000) m^2 most favours natural regeneration. Much seed is eaten by animals or destroyed by larvae, as fallen seed may take some months to germinate.

Coppicing experiments in the Philippines revealed that regeneration of local *Lithocarpus* species is very feasible; stumps of 5–40 cm diameter all sprouted satisfactorily with 4–11 sprouts per stump.

Diseases and pests Many animals feed on the fruits, thus limiting the possibilities of natural regeneration in silvicultural management.

Harvesting Mempening is harvested by selective cutting systems, as the trees occur scattered, and since mountainous forest is often protected for erosion control and watershed management.

The bark can be removed from the bole easily.

Yield No plantation trials have been set up. An 8 m tall *L. sundaicus* tree with a diameter at breast height of 12 cm yields an average of 3.5 kg bark for tannin production.

Handling after harvest The timber should be treated with anti-stain chemicals immediately after sawing.

Genetic resources No germplasm or seedbank activities for Malesian *Lithocarpus* species are known to exist. In general, the species are not liable to genetic erosion, as their economic importance and hence the amount harvested is generally small, with the possible exception of Papua New Guinea and/or Sabah. For some of the rarer species, however, forest conversion or indiscriminate forest exploitation may be a threat to their genetic diversity.

Prospects Very little is known on the cultivation of mempening in South-East Asia, and *Lithocarpus* does not seem to have prospects as a timber plantation tree. Its utilization as part of the natural forest by harvesting through selective cutting systems is not expected to change drastically in the near future. However, its importance in sustainable management of mountainous forest may increase, thus warranting further investigation.

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Selection of species

Lithocarpus andersonii Soepadmo

Reinwardtia 8: 215, fig. 10 (1970).

Distribution Borneo (Sarawak, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 27 m tall, bole up to 60 cm in diameter, occasionally stilt-rooted up to 1.8 m tall, bark surface smooth, pale grey; leaves elliptical, (6–)7–10(–11.5) cm × (2–)2.5–3.5(–5) cm, long acuminate, the surfaces concolourous, glabrous above, sparsely stellate tomentose below, with 9–11 pairs of secondary veins obscure to rather prominent below, reticulation areolate and obscure, petiole 5–8 mm long; male flowers in clusters of 3, female flowers solitary; cupule sessile or on a stalk up to 4 mm long, saucer-shaped, 15–22 mm across, covering the basal part of the nut, lamellate, densely stellate hairy; nut ovoid-conical, glabrous, for the greater part free from the cupule. *L. andersonii* is found in peat-swamp forest at low altitude.

Selected sources 162, 583.

Lithocarpus apoensis (Elmer) Rehder

Journ. Arn. Arb. 1: 123 (1919).

Synonyms *Quercus apoensis* Elmer (1910).

Vernacular names Philippines: apo oak (En), ulayan (Bagobos).

Distribution The Philippines.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 25 m tall, bole up to 130 cm in diameter, bark surface finely fissured, pale grey; leaves elliptical to elliptical-ovate, (12–)15–17(–22) cm × (5–)6–8(–10) cm, apex bluntly acute to distinctly acuminate, the surfaces discolourous, glabrous above, densely glaucous tomentose below, with (7–)8–9(–10) pairs of secondary veins prominent below, reticulation subscalariform and obscure to distinct below, petiole 1–2 cm long; male flowers solitary or in clusters of 2–3, female flowers solitary or in clusters of 3; cupule subsessile, cup-shaped, 2–2.5 cm across, covering the lower quarter of the nut, with 7–9 lamellae, densely hairy; nut ovoid, densely tomentose, for the greater part free from the cupule. *L. apoensis* is found in montane forest up to 1700 m altitude.

Selected sources 83, 162, 544, 583.

Lithocarpus bancanus (Scheff.) Rehder

Journ. Arn. Arb. 10: 132 (1929).

Synonyms *Quercus bancanus* Scheff. (1870), *Lithocarpus rajah* (Hance) A. Camus (1932), *Lithocarpus scyphigera* (Hance) A. Camus var. *riedelii* (King) A. Camus (1954).

Distribution Peninsular Malaysia, Sumatra, Borneo (Sarawak, Brunei, Kalimantan) and intermediate islands.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 27 m tall, bole up to 60 cm in diameter, bark surface smooth to finely scaly, yellowish-brown to greyish-brown, inner bark fibrous, dull brown; leaves elliptical, (9–)12–14(–17) cm × (4–)5–6(–7) cm, bluntly to sharply acuminate, the surfaces discolourous, glabrous above, minutely tomentose below, with 9–13(–16) pairs of secondary veins obscure on both surfaces, reticulation obscure, petiole 0.5–1.3 cm long; male and female flowers solitary; cupule sessile, saucer-shaped, 1.5–2.1 cm across, covering the base of the nut, with 4–8 lamellae, stellate hairy; nut ovoid, densely tomentose, for the greater part free from the cupule. *L.*

bancanus is uncommon in lowland forest up to 250 m altitude.

Selected sources 162, 583, 705.

Lithocarpus beccarianus (Benth.) A. Camus

Riviera Scient. 18: 39 (1932).

Synonyms *Quercus beccariana* Benth. (1880), *Pasania beccariana* (Benth.) Prantl (1889), *Synaedrys beccariana* (Benth.) Koidz. (1916).

Distribution Borneo (Sabah, Sarawak, Kalimantan).

Uses The wood has probably been used as mempening for house construction.

Observations A medium-sized tree up to 30 m tall, bole up to 70 cm in diameter, bark surface smooth to scaly, greyish-brown to dark brown; leaves elliptical to narrowly elliptical, apex abruptly acute to acuminate, the surfaces discolourous, glabrous above, densely tomentose below, with (5–)7–8(–9) pairs of secondary veins prominent below, reticulation scalariform and distinct below, petiole 1–2 cm long; male flowers solitary or in clusters of 3, female flowers solitary; cupule on a stalk 1–1.5 cm long, ellipsoid, up to 6 cm across, covering the nut completely, longitudinally ridged and with 5–8 undulating lamellae, densely shortly tomentose; nut ellipsoid, densely tomentose, for the greater part adnate to the cupule. *L. beccarianus* occurs scattered in forest up to 1500 m altitude, found on dark brown sandstone-derived soils.

Selected sources 162, 234, 583.

Lithocarpus bennettii (Miq.) Rehder

Journ. Arn. Arb. 1: 123 (1919).

Synonyms *Quercus bennettii* Miq. (1856), *Quercus miqueliana* Scheff. (1870), *Pasania bennettii* (Miq.) Gamble (1915).

Vernacular names Indonesia: pasang-pasang suluh (Sumatra). Malaysia: mempening bagan (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra, Bangka and Borneo.

Uses The wood is used as mempening, e.g. for house construction, furniture and interior finish.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 100 cm in diameter, sometimes with low buttresses or stilt roots, bark surface smooth to fissured, grey-brown, inner bark fibrous inwards, granular outwards, dull brown to red; leaves narrowly elliptical, (7–)9–12(–15) cm × (2.5–)3–5(–6) cm, apex bluntly to sharply and long acuminate, the surfaces discolourous, glabrous above, densely glaucous tomentose below, with 9–13 pairs of thin secondary veins prominent below, reticulation subscalariform, obscure, petiole 0.5–1.5 cm long; male flowers solitary or in clusters of 2–3, female flowers solitary; cupule short-stalked, saucer-shaped, 1–2 cm across, covering the basal part of the nut, with 5–7 lamellae, densely stellate hairy; nut ovoid-conical, glabrous, for the greater part free from the cupule. *L. bennettii* is fairly common in lowland and lower montane forest, sometimes in swamp forest, heath forest or mixed dipterocarp forest, on various soil types, up to 1000(–1500) m altitude. The wood is heavy and hard and has a density of 900–1105 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 83, 104, 140, 162, 234, 330, 583, 705.

Lithocarpus cantleyanus (King ex Hook.f.) Rehder

Journ. Arn. Arb. 10: 132 (1929).

Synonyms *Quercus cantleyana* King ex Hook.f. (1888), *Pasania cantleyana* (King ex Hook.f.) Gamble (1915), *Synaedrys cantleyana* (King ex Hook.f.) Koidz. (1916).

Distribution Peninsular Malaysia, Singapore and Borneo (Sabah, Sarawak, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 120 cm in diameter, often fluted, sometimes with small buttresses, bark surface rugose, sometimes shallowly fissured and flaking, grey or greyish-brown, inner bark often fibrous, red-brown to pink; leaves elliptical to elliptical-obovate, (10–)14–18(–25) cm × (4–)5–6(–8) cm, apex acuminate, the surfaces discolourous, glabrous above, densely glaucous tomentose below, with 11–17 pairs of secondary veins, reticulation scalariform and distinct below, petiole 1–1.5 cm long; male flowers in clusters of 3, female flowers solitary or in clusters of 3–5; cupule short-stalked, cup-shaped, 1.5–2.3 cm across, covering the basal part of the nut, with 5–8 lamellae, densely stellate hairy; nut depressed-ovoid, densely tomentose but glabrescent, for the greater part free from the cupule. *L. cantleyanus* is locally common in primary lowland forest, up to 850 m altitude, occasionally on river banks, and on sandy clayey or ultrabasic soils.

Selected sources 78, 83, 99, 162, 583, 705.

Lithocarpus caudatifolius (Merr.) Rehder

Journ. Arn. Arb. 1: 123 (1919).

Synonyms *Quercus caudatifolius* Merr. (1908), *Lithocarpus minahassae* (Koord. ex Elmer) Rehder (1929), *Lithocarpus bulusanensis* (Elmer) A. Camus (1948).

Vernacular names Philippines: katabang (Tagalog), Minahassa oak (En), tikalod (Bikol).

Distribution Borneo (Sabah, Kalimantan) and the Philippines.

Uses *L. caudatifolius* is a minor source of mempening timber.

Observations A medium-sized tree up to 30 m tall, bole up to 80 cm in diameter, sometimes with small buttresses, bark surface scaly, greyish-brown; leaves narrowly elliptical, (6–)10–14(–17) cm × (2–)3–6(–9) cm, apex caudate-acuminate, the surfaces discolourous, glabrous above except for the midrib and secondary veins, with (7–)8–10(–11) pairs of secondary veins prominent below, reticulation subscalariform and obscure, petiole 0.5–1.5 cm long; male flowers in clusters of 3–5 or rarely solitary, female flowers solitary; cupule sessile to short-stalked, cup- to saucer-shaped, 1.2–2.0 cm across, covering the basal part of the nut, with 5–6 lamellae, densely tomentose; nut ovoid-conical, densely tomentose, for the greater part free from the cupule. *L. caudatifolius* is locally common in primary and secondary forest, on hills and ridges but also on level or swampy locations near rivers, on sandy, clayey or basalt-derived soils, up to 1350 m altitude.

Selected sources 83, 162, 527, 583.

Lithocarpus celebicus (Miq.) Rehder

Journ. Arn. Arb. 1: 123 (1919).

Synonyms *Lithocarpus llanosii* (A.DC.) Rehder (1919), *Lithocarpus papuana* (Warb.) Rehder (1929), *Lithocarpus mabesae* (Merr.) A. Camus (1945).

Vernacular names Philippines: Celebes oak, Mabesa oak (En), ulaian (general).

Distribution The Philippines, Sulawesi, the Moluccas and New Guinea.

Uses The wood is used as mempening. The nuts are edible.

Observations A medium-sized tree up to 33 m tall, bole up to 100 cm in diameter, with buttresses up to 1 m high, bark surface fissured to scaly, grey-brown; leaves narrowly elliptical to narrowly elliptical-ovate, (8–)12–16(–20) cm × (3–)4–6(–8) cm, apex abruptly to gradually acuminate, the surfaces dicolorous, sparsely pubescent but glabrescent above, thinly stellate hairy below, with (6–)8–10(–12) pairs of secondary veins flat on both surfaces, reticulation subscalariform, obscure, petiole 0.5–1.0 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule sessile to shortly stalked, cup-shaped, 2–3 cm across, covering the basal quarter of the nut, set with scales in concentric rows or imbricate, densely stellate hairy; nut ovoid-conical, glabrous, for the greater part free from the cupule. *L. celebicus* is locally common in lowland and lower montane forest, on clayey soils, up to 800(–1200) m altitude. The density of the wood is 810–940 kg/m^3 at 15% moisture content.

Selected sources 145, 162, 474, 527, 544, 583.

Lithocarpus clementianus (King ex Hook.f.) A. Camus

Riviera Scient. 18: 40 (1932).

Synonyms *Quercus clementiana* King ex Hook.f. (1888), *Pasania clementiana* (King ex Hook.f.) Gamble (1915), *Synaedrys clementiana* (King ex Hook.f.) Koidz. (1916).

Vernacular names Malaysia: Clementi's oak (En).

Distribution Peninsular Malaysia and Borneo (Sabah, Sarawak).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 70 cm in diameter, bark surface deeply fissured, brownish, inner bark fibrous, dark brown; leaves narrowly elliptical to narrowly elliptical-ovate, (10–)12–16(–20) cm × (3–)4–5(–7) cm, apex acuminate, the surfaces discolourous, glabrous above, densely tomentose below, with 10–14 pairs of secondary veins prominent below, reticulation subscalariform, obscure, petiole 0.5–1 cm long; male flowers in clusters of 3–7, female flowers solitary or in clusters of 2–3; cupule sessile, cup-shaped, 2.5–3 cm across, covering the basal part of the nut, with 6–8 lamellae, sparsely stellate hairy; nut depressed subglobose, glabrous, for the greater part free from the cupule. *L. clementianus* is uncommon but may be locally common in forest at 600–1900 m altitude.

Selected sources 104, 162, 583, 705.

Lithocarpus confragosus (King ex Hook.f.) A. Camus

Riviera Scient. 18: 40 (1932).

Synonyms *Quercus confragosa* King ex Hook.f. (1888), *Pasania confragosa* (King ex Hook.f.) Schottky (1912).

Distribution Peninsular Malaysia, northern Sumatra and Borneo (Sabah, Sarawak, Nunukan Island).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 30 m tall, bole up to 100 cm in diameter, bark surface smooth to scaly, pale brown to greyish-brown, inner bark pale pink; leaves elliptical to narrowly elliptical, (10–)12–20(–30) cm × (3.5–)5–8(–13) cm, apex acute to acuminate, the surfaces concolorous, glabrous above, densely tomentose below, with (5–)6–8(–10) pairs of secondary veins prominent below, reticulation subscalariform, obscure, petiole 1–2 cm long; inflorescence unknown; cupule sessile or on a stalk up to 1 cm long, depressed ovoid-globose, 3–5.5 cm across, covering the nut almost completely, irregularly set with short rounded to pointed tubercles; nut depressed ovoid-globose, densely tomentose, for the greater part free from the cupule. *L. confragosus* is rare but occurs frequently in Sabah. It is found scattered in lowland to montane forest, sometimes on yellowish-brown sandy soils, up to 2000 m altitude.

Selected sources 83, 99, 162, 583, 705.

Lithocarpus conocarpus (Oudem.) Rehder

Journ. Arn. Arb. 1: 123 (1919).

Synonyms *Quercus conocarpa* Oudem. (1861), *Pasania conocarpa* (Oudem.) Schottky (1913), *Synaedrys conocarpa* (Oudem.) Koidz. (1916).

Vernacular names Indonesia: pasang ijang (general). Malaysia: Singapore oak (En).

Distribution Peninsular Malaysia, Singapore, Sumatra, western Java and Borneo.

Uses The wood has been used as mempening, e.g. for house building.

Observations A large tree up to 45 m tall, bole up to 100 cm in diameter, bark surface greyish-brown, inner bark pink; leaves narrowly elliptical to narrowly elliptical-obovate, (6–)8–12(–14) cm × (2–)3–4(–5.5) cm, apex acute to acuminate, the surfaces discolourous, sparsely stellate hairy especially on the midrib above, densely stellate hairy below, with 9–12(–15) pairs of secondary veins prominent below, reticulation subscalariform, distinct below, petiole 0.5–1 cm long; male flowers in clusters of 2–3, female flowers solitary or rarely in clusters of 2–3; cupule on a stalk 3–8 mm long, cup-shaped, 1.6–2.0 cm across, covering the basal part of the nut, with 6–7 lamellae, densely stellate hairy; nut ovoid-conical, densely tomentose but subglabrescent, for the greater part free from the cupule. *L. conocarpus* is quite common in Borneo but rare in the other areas. It occurs in lowland to montane forest, up to 1800 m altitude. The wood is reported to be liable to split and not durable and has a density of 820–1040 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 83, 99, 104, 162, 234, 474, 583, 705.

Lithocarpus coopertus (Blanco) Rehder

Journ. Arn. Arb. 1: 124 (1919).

Synonyms *Quercus cooperta* Blanco (1845), *Lithocarpus boholensis* (Merr.) Rehder (1929), *Lithocarpus reflexa* (King) A. Camus (1932).

Vernacular names Philippines: barusang (Tagalog), Bohol oyagan (Filipino), dalutan (Iloko).

Distribution Peninsular Malaysia, Borneo (Sabah, Brunei, Sarawak) and the Philippines.

Uses The wood is used as mempening, e.g. for house construction; it is also used as firewood.

Observations A large tree up to 45 m tall, bole up to 70 cm in diameter, with buttresses up to 2 m high, bark surface smooth to flaky, greyish-brown, inner bark granular, deep red; leaves elliptical to narrowly elliptical, (5–)10–14(–17) cm × (2–)4–6 (–7) cm, apex acute to acuminate, the surfaces discolourous, glabrous above, densely tomentose below, with (10–)12–14(–16) pairs of secondary veins prominent on both sides, reticulation scalariform, obscure, petiole 4–6 mm long; male flowers solitary or rarely in clusters of 2–3, female flowers solitary; cupule subsessile, ovoid-conical, 1.5–2.5 cm across, covering the nut completely, irregularly set with recurved spines, densely tomentose; nut ovoid-conical, densely tomentose, for the greater part free from the cupule. *L. coopertus* is found in lowland and montane forest, up to 1800 m altitude, usually on rich yellowish sandy soils, occasionally in peat-swamp or heath forest. The density of the wood is 830–910 kg/m^3 at 15% moisture content.

Selected sources 77, 83, 162, 474, 583, 705.

Lithocarpus curtisii (King ex Hook.f.) A. Camus

Riviera Scient. 18: 40 (1932).

Synonyms *Quercus curtisii* King ex Hook.f. (1888), *Pasania curtisii* (King ex Hook.f.) Gamble (1915), *Synaedrys curtisii* (King ex Hook.f.) Koidz. (1916).

Vernacular names Malaysia: mempening gajah (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 27 m tall, bole up to 60 cm in diameter, with buttresses, bark surface pale grey, inner bark fibrous, brown to red-brown; leaves narrowly elliptical to narrowly elliptical-ovate, (12–)15–22(–24) cm × (4–)5–7 (–10) cm, apex long acuminate, the surfaces concolourous, glabrous above, densely tomentose below, with 9–11 pairs of secondary veins prominent below, reticulation subscalariform to irregular, obscure, petiole 0.5–1 cm long; male flowers solitary or rarely in clusters of 2–3, female flowers solitary; cupule sessile, saucer-shaped, 2.0–2.7 cm across, covering the basal part of the nut, appressed scaly, densely stellate hairy; nut ovoid-globose, densely tomentose, for the greater part free from the cupule. *L. curtisii* occurs in lowland forest, on clayey soils, up to 300 m altitude.

Selected sources 162, 583, 705.

Lithocarpus cyclophorus (Endl.) A. Camus

Riviera Scient. 18: 40 (1932).

Synonyms *Quercus cyclophora* Endl. (1847), *Quercus penangensis* Miq. (1856), *Lithocarpus pseudoplatycarpus* A. Camus (1932).

Vernacular names Indonesia: pasang simpenu (Sumatra). Malaysia: berangan hutan, mempening merah (Peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore and Sumatra.

Uses The wood is used as mempening, e.g. for tool handles, rice pounders and general construction.

Observations A large tree up to 45 m tall, bole up to 120 cm in diameter, with buttresses up to 2 m high, bark surface deeply fissured and often flaking along the ridges, dark red-brown, inner bark fibrous, red to orange-red; leaves elliptical-oblong, (18–)20–25(–31) cm × (6–)7–9(–12) cm, apex broadly acuminate, the surfaces discolourous, glabrous above, densely stellate hairy below, with (9–)14–17(–20) pairs of secondary veins prominent below, reticulation scalariform, distinct below, petiole 1–2 cm long; male flowers in clusters of 3, female flowers solitary or in clusters of 2–3; cupule sessile, broadly obconical to cup- or saucer-shaped, 4–6 cm across, covering one third to half of the nut, with 8–10 lamellae, densely stellate hairy; nut broadly depressed subglobose, densely tomentose, for the greater part free from the cupule. *L. cyclophorus* is rather common in primary and secondary forest at 150–1500 m altitude. The wood is reported to split easily and to be non-durable.

Selected sources 78, 83, 104, 162, 234, 583, 705.

Lithocarpus daphnoideus (Blume) A. Camus

Riviera Scient. 18: 40 (1932).

Synonyms *Lithocarpus poculiformis* (von Seemen) A. Camus (1932), *Lithocarpus sarawakensis* E.F. Warb. (1936), *Lithocarpus nitida* (Blume) A. Camus (1945).

Vernacular names Indonesia: pasang minyak, pasang kayang (Sundanese, Java).

Distribution Peninsular Malaysia, Sumatra, western Java and Borneo (Sarawak, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 31 m tall, bole up to 80 cm in diameter, often with small buttresses, bark surface smooth, grey, inner bark red-brown to fawn; leaves elliptical-oblong, (7–)10–13(–16) cm × (3–)4–5 cm, apex acute to long acuminate, the surfaces discolourous, glabrous above, densely tomentose below, with (7–)8–11 (–12) pairs of secondary veins prominent below, reticulation subscalariform, distinct below, petiole 0.7–1.2 cm long; male flowers in clusters of 3 or rarely solitary, female flowers solitary or rarely in clusters of 3; cupule sessile, cup-shaped, 2–2.5 cm across, covering the basal part of the nut, with 7–10 lamellae, densely stellate hairy; nut ovoid-conical, densely tomentose, for the greater part free from the cupule. *L. daphnoideus* occurs scattered in lowland and lower montane forest, up to 1350 m altitude. The density of the wood is 550–890 kg/m^3 at 15% moisture content.

Selected sources 83, 162, 303, 474, 583, 705.

Lithocarpus echinifer (Merr.) A. Camus

Bull. Soc. Bot. Fr. 80: 818 (1934).

Synonyms *Quercus echinifera* Merr. (1929).

Distribution Borneo (Sabah, Brunei, Sarawak).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 80 cm in diameter, with buttresses up to 3 m high, bark surface irregularly fissured to flaky, greyish-brown; leaves narrowly elliptical or rarely narrowly elliptical-obovate, (15–)18–25(–30) cm × (5–)7–12(–15) cm, apex acuminate, the surfaces concolourous, glabrous above, densely stellate tomentose below, with (9–)11–12(–13) pairs of secondary veins slightly prominent below, reticulation subscalariform, obscure, petiole 1.5–2.5 cm long; male flowers in clusters of 3–7; cupule subsessile or on a stalk up to 2 cm long, obconical, 3–5 cm across, covering almost the entire nut, set with recurved spines, densely stellate tomentose; nut subhemispherical, with dense stellate hairs, for the greater part adnate to the cupule. *L. echinifer* is found on sandy clayey soils, usually on river banks, up to 1800 m altitude.

Selected sources 99, 162, 583.

Lithocarpus echinulatus Soepadmo

Reinwardtia 8: 235 (1970).

Distribution Borneo (Sabah, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A fairly large tree up to 40 m tall, bole up to 80 cm in diameter, with buttresses up to 2 m high, bark surface smooth, pale greyish-brown; leaves narrowly elliptical, (9–)13–18(–21) cm × (3–)4–6(–7) cm, apex distinctly acuminate, the surfaces concolourous, glabrous above, densely stellate tomentose below, with 7–9 pairs of secondary veins prominent below, reticulation subscalariform, obscure, petiole 0.7–1.5 cm long; inflorescence unknown; cupule sessile, saucer-shaped, 2–2.5 cm across, covering the basal part of the nut, irregularly set with patent spines, densely stellate tomentose; nut depressed ovoid-globose, densely tomentose, for the greater part free from the cupule. *L. echinulatus* occurs scattered in lowland forest, on sandy loamy soils, up to 300 m altitude.

Selected sources 99, 162, 583.

Lithocarpus elegans (Blume) Hatus. ex Soepadmo

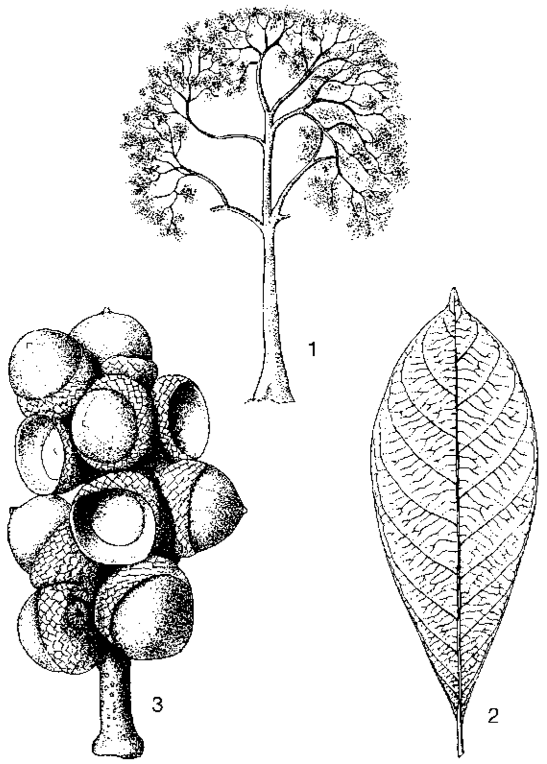
Reinwardtia 8: 236 (1970).

Synonyms *Lithocarpus spicatus* (Sm.) Rehder & Wils. (1917), *Lithocarpus rhioensis* (Hance) A. Camus (1932), *Lithocarpus microcalyx* (Korth.) A. Camus (1945).

Vernacular names Indonesia: pasang bodas (Sundanese, Java), pasang bungkus (Sumatra), kasunu (Sulawesi). Malaysia: mempening bangkas, berangan landak (Peninsular). Burma (Myanmar): thitcha. Thailand: ko mon (northern), ko muu, pit-chui (peninsular). Vietnam: s[oof]i b[oo]ng, d[er] d[or].

Distribution Northern India, Nepal, eastern Pakistan, Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, western Java, Borneo and Sulawesi.

Uses *L. elegans* is an important source of mempening; the wood is also used as firewood and is suitable for making charcoal. The nuts are edible but apparently only rarely eaten.



Lithocarpus elegans (Blume) Hatus. ex Soepadmo – 1, tree habit; 2, leaf; 3, infructescence.

Observations A medium-sized to fairly large tree up to 35 m tall, bole branchless for up to 20 m, up to 90 cm in diameter, sometimes with buttresses up to 1 m high, bark surface deeply fissured, greyish-brown, inner bark fawn; leaves elliptical to elliptical-oblong, (9–)12–17(–20) cm × (3–)4–6(–8) cm, apex acute to acuminate, the surfaces concolourous, glabrous on both sides, with (10–)12–15(–18) pairs of secondary veins prominent below, reticulation subscalariform to irregular, obscure to distinct below, petiole 0.3–2.5 cm long; male flowers in clusters of (3–)7–15(–24), female flowers in clusters of (3–)5–7(–10); cupule sessile or on a stalk up to 5 mm long, cup- to saucer-shaped, (1–)2–3(–3.5) cm across, covering the lower quarter to one third of the nut, set with small spines in more or less concentric rows, with dense stellate hairs; nut ovoid-conical to depressed ovoid-globose, glabrous, for the greater part free from the cupule. *L. elegans* is common occurring generally in lower montane forest, on various types of soil, also in secondary and degraded locations, at (0–)1000–1600(–2400) m altitude. The wood is reported as fairly durable, it splits less easily than that of most other *Lithocarpus* species, and has a density of 720–960 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 83, 104, 162, 218, 234, 303, 403, 465, 474, 508, 574, 583, 705.

Lithocarpus encleisacarpus (Korth.) A. Camus

Riviera Scient. 18: 40 (1932).

Synonyms *Quercus encleisacarpa* Korth. (1844), *Pasania encleisacarpa* (Korth.) Gamble (1915), *Castanopsis encleisacarpa* (Korth.) Rehder (1919).

Vernacular names Indonesia: pasang bungkus beranak (Sumatra). Malaysia: mempening puteh, berangan babi hutan (Peninsular). Thailand: kopaen, ko-mu, ko-hin (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra and Borneo (Sabah, Sarawak).

Uses The wood is used as mempening, e.g. for house construction; it is also used as firewood. The bark contains tannin and is also used to dye rattan and cotton brown.

Observations A large tree up to 50 m tall, bole up to 90 cm in diameter, with small buttresses up to 1 m high, bark surface smooth to scaly, grey, inner bark fibrous, red to brown; leaves elliptical, 12–15 cm × 4–6 cm, apex acute to acuminate, the surfaces discolourous, subglabrous above, densely glaucous stellate hairy below, with (6–)8–10(–12) pairs of secondary veins prominent below, reticulation subscalariform to irregular, distinct below, petiole 0.5–1.3 cm long; male flowers solitary or in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule on a stalk 1–1.5 cm long, ovoid-globose, 2–3 cm across, completely covering the nut or sometimes leaving a small aperture, with 5–7 lamellae, densely stellate tomentose; nut depressed ovoid-globose, densely tomentose, for the greater part free from the cupule. *L. encleisacarpus* is found in lowland and lower montane forest, up to 1300 m altitude. The density of the wood is about 720 kg/m^3 at 15% moisture content.

Selected sources 78, 83, 104, 140, 162, 234, 474, 574, 583, 705.

Lithocarpus ewyckii (Korth.) Rehder

Journ. Arn. Arb. 10: 132 (1929).

Synonyms *Quercus ewyckii* Korth. (1844), *Pasania ewyckii* (Korth.) Gamble (1915), *Lithocarpus pseudolamponga* A. Camus (1949).

Vernacular names Malaysia: berangan bukit (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses The wood is used as mempening.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 100 cm in diameter, with buttresses up to 1.2 m high, bark surface smooth to scaly, hoop-marked, greyish-brown to reddish-brown, inner bark gritty to granular, red or pink to yellow-brown; leaves elliptical to elliptical-oblong, (6–)12–15(–18) cm × (2–)4–6(–7) cm, apex acuminate, the surfaces discolourous, glabrous above, densely stellate tomentose below, with (10–)12–15(–16) pairs of secondary veins prominent below, reticulation scalariform, distinct below, petiole 0.5–1.5 cm long; male flowers solitary or in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule on a stalk 0.5–1 cm long, cup- to saucer-shaped, 2–3 cm across, covering the basal part of the nut, having 6–8 lamellae, with dense stellate hairs; nut ovoid, glabrescent, for the greater part free from the cupule. *L. ewyckii* is fairly common in primary and secondary lowland and montane forest, also in swamp forest, on ridges or rocky locations, up to 1800 m altitude.

Selected sources 78, 83, 99, 162, 465, 583, 705, 722.

Lithocarpus gracilis (Korth.) Soepadmo

Reinwardtia 8: 243 (1970).

Synonyms *Lithocarpus cyrtorhyncha* (Miq.) Rehder (1919), *Lithocarpus diepenhorstii* (Miq.) Barnett (1944), *Lithocarpus cyathiformis* A. Camus (1947).

Vernacular names Malaysia: mempening puteh, berangan babi (Peninsular).

Distribution Peninsular Malaysia, Singapore, southern Sumatra and Borneo.

Uses The wood is used as mempening, e.g. for general construction.

Observations A fairly large tree up to 40 m tall, bole up to 90 cm in diameter, with buttresses up to 1.5 m high, bark surface smooth to finely fissured, rarely scaly, greyish-brown to dark grey-black, inner bark fibrous, yellow-cream darkening to dull red-brown; leaves elliptical to narrowly elliptical, (10–)15–20(–33) cm × (4–)5–8(–13) cm, apex acute to acuminate, the surfaces discolourous, glabrous above, with minute stellate hairs below, with (11–)12–16(–17) pairs of secondary veins prominent on both surfaces, reticulation subscalariform to irregular, distinct below, petiole 0.5–1.0 cm long; male flowers solitary or in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule sessile or on a stalk up to 5 mm long, saucer- to cup-shaped, 2.0–2.7 cm across, covering up to one third of the nut, with 6–8 lamellae, minutely stellate tomentose; nut ovoid-conical, glabrous, for the greater part free from the cupule. *L. gracilis* is fairly common and occurs in primary or sometimes secondary forest, heath forest, on ridges and hills but also along rivers or in flat swampy locations, usually on sandy or rarely on limestone derived soils, up to 1500 m altitude. The density of the wood is 510–720 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 83, 99, 162, 465, 474, 583, 705.

Lithocarpus hallieri (von Seemen) A. Camus

Riviera Scient. 18: 40 (1932).

Synonyms *Quercus hallieri* von Seemen (1906), *Synaedrys hallieri* (von Seemen) Koidz. (1916).

Distribution Borneo (Sabah, Sarawak, western Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized, sometimes large tree up to 25(–48) m tall, bole up to 70 cm in diameter, bark surface smooth to flaky, greyish-brown; leaves elliptical to elliptical-obovate, 15–25(–30) cm × 6–10(–11) cm, apex acute to acuminate, the surfaces concolourous, glabrous above, sparsely to densely stellate tomentose below, with (8–)10–11(–13) pairs of secondary veins prominent below, reticulation subscalariform, obscure on both sides, petiole 1–3 cm long; male inflorescence unknown, female flowers solitary; cupule sessile or on a stalk up to 1 cm long, obovoid-globose, 5–7 cm across, almost completely covering the nut, with 5–7 spiral or rarely concentric lamellae, densely tomentose; nut subglobose, densely tomentose, for the greater part adnate to the cupule. *L. hallieri* occurs scattered in forest, on yellowish sandy soils, up to 1350(–1800) m altitude.

Selected sources 99, 162, 583.

Lithocarpus hystrix (Korth.) Rehder

Journ. Arn. Arb. 1: 127 (1919).

Synonyms *Quercus hystrix* Korth. (1844), *Quercus cryptopoda* Miq. (1858), *Lithocarpus cryptopoda* (Miq.) A. Camus (1949).

Vernacular names Malaysia: mempening merah, pokok mandong (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo (south-eastern Kalimantan).

Uses The wood is used as mempening. The bark contains tannin.

Observations A medium-sized tree up to 30 m tall, bole up to 90 cm in diameter, occasionally stilt-rooted, bark surface pale brown; leaves elliptical to narrowly elliptical, (12–)14–18(–20) cm × (5–)6–7(–8) cm, apex broadly to shortly acuminate, the surfaces discolourous, densely pubescent especially on the main veins above, with dense stellate hairs below, with 12–16 pairs of secondary veins strongly prominent below, reticulation scalariform, distinct below, petiole 0.5–1 cm long; male flowers solitary or in clusters of 2–3, female flowers solitary or rarely in clusters of 2–3; cupule sessile or on a stalk up to 5 mm long, saucer- to cup-shaped, 2–3 cm across, covering the basal part of the nut, set with linear patent to recurved spines, densely stellate tomentose; nut depressed ovoid, glabrous, for the greater part free from the cupule. *L. hystrix* closely resembles *L. sundaicus* and some doubt about its presence in Peninsular Malaysia has arisen. It is frequently found in lowland and lower montane forest, mostly up to 800 m but sometimes ascending to 1800 m altitude. The density of the wood is about 720 kg/m^3 at 15% moisture content.

Selected sources 78, 83, 99, 104, 140, 162, 289, 583.

Lithocarpus indutus (Blume) Rehder

Journ. Arn. Arb. 1: 127 (1919).

Synonyms *Quercus induta* Blume (1823), *Synaedrys induta* (Blume) Koidz. (1916), *Pasania induta* (Blume) S. Moore (1925).

Vernacular names Indonesia: bataruwa, pasang bodas (Sundanese), pasang balung (Javanese).

Distribution Western Java.

Uses The wood is used as mempening, e.g. for house construction. The bark is rich in tannin.

Observations A large tree up to 45 m tall, bole up to 150 cm in diameter, with buttresses, bark surface fissured, dark greyish-brown, inner bark yellowish turning pinkish-red; leaves narrowly elliptical to elliptical-lanceolate, (15–)18–20(–26) cm × (5–)7–9(–11) cm, apex acute to acuminate, the surfaces discolourous, glabrous above, thinly glaucous tomentose with stellate or simple hairs, with (11–)12–14(–15) pairs of secondary veins flat on both surfaces, reticulation subscalariform, distinct below, petiole 1–2 cm long; male and female flowers solitary or in clusters of 2–3; cupule on a stalk 1–1.5 cm long, broadly cup-shaped, 3–4 cm across, covering the basal third to two thirds of the nut, obscurely tuberculate with the tubercles in concentric rows or irregular; nut subhemispherical, densely tomentose, for the greater part free from the cupule. *L. indutus* is rather common in lowland and montane forest at 50–1800 m altitude. The density of the wood is 760–910 kg/m^3 at 15% moisture content.

Selected sources 83, 162, 218, 234, 303, 332, 474, 583.

Lithocarpus javensis Blume

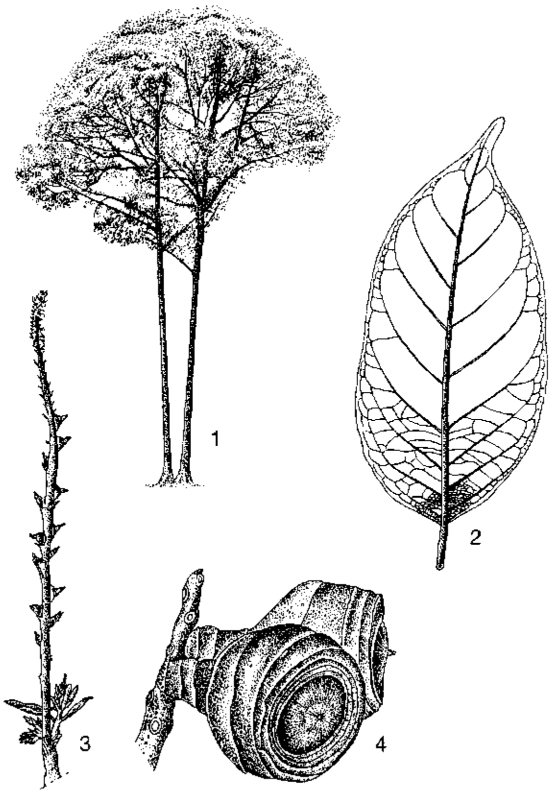
Bijdr. Fl. Ned. Ind.: 527 (1826).

Synonyms *Quercus costata* Blume (1826), *Quercus javensis* (Blume) Miq. (1863), *Lithocarpus costata* (Blume) Rehder (1919).

Vernacular names Indonesia: pasang poh (Javanese), pasang jambe, pasang tangogo (Sundanese).

Distribution Peninsular Malaysia, Sumatra and Java.

Uses The wood is used as mempening, e.g. for general construction. The bark is rich in tannin.



Lithocarpus javensis Blume – 1, tree habit; 2, leaf; 3, branchlet with inflorescence; 4, branchlet with fruits.

Observations A large tree up to 52 m tall, bole straight, up to 100 cm in diameter, with buttresses up to 1.5 m high, bark surface shallowly fissured, greyish, inner bark dirty white soon darkening to pinkish-brown or deep red; leaves elliptical to elliptical-lanceolate, (5–)8–12(–16) cm × (2–)3–4(–6) cm, apex acute to acuminate, the surfaces concolourous, glabrous above, densely stellate tomentose but glabrescent below, with 10–14 pairs of secondary veins not prominent below, reticulation areolate, obscure on both surfaces, petiole 0.5–1.5 cm long; male flowers in clusters of 3–7, female flowers solitary or sometimes in clusters of 2–3; cupule sessile or on a stalk up to 1.5 cm long, ellipsoid-globose to obovoid, 3.5–5.5 cm across, covering the nut almost completely, with 5–10 thin to prominent lamellae, densely tomentose with simple and stellate hairs; nut depressed ovoid-globose, densely tomentose but glabrescent, for the greater part adnate to the cupule. *L. javensis* occurs scattered in lowland and montane forest on fertile soils, up to 1800 m altitude. The density of the wood is 520–890 kg/m^3 at 15% moisture content.

Selected sources 78, 83, 162, 234, 303, 332, 474, 583, 705.

Lithocarpus korthalsii (Endl.) Soepadmo

Reinwardtia 8: 251 (1970).

Synonyms *Quercus teysmannii* Blume (1850), *Lithocarpus heliciformis* (von Seemen) Rehder (1919), *Lithocarpus teysmannii* (Blume) Rehder (1919).

Vernacular names Indonesia: pasang abu, pasang susu (Sundanese), pasang kapur (Javanese).

Distribution Sumatra and Java.

Uses The wood is used as mempening, e.g. for house construction.

Observations A large tree up to 45 m tall, bole branchless for up to 20 m, up to 150 cm in diameter, with small buttresses, bark surface fissured to scaly, dark grey, inner bark whitish soon darkening to pinkish; leaves elliptical-oblong, (11–)13–16 (–23) cm × (3–)4–7(–9) cm, apex broadly to sharply acuminate, the surfaces discolourous, glabrous above, densely glaucous stellate tomentose below, with (13–)15–20(–25) pairs of secondary veins prominent below, reticulation subscalariform, obscure to distinct below, petiole 0.5–2 cm long; male flowers in clusters of 3, female flowers solitary or in clusters of 2–3; cupule subsessile, saucer-shaped, 3.5–4.5 cm across, covering one third to half of the nut, with 6–9 lamellae, densely tomentose; nut depressed ovoid-globose to subhemispherical, glabrous, for the greater part free from the cupule. *L. korthalsii* occurs locally commonly but scattered in lowland and montane forest at 150–1900 m altitude. The density of the wood is about 900 kg/m^3 at 15% moisture content.

Selected sources 77, 162, 216, 234, 303, 332, 474, 583.

Lithocarpus kostermansii Soepadmo

Reinwardtia 8: 251 (1970).

Vernacular names Indonesia: pasang batu (Sundanese).

Distribution Western Java.

Uses The wood is used as mempening, e.g. for general construction. The bark contains tannin.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, with buttresses up to 4 m high, bark surface grey; leaves elliptical to narrowly elliptical, (12–)16–22(–30) cm × (4–)6–8(–10) cm, apex acute to acuminate, the surfaces discolourous, glabrous above, densely stellate tomentose below, with (8–)10–11(–13) pairs of secondary veins prominent below, reticulation subscalariform, obscure on both sides, petiole 1–2 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule subsessile, depressed ovoid-globose, 2.7–3 cm across, covering the nut completely, with 3–4 lamellae in the basal half and almost smooth or set with obscure scales in the upper half, with dense stellate hairs; nut depressed ovoid-globose, densely tomentose, for the greater part free from the cupule. *L. kostermansii* is found in primary forest, up to 1000 m altitude.

Selected sources 162, 234, 303, 583.

Lithocarpus lampadarius (Gamble) A. Camus

Riviera Scient. 18: 41 (1932).

Synonyms *Pasania lampadaria* Gamble (1914), *Synaedrys lampadaria* (Gamble) Koidz. (1916), *Quercus lampadaria* (Gamble) Burkill (1935).

Vernacular names Malaysia: clustered oak (En).

Distribution Peninsular Malaysia and Borneo (Sabah).

Uses The wood is reputed to be used as mempening. Small stems have been used locally as torches to attract fish.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 100 cm in diameter, sometimes with buttresses up to 1.2 m high, bark surface rugose, often fissured and flaky, dark grey to dark brown, inner bark dull red; leaves elliptical to narrowly elliptical, (15–)20–30(–35) cm × (6–)8–13(–15) cm, apex broadly acute to acuminate, the surfaces discolourous, glabrous above, densely glaucous stellate tomentose below, with (10–)12–15(–18) pairs of secondary veins prominent below, reticulation scalariform, distinct below, petiole 1–3 cm long; male flowers in clusters of 3–7, female flowers in clusters of 3–7 or rarely solitary; cupule subsessile, cup- or saucer-shaped, 2–3 cm across, covering the basal part of the nut, set with obscure scales in concentric rows, with dense stellate hairs; nut depressed ovoid-globose, densely tomentose, for the greater part free from the cupule. *L. lampadarius* is found in lowland heath forest but also in montane forest at 900–2000 m altitude. The density of the wood is 850–1030 kg/m^3 at 15% moisture content.

Selected sources 78, 83, 99, 104, 140, 162, 583, 703, 705.

Lithocarpus lauterbachii (von Seemen) Markgr.

Bot. Jahrb. Syst. 59: 69 (1924).

Synonyms *Quercus lauterbachii* von Seemen (1897), *Synaedrys lauterbachii* (von Seemen) Koidz. (1916), *Lithocarpus solanicarpa* Markgr. (1924).

Vernacular names Papua New Guinea: taro.

Distribution New Guinea.

Uses The wood is used as mempening, e.g. locally for general construction and fencing.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 80 cm in diameter, bark surface slightly fissured or scaly, grey-brown; leaves elliptical to elliptical-ovate, (8–)10–13(–16) cm × (4–)5–6(–8) cm, apex bluntly acuminate, the surfaces discolourous, glabrous above, densely glaucous to pale grey stellate tomentose, with (7–)8–9(–10) pairs of secondary veins prominent below, reticulation subscalariform, distinct below, petiole 0.5–1 cm long; male flowers in clusters of 3, female flowers solitary; cupule on a stalk 0.5–1.5 cm long, deeply and broadly cup-shaped, 3–4 cm across, covering one third to half of the nut, with thick imbricate scales in concentric rows, with dense stellate hairs; nut depressed subglobose, glabrous, for the greater part free from the cupule. *L. lauterbachii* is locally common in primary and occasionally also in secondary forest, at 300–2400 m altitude.

Selected sources 83, 162, 400, 583, 680.

Lithocarpus leptogyne (Korth.) Soepadmo

Reinwardtia 8: 254 (1970).

Synonyms *Quercus leptogyne* Korth. (1844), *Cyclobalanus leptogyne* (Korth.) Oerst. (1871).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sabah, Sarawak).

Uses The wood is reputed to be used as mempening.

Observations A fairly large tree up to 40 m tall, bole up to 90 cm in diameter, stilt-rooted or with buttresses up to 1.5 m high, bark surface pale grey-brown; leaves narrowly elliptical to narrowly elliptical-obovate, (8–)12–15(–18) cm × (3–)3.5–5(–5.5) cm, apex abruptly acuminate, the surfaces discolourous, sparsely stellate hairy especially on the main veins, minutely stellate hairy below, with 11–14 pairs of secondary veins prominent below, reticulation subscalariform, obscure to fairly distinct below, petiole 3–6 mm long; male flowers in clusters of 3, female flowers solitary; cupule on a stalk c. 3 mm long, saucer-shaped, 1.3–2 cm across, covering the basal part of the fruit, with appressed scales set in concentric rows, densely stellate hairy; nut depressed ovoid, densely tomentose, for the greater part free from the cupule. *L. leptogyne* is uncommon in Peninsular Malaysia and Sumatra but locally common in Borneo. It occurs up to 1800 m altitude.

Selected sources 99, 162, 583, 705.

Lithocarpus lucidus (Roxb.) Rehder

Journ. Arn. Arb. 1: 128 (1919).

Synonyms *Quercus lucida* Roxb. (1832), *Quercus omalokos* Korth. (1844), *Lithocarpus omalokos* (Korth.) Rehder (1919).

Vernacular names Malaysia: babi kurus, mempening kurus, giring-giring (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo (Sabah, Sarawak, north-eastern Kalimantan).

Uses The wood is used as mempening, e.g. for house construction.

Observations A large tree up to 45 m tall, bole up to 120 cm in diameter, often fluted and usually with buttresses up to 1 m high, bark surface shallowly fissured, greyish-brown, inner bark fibrous, red-brown to pale brown; leaves elliptical to elliptical-obovate or narrowly elliptical-obovate, (4–)8–15(–18) cm × (2–)3–5(–7) cm, apex from slightly emarginate to acute or occasionally even cuspidate, the surfaces concolourous, glabrous on both sides, with (10–)14–16(–20) pairs of secondary veins obscure on both sides, reticulation areolate, obscure, petiole 2–5 mm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule sessile, cup- or saucer-shaped, 3–3.5 cm across, covering the basal part of the fruit, with 8–10 lamellae, densely stellate hairy; nut depressed ovoid, glabrous, for the greater part free from the cupule. *L. lucidus* is fairly common in primary and occasionally also in secondary forest, up to 1600 m altitude. The density of the wood is 575–1030 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 99, 104, 140, 162, 583, 705.

Lithocarpus luteus Soepadmo

Reinwardtia 8: 255 (1970).

Distribution Borneo (Sabah, Sarawak, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A fairly large tree up to 40 m tall, bole up to 100 cm in diameter, with buttresses up to 2 m high, bark surface deeply fissured to scaly, reddish-brown; leaves elliptical to narrowly elliptical, (7–)9–12(–15) cm × (2.5–)3.5–5(–6) cm, apex acute to acuminate, the surfaces concolourous, glabrous above, thinly stellate hairy below, with 9–12 pairs of secondary veins prominent below, reticulation scalariform, distinct below, petiole 8–13 mm long; male flowers in clusters of 3–7, female flowers solitary or in clusters of 2–3; cupule sessile, cup-shaped, 2.5–3 cm across, covering about one third of the nut, obscurely lamellate, densely stellate hairy; nut ovoid to subhemispherical, densely tomentose, for the greater part free from the cupule. *L. luteus* is common in montane forest, on brownish sandstone-derived soils, at 1100–1800 m altitude.

Selected sources 99, 162, 583.

Lithocarpus macphailii (M.R. Henderson) Barnett

Trans. & Proc. Bot. Soc. Edinb. 34: 178 (1944).

Synonyms *Pasania macphailii* M.R. Henderson (1930).

Distribution Peninsular Thailand, Peninsular Malaysia and Sumatra.

Uses The wood is reputed to be used as mempening.

Observations A large tree up to 45 m tall, bole up to at least 50 cm in diameter, sometimes with small buttresses, bark surface smooth to fissured, greyish-brown, inner bark fibrous, pink-brown; leaves elliptical to elliptical-ovate or elliptical-oblong, 15–22 cm × 6–8 cm, apex abruptly acuminate, the surfaces discolourous, glabrous above, densely glaucous stellate tomentose below, with (10–)12–16(–18) pairs of secondary veins prominent below, reticulation subscalariform, distinct below, petiole 1–1.7 cm long; male flowers in clusters of 3, female flowers solitary or in clusters of 2–3; cupule sessile or on a stalk up to 5 mm long, deeply cup-shaped to almost completely covering the nut, 2–3 cm across, with 5–8 lamellae, densely tomentose; nut depressed ovoid-globose, densely tomentose, for the greater part free from the cupule. *L. macphailii* often occurs in forest on river banks, up to 900 m altitude.

Selected sources 162, 583, 705.

Lithocarpus megacarpus Soepadmo

Reinwardtia 8: 259 (1970).

Distribution New Guinea.

Uses The wood is used as mempening.

Observations A medium-sized tree up to 30 m tall, bole branchless for up to 24 m, up to 100 cm in diameter, bark surface grey, inner bark red-brown; leaves usually elliptical or narrowly elliptical, (9–)11–14(–16) cm × (3.5–)5–6(–8) cm, apex acute to acuminate, the surfaces concolourous, glabrous above, thinly minutely stellate hairy but glabrescent below, with (7–)8–10(–11) pairs of secondary veins prominent below, reticulation subscalariform, distinct below, petiole 6–10 mm long; male flowers in clusters of 3, female flowers solitary or in clusters of 2–3; cupule subsessile, broadly saucer-shaped, covering the basal part of the fruit, set with imbricate scales in concentric rows, densely stellate tomentose; nut depressed globose or rarely ovoid, glabrous, for the greater part free from the cupule. *L. megacarpus* is locally common in forest on steep slopes, at 1200–1900 m altitude. The density of the wood is 750–820 kg/m^3 at 15% moisture content.

Selected sources 145, 162, 330, 583.

Lithocarpus meijeri Soepadmo

Reinwardtia 8: 260 (1970).

Distribution Borneo (Sabah, Brunei, Sarawak).

Uses The wood is reputed to be used as mempening.

Observations A fairly large tree up to 42 m tall, bole up to 100 cm in diameter, usually with buttresses, bark surface smooth to deeply fissured or scaly, greyish to reddish-brown, inner bark dark brown to yellow-brown; leaves elliptical to elliptical-obovate, (11–)13–20(–25) cm × (4–)5–9(–12.5) cm, apex acute to abruptly acuminate, the surfaces discolourous, glabrous above, densely stellate tomentose below, with 10–13 pairs of secondary veins prominent below, reticulation subscalariform, obscure, petiole 1–1.5 cm long; male flowers in clusters of 3–7 or rarely solitary, female flowers solitary or rarely in clusters of 2–3; cupule sessile, cup-shaped, 2–2.5 cm across, covering the basal part of the nut, with 6–8 lamellae, densely stellate hairy; nut depressed ovoid, densely tomentose, for the greater part free from the cupule. *L. meijeri* is locally common in primary and occasionally also in secondary forest, in mixed dipterocarp forest, on yellowish-brown sandy loams or blackish basalt-derived soils, on low ridges, up to 1000 m altitude.

Selected sources 99, 162, 583.

Lithocarpus nieuwenhuisii (von Seemen) A. Camus

Bull. Soc. Bot. Fr. 92: 255 (1945).

Synonyms *Lithocarpus borneensis* (Merr.) Rehder (1929), *Lithocarpus clementis* (Merr.) A. Camus (1932), *Lithocarpus ochrocea* (Schottky) A. Camus (1932).

Vernacular names Philippines: Clemens oak (En).

Distribution Borneo and the Philippines (Mindanao, Basilan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 25 m tall, bole up to 70 cm in diameter, sometimes with buttresses or stilt-rooted, bark surface scaly, greyish-brown; leaves narrowly elliptical to elliptical-lanceolate, (9–)14–20(–24) cm × (3–)4–6(–8.5) cm, apex emarginate to sharply acuminate, the surfaces discolourous, glabrous or hairy on the midrib above, densely hairy with simple and stellate hairs, the intervenal parts glabrescent, with (8–)10(–14) pairs of secondary veins strongly prominent below, reticulation subscalariform, distinct below, petiole (3–)5–10(–12) mm long; male and female flowers solitary; cupule subsessile, cup-shaped, 2–2.7 cm across, covering one quarter to half of the nut, with minute scales placed in more or less concentric rows or irregularly, with dense stellate hairs; nut ovoid-globose to cylindrical, densely tomentose, the greater part free from the cupule. *L. nieuwenhuisii* occurs widespread in primary lowland forest, sometimes in peat-swamp forest or heath forest, on sandy clayey to ultrabasic soils, often along streams.

Selected sources 99, 162, 544, 583.

Lithocarpus pseudokunstleri A. Camus

Bull. Soc. Bot. Fr. 92: 10 (1945).

Distribution Borneo (Sabah, Sarawak, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 25 m tall, bole up to 60 cm in diameter, with buttresses up to 1 m high, bark surface scaly, greyish-brown; leaves narrowly elliptical to elliptical-oblanceolate, (8–)11–15(–16) cm × (2.5–)4–6(–6.5) cm, apex acute to acuminate, the surfaces concolourous, glabrous on both sides, with 7–8 pairs of secondary veins prominent below, reticulation scalariform, distinct on both sides, petiole 4–6 mm long; male flowers in clusters of 2–3, female flowers solitary; cupule sessile, cup-shaped, 1.7–2.3 cm across, covering the basal part of the nut, set with appressed imbricate scales, with dense stellate hairs; nut cylindrical, densely tomentose but soon glabrescent, for the greater part free from the cupule. *L. pseudokunstleri* is found in primary forest, occasionally in peat-swamp forest, from sea-level up to 1500 m altitude.

Selected sources 99, 162, 583.

Lithocarpus pseudomoluccus (Blume) Rehder

Journ. Arn. Arb. 1: 130 (1919).

Synonyms *Quercus angustata* Blume (1823), *Quercus pseudomolucca* Blume (1823), *Quercus thelecarpa* Miq. (1851).

Vernacular names Indonesia: pasang batu, pasang jangkar, pasang kayang (Sundanese).

Distribution Sumatra and Java.

Uses The wood is used as mempening, e.g. for general construction. The cupules contain a large amount of tannin, but there are no reports of their use.

Observations A medium-sized tree up to 28 m tall, bole up to 65 cm in diameter, fluted below and occasionally with stilt and/or aerial roots, bark surface fissured, greyish or brown, inner bark pale reddish-brown; leaves elliptical to narrowly elliptical, (8–)13–17(–22) cm × (2.5–)5–6(–8) cm, apex blunt to distinctly acuminate, the surfaces discolourous, glabrous above, densely glaucous stellate tomentose below, with 10–12 pairs of secondary veins prominent below, reticulation subscalariform to irregular, distinct below, petiole 0.7–2 cm long; male flowers solitary or in clusters of 3, female flowers solitary or rarely in clusters of 3; cupule sessile, saucer-shaped, 2–3.5 cm across, covering the basal part of the nut, with imbricate scales irregularly distributed or occasionally set in concentric rows, densely stellate hairy; nut depressed subglobose to ovoid, glabrous except around the umbo, for the greater part free from the cupule. *L. pseudomoluccus* occurs scattered in primary forest at 600–1700 m altitude. The density of the wood is 710–890 kg/m^3 at 15% moisture content.

Selected sources 83, 162, 218, 234, 303, 583.

Lithocarpus pulcher (King) Markgr.

Bot. Jahrb. Syst. 49: 67 (1925).

Synonyms *Quercus pulchra* King (1889), *Synaedrys pulchra* (King) Koidz. (1916).

Distribution Borneo (Sabah, Sarawak, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 60 cm in diameter, with buttresses up to 2.5 m high, bark surface irregularly fissured to scaly, chocolate-brown; leaves elliptical to narrowly elliptical or rarely elliptical-obovate, (10–)15–20(–22) × (4–)6–8(–12) cm, apex acute to acuminate, the surfaces discolourous, glabrous above except for the main veins, densely stellate tomentose below, with (12–)15–18(–22) pairs of secondary veins strongly prominent below, reticulation scalariform, distinct below, petiole 1–2 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule sessile, obconical, 4–6 cm across, covering the greater part of the nut, the lower half irregularly set with tubercles, the upper half with spirally set tubercles, densely stellate hairy; nut subhemispherical, densely tomentose, for the greater part adnate to the cupule. *L. pulcher* is found in lowland forest, up to 1000 m altitude.

Selected sources 99, 162, 583.

Lithocarpus pusillus Soepadmo

Reinwardtia 8: 270 (1970).

Distribution Borneo (Sabah, Sarawak, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 25 m tall, bole up to 80 cm in diameter, occasionally stilt-rooted, bark surface finely scaly, greyish-brown; leaves elliptical to narrowly elliptical, (4–)6–10(–12.5) cm × (1.7–)2.5–4(–5) cm, apex acuminate-caudate, the surfaces concolourous, glabrous above, densely stellate tomentose below, with (6–)8–10(–11) pairs of secondary veins obscure to distinct below, reticulation irregular to areolate, obscure, petiole 0.5–1 cm long; male and female flowers solitary; cupule sessile to short-stalked, cup-shaped, 8–12 mm across, covering the basal part of the nut, with 4–5 lamellae, with dense stellate hairs; nut ovoid-conical, glabrous, for the greater part free from the cupule. *L. pusillus* is found in lowland to montane forest, up to 1800 m altitude. It seems confined to peat-swamp forest and heath forest.

Selected sources 99, 162, 583.

Lithocarpus rassa (Miq.) Rehder

Journ. Arn. Arb. 1: 130 (1919).

Synonyms *Quercus rassa* Miq. (1861), *Lithocarpus symingtoniana* A. Camus (1932), *Lithocarpus wenzigiana* (King ex Hook.f.) A. Camus (1932).

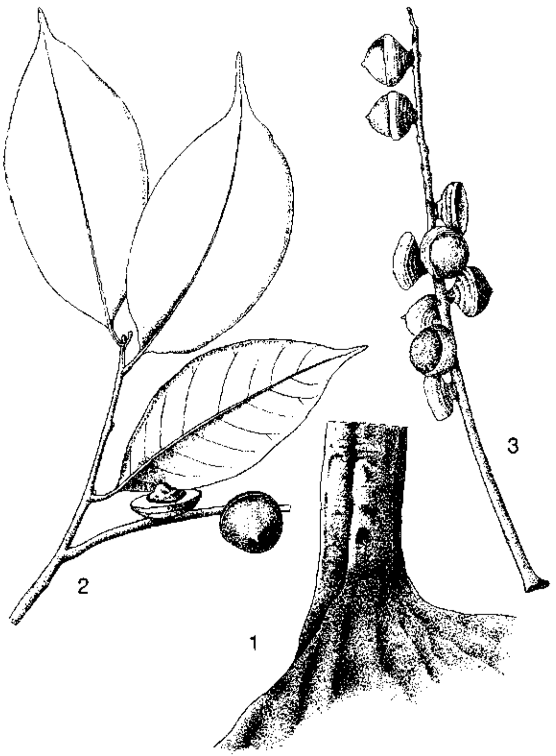
Vernacular names Malaysia: berangan babi (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sabah, Sarawak).

Uses The wood is used as mempening.

Observations A medium-sized tree up to 24 m tall, bole up to 90 cm in diameter, with short buttresses up to 0.7 m high, bark surface minutely dippled and fissured to scaly, pale greyish-brown, inner bark fibrous, dark red; leaves usually narrowly elliptical to elliptical-lanceolate, occasionally elliptical to elliptical-ovate, apex bluntly acute to acuminate-caudate, the surfaces discolourous, glabrous above, with dense stellate hairs but glabrescent below, with (8–)10–14(–16) pairs of secondary veins slightly prominent below, reticulation areolate, obscure, petiole 0.5–2 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule sessile or on a stalk up to 4 mm long, cup- to saucer-shaped, 1.4–2.2 cm across, covering one quarter to one third of the nut, with 6–10 lamellae, densely stellate hairy; nut subhemispherical, glabrous except around the umbo, for the greater part free from the cupule. *L. rassa* is variable, occurring in primary forest from sea-level up to 1800 m altitude; occasionally found in peat-swamp forest. The density of the wood is 880–1045 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 99, 104, 140, 162, 583, 703, 705.



Lithocarpus rassa (Miq.) Rehder – 1, trunk base; 2, fruiting twig; 3, infructescence.

Lithocarpus rotundatus (Blume) A. Camus

Riviera Scient. 18: 41 (1932).

Synonyms *Lithocarpus clathrata* (von Seemen) Rehder (1919), *Lithocarpus curranii* (Merr.) Rehder (1919), *Lithocarpus pyriformis* (von Seemen) Rehder (1919).

Vernacular names Indonesia: pasang koppia, pasang tapok (Java). Philippines: curran oak (En).

Distribution Western Java, Borneo (Sabah) and the Philippines (Luzon).

Uses The wood is reputed to be used as mempening.

Observations A fairly large tree up to 40 m tall, bole up to 100 cm in diameter; leaves narrowly elliptical to narrowly elliptical-obovate, (10–)13–15(–20) cm × (4–)5–6(–9) cm, apex bluntly acute to acuminate, the surfaces concolourous, glabrous above, densely stellate tomentose below, with 9–11 pairs of secondary veins prominent below, reticulation subscalariform, obscure on both sides, petiole 0.5–1.5 cm long; male flowers in clusters of 3–7, female flowers solitary; cupule on a stalk 0.5–2 cm long, obovoid to pear-shaped, 3–4 cm across, covering the greater part of the nut, with dense stellate hairs, the lower part smooth or ridged, the top set with imbricate scales or tubercles; nut subhemispherical, for the greater part adnate to the cupule. *L. rotundatus* is uncommon and occurs from sea-level up to 1500 m altitude.

Selected sources 83, 162, 303, 583.

Lithocarpus rufovillosus (Markgr.) Rehder

Journ. Arn. Arb. 10: 133 (1929).

Synonyms *Pasania rufovillosa* Markgr. (1924).

Distribution New Guinea.

Uses The wood is used as mempening.

Observations A fairly large tree up to 40 m tall, bole up to 60 cm in diameter, bark surface fissured to scaly, pale to dark grey-brown; leaves elliptical to elliptical-ovate or narrowly so, (6–)10–15(–18) cm × (3–)4–6(–8) cm, apex acute to acuminate, the surfaces discolourous, sparsely pubescent especially on the main veins above but soon glabrescent, with dense stellate hairs and woolly below, with 9–11 pairs of secondary veins prominent below, reticulation subscalariform, distinct below, petiole 0.5–1 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule sessile, cup-shaped, 2–3(–3.5) cm across, covering the basal part of the nut, set with ovate pointed scales set alternately but concentrically, densely stellate tomentose; nut ovoid-conical, glabrous, for the greater part free from the cupule. *L. rufovillosus* is common in forest on sandy or clayey soils, at (0–)700–2300 m altitude.

Selected sources 145, 162, 400, 583.

Lithocarpus schlechteri Markgr.

Bot. Jahrb. Syst. 59: 69, fig. 2 (1924).

Synonyms *Lithocarpus perclusa* Markgr. (1924).

Vernacular names Papua New Guinea: New Guinea oak.

Distribution New Guinea.

Uses The wood is used as mempening, e.g. for general construction and furniture.

Observations A medium-sized tree up to 26 m tall, bole up to 50 cm in diameter, bark surface fissured, pale grey-brown; leaves elliptical or rarely elliptical-ovate, (7–)8–12(–16) cm × (3–)3.5–5(–6) cm, apex bluntly acute to acuminate, the surfaces discolourous, glabrous above, with a thin cover of minute stellate hairs below, with (7–)8–9(–10) pairs of secondary veins slightly prominent below, reticulation subscalariform, distinct below, petiole 5–8 mm long; male flowers in clusters of 2–3, female flowers solitary or rarely in clusters of 2–3; cupule sessile, obconical, 4.5–5.5 cm across, covering about two thirds of the nut, set with imbricate scales in concentric rows, with stellate hairs; nut depressed globose, glabrous, for the greater part free from the cupule. *L. schlechteri* is fairly common and often gregarious in fagaceous forest or in the lower zones of *Nothofagus* forest, on sandy clayey soils, at 800–2200 m altitude. The density of the wood is about 720 kg/m^3 at 12% moisture content.

Selected sources 83, 162, 166, 400, 583.

Lithocarpus scortechinii (King ex Hook.f.) A. Camus

Riviera Scient. 18: 42 (1932).

Synonyms *Quercus scortechinii* King ex Hook.f. (1888), *Lithocarpus eriolepis* A. Camus (1937), *Lithocarpus smitinandiana* A. Camus (1952).

Vernacular names Malaysia: Scortechini's oak (En). Thailand: ko-khailaen, ko-fapun (peninsular).

Distribution Vietnam, Thailand and Peninsular Malaysia.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 30 m tall, bole up to 100 cm in diameter, bark surface dark grey; leaves narrowly elliptical or rarely narrowly elliptical-ovate, (10–)14–16(–20) cm × 3–6 cm, apex rounded to acute or rarely acuminate, the surfaces concolourous, glabrous on both sides, with 8–10 pairs of secondary veins prominent below, reticulation subscalariform to irregular, obscure, petiole 10–13 mm long; male flowers in clusters of 2–3, female flowers solitary or rarely in clusters of 2; cupule sessile, saucer-shaped, 2.5–3 cm across, covering the basal part of the nut, densely set with subulate scales, densely stellate hairy; nut subglobose to cylindrical, glabrous, for the greater part free from the cupule. *L. scortechinii* is found in evergreen forest at 700–1200 m altitude. The density of the wood is about 1010 kg/m^3 at 15% moisture content.

Selected sources 83, 104, 140, 162, 574, 583, 705.

Lithocarpus sericobalanus E.F. Warb.

Kew Bull.: 20 (1936).

Vernacular names: Malaysia: impinit, alun (Kenyah, Sarawak).

Distribution Borneo (Sabah, Sarawak, Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A large tree up to 50 m tall, bole up to 100 cm in diameter, with buttresses up to

1.8 m high, bark surface deeply fissured to scaly, pale to dark brown; leaves elliptical to narrowly elliptical, (9–)12–15(–20) cm × (3–)4–6(–8) cm, apex bluntly acuminate, the surfaces discolourous, glabrous above, densely glaucous stellate tomentose below, with 10–12 pairs of secondary veins prominent below, reticulation scalariform, obscure, petiole 1-2 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule on a stalk 0.5–1 cm long, broadly cup-shaped, 3–4.5 cm across, covering half to two thirds of the nut, with 6–10 lamellae, tomentose; nut broadly depressed ovoid-globose to discoid, densely tomentose, for the greater part free from the cupule. *L. sericobalanus* is found in primary and secondary forest, on sandy or rocky soils, in heath forest, on hills or low ridges, up to 1200 m altitude.

Selected sources 83, 162, 583, 683.

Lithocarpus sogerensis (S. Moore) Markgr. ex A. Camus

Chênes 3: 795, t. 415: 12–14 (1954).

Synonyms *Pasania sogerensis* S. Moore (1923).

Distribution Papua New Guinea.

Uses The wood is used as mempening.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 80 cm in diameter, bark surface finely fissured, pale brown to dark grey; leaves elliptical to elliptical-ovate, (6–)8–10(–12) cm × (3–)4(–5) cm, apex bluntly acuminate, the surfaces dicolorous, glabrous above, sparsely stellate tomentose below, with 8–10 pairs of secondary veins prominent below, reticulation subscalariform, distinct below, petiole 0.7–1.0 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule on a stalk 0.7–1.0 cm long, cup-shaped, 2–3 cm across, covering one quarter to one third of the nut, mainly the upper half set with scales in concentric rows; nut conical, glabrous, for the greater part free from the cupule. *L. sogerensis* occurs in forest at 900–1600 m altitude.

Selected sources 83, 145, 162, 583.

Lithocarpus solerianus (S. Vidal) Rehder

Journ. Arn. Arb. 1: 131 (1919).

Synonyms *Quercus soleriana* S. Vidal (1886), *Synaedrys soleriana* (S. Vidal) Koidz. (1916), *Lithocarpus bicolorata* (Elmer) A. Camus (1932).

Vernacular names Philippines: manaring (general), malalipakon (Filipino), ulian (Cagayan).

Distribution The Philippines.

Uses The wood is used as mempening, e.g. for house construction, flooring and railway ties. The bark contains abundant tannin. The nuts are edible.

Observations A small to medium-sized tree up to 25 m tall, bole generally short, up to 100 cm in diameter, bark surface smooth to fissured, pale to dark greyish-brown, inner bark reddish; leaves elliptical, (5–)8–12(–16) cm × (3–)4–6(–7.5) cm, apex bluntly acuminate to acuminate-caudate, the surfaces discolourous, glabrous above, densely glaucous stellate tomentose below, with 9–12 pairs of secondary veins prominent below, reticulation scalariform, distinct below, petiole 7–15 mm long; male flowers in clusters of 3, female flowers solitary; cupule subsessile, cup-shaped, 2–2.5 cm across, covering one quarter to one third of the nut, with 5–7 lamellae, densely stellate hairy; nut ovoid, glabrous, for the greater part free from the cupule. *L. solerianus* is widespread but not common and occurs in forest at 700–1200 m altitude. The density of the wood is about 915 kg/m^3 at 15% moisture content.

Selected sources 83, 162, 330, 527, 544, 583.

Lithocarpus sulitii Soepadmo

Reinwardtia 8: 280 (1970).

Vernacular names Philippines: pangnan (general), katiban (Bataan), olayan (Laguna).

Distribution The Philippines.

Uses The wood is used as mempening, e.g. for house construction, furniture, wood tiles and turnery; it is also suitable for picker sticks.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 80 cm in diameter, with short buttresses, bark surface smooth to fissured, grey to brown; leaves elliptical, (6–)9–11(–13) cm × (2.5–)4–5(–6) cm, apex acute to bluntly acuminate, the surfaces discolourous, glabrous above, densely stellate tomentose below, with (8–)9–10(–13) pairs of secondary veins not prominent on both sides, reticulation areolate, obscure, petiole 7–12 mm long; male flowers in clusters of 3, female flowers solitary; cupule sessile, saucer-shaped, 2–2.5 cm across, covering the basal part of the nut, with 4–5 lamellae, densely stellate hairy; nut ovoid, densely tomentose, for the greater part free from the cupule. *L. sulitii* is widespread but not common in lowland forest, up to 600 m altitude. The density of the wood is 1025–1105 kg/m^3 at 15% moisture content.

Selected sources 125, 162, 527, 544, 583.

Lithocarpus sundaicus (Blume) Rehder
Journ. Arn. Arb. 1: 131 (1919).

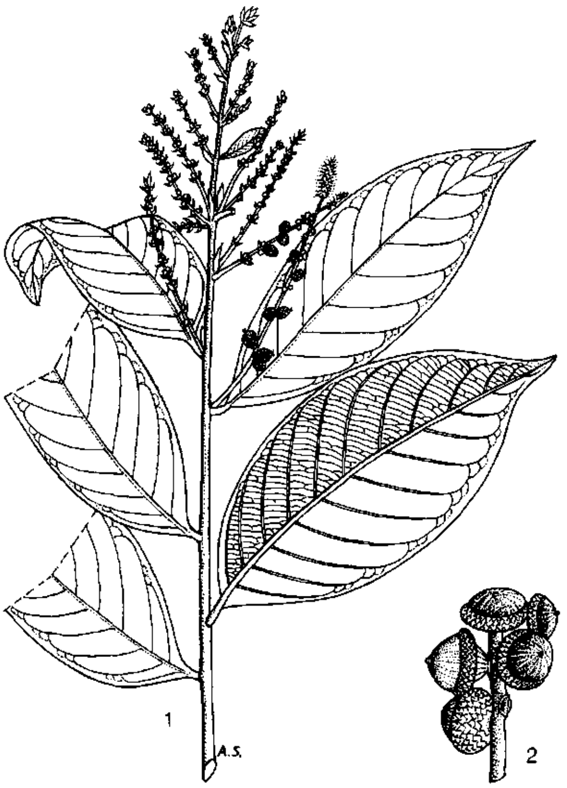
Synonyms *Lithocarpus lamponga* (Miq.) Rehder (1919), *Lithocarpus pruinosa* (Blume) Rehder (1919), *Lithocarpus grandifrons* (King ex Hook.f.) A. Camus (1932).

Vernacular names Sunda oak (En). Indonesia: pasang (general), pasang parengpeng (Sundanese), pasang balung (Javanese). Malaysia: mempening bagan, bintangor tuba (Peninsular). Philippines: wax oak, Sunda oak (Filipino). Thailand: ko-laptaopun (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, Java, Borneo (Sabah, Sarawak, Kalimantan) and the Philippines.

Uses *L. sundaicus* is an important source of mempening; the wood is used e.g. for house and bridge construction (beams, columns, planks) and occasionally for making furniture and tool handles. The bark has been used occasionally to tan hides into leather.

Observations A medium-sized to fairly large tree up to 36 m tall, bole branchless for up to 20 m, up to 100 cm in diameter, often with buttresses, occasionally stilt-rooted, bark surface fissured to scaly, grey-brown, inner bark pinkish; leaves elliptical to elliptical-ovate, (10–)12–16(–24) cm × (4–)5–6(–10) cm, apex acute to acuminate, the surfaces discolourous, hairy on the main veins above but soon glabrescent, densely tomentose with stellate and simple hairs below, with (10–)12–14(–17) pairs of secondary veins prominent below, reticulation scalariform, obscure to distinct below, petiole 0.5–1.2 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule sessile or on a stalk up to 1 cm long, saucer-shaped, 2–3 cm across, covering the basal part of the fruit, with appressed scales set in concentric rows, densely stellate hairy; nut depressed-ovoid, glabrous, for the greater part free from the cupule. *L. sundaicus* is common in primary lowland to montane forest of Peninsular Malaysia and western Java, but much rarer elsewhere. It is occasionally found in peat-swamp forest and occurs up to 2600 m altitude. The density of the wood is 520–755 kg/m^3 at 15% moisture content. See also the table on wood properties.



Lithocarpus sundaicus (Blume) Rehder – 1, flowering twig; 2, infructescence.

Selected sources 77, 78, 83, 99, 104, 140, 162, 194, 218, 234, 303, 330, 332, 368, 403, 508, 574, 583, 703, 705, 745.

Lithocarpus urceolaris (Jack) Merr.
Journ. Arn. Arb. 33: 241 (1952).

Synonyms *Quercus urceolaris* Jack (1822), *Quercus oligoneura* Korth. (1844), *Lithocarpus cratephora* (Fisher) A. Camus (1935).

Vernacular names Malaysia: great oak (En).

Distribution Peninsular Malaysia, Sumatra, Bangka and Borneo.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 130 cm in diameter, with buttresses up to 2 m high, bark surface smooth to deeply fissured or scaly, greyish-brown, inner bark fibrous, red-brown to reddish-ochre; leaves elliptical to narrowly elliptical, (10–)18–25(–35) cm × (5–)8–10(–17) cm, apex acute to acuminate, the surfaces discolourous, glabrous or sparsely hairy on the main veins above, glaucous stellate tomentose below, with (7–)9–10(–12) pairs of secondary veins flat on both surfaces, reticulation scalariform, obscure to distinct below, petiole (0.5–)1–1.5(–2.5) cm long; male flowers in clusters of 3–7, female flowers solitary or rarely in clusters of 3; cupule sessile or on a stalk up to 1 cm long, deeply cup-shaped, 4–5 cm across, covering one third to half of the nut, obscurely lamellate and set with scales in concentric rows, densely stellate tomentose; nut depressed subglobose to globular-cylindrical, densely tomentose, for the greater part free from the cupule. *L. urceolaris* occurs in primary and secondary forest, in swamp forest, on volcanic or granitic sandy or loamy soils, up to 1800 m altitude.

Selected sources 99, 104, 162, 583, 705.

Lithocarpus vinkii Soepadmo

Reinwardtia 8: 286 (1970).

Distribution New Guinea and the Louisiada Archipelago.

Uses The wood is used as mempening.

Observations A medium-sized tree up to 30 m tall, bole up to 50 cm in diameter, sometimes with buttresses up to 2.5 m high, bark surface smooth to shallowly fissured, grey-brown; leaves elliptical to narrowly elliptical or rarely elliptical-ovate, (7–)8–14(–18) cm × (3–)4–5(–7) cm, apex acute to shortly acuminate, the surfaces discolourous, glabrous above, glaucous stellate tomentose below, with (8–)10–12 pairs of secondary veins not prominent below, reticulation irregular, obscure on both sides, petiole 0.7–1.0 cm long; male flowers in clusters of 3, female flowers solitary or rarely in clusters of 2; cupule subsessile, saucer-shaped, 1.5–2 cm across, covering the basal part of the nut, with 4–6 lamellae, densely stellate tomentose; nut conical, glabrous, for the greater part free from the cupule. *L. vinkii* is locally common in forest on sandy to clayey soils overlying limestone and may form pure stands on low ridges, up to 1800 m altitude but more common below 700 m.

Selected sources 145, 162, 583.

Lithocarpus wallichianus (Lindl. ex Hance) Rehder

Journ. Arn. Arb. 1: 132 (1919).

Synonyms *Quercus wallichiana* Lindl. ex Hance (1870), *Pasania wallichiana* (Lindl. ex Hance) Gamble (1915), *Synaedrys wallichiana* (Lindl. ex Hance) Koidz. (1916).

Vernacular names Malaysia: mempening merah, pokok berih jantan (Peninsular). Thailand: chaeng (south-eastern).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore and Sumatra.

Uses The wood is used as mempening. The acorns are edible but bitter.

Observations A medium-sized to large tree up to 45 m tall, bole up to 90 cm in diameter, fluted and sometimes with small buttresses, inner bark fibrous, red-brown; leaves narrowly elliptical to narrowly elliptical-obovate, (10–)14–18(–23) cm × (3–)4–5.5(–7) cm, apex acute to acuminate, the surfaces discolourous, stellate hairy especially on the main veins above, densely stellate hairy below, with (10–)12–16(–18) pairs of secondary veins prominent below, reticulation scalariform, distinct below, petiole (0.5–)1.0–1.2(–1.7) cm long; male and female flowers in clusters of 3; cupule subsessile, saucer- to cup-shaped, 1.5–1.7 cm across, covering the basal part of the nut, with scales set in concentric rows, densely stellate hairy; nut depressed ovoid to subhemispherical, densely tomentose, for the greater part free from the cupule. *L. wallichianus* occurs frequently in primary forest, usually on poor soils, from sea-level up to 1600 m altitude.

Selected sources 78, 83, 99, 104, 162, 583.

Lithocarpus woodii (Hance) A. Camus

Riviera Scient. 18: 42 (1932).

Synonyms *Quercus woodii* Hance (1874), *Synaedrys woodii* (Hance) Koidz. (1916), *Lithocarpus loheri* A. Camus (1949).

Vernacular names Philippines: tigdog (Igorot), Loher's oak (Filipino), tiklik.

Distribution The Philippines.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 30 m tall, bole up to 90 cm in diameter; leaves elliptical to elliptical-ovate, (6–)9–12(–17) cm × (4–)5–7(–10) cm, apex bluntly acute to sharply acuminate, the surfaces discolourous, glabrous above, densely glaucous stellate tomentose below, with 8–11 pairs of secondary veins strongly prominent below, reticulation subscalariform, distinct below, petiole 0.7–1.5 cm long; male flowers solitary or in clusters of 3, female flowers solitary or rarely in clusters of 2–3; cupule subsessile, cup-shaped, 2.5–3.5 cm across, covering about one quarter of the nut, with 7–10 lamellae, densely stellate hairy; nut subhemispherical, glabrous except near the apex, for the greater part free from the cupule. *L. woodii* is found in montane forest at 1200–2300 m altitude.

Selected sources 83, 162, 544, 583.

Lithocarpus wrayi (King) A. Camus

Riviera Scient. 18: 42 (1932).

Synonyms *Quercus wrayi* King (1889), *Pasania wrayi* (King) Gamble (1915), *Lithocarpus lappaceus* (Roxb.) Rehder var. *perakensis* A. Camus (1945).

Vernacular names Malaysia: mempening merah, berih (Peninsular). Thailand: ko-kriam, komu (Nakhon Si Thammarat), talaptaopun (Trang).

Distribution Peninsular Thailand, Peninsular Malaysia and Sumatra.

Uses The wood is used as mempening.

Observations A medium-sized tree up to 30 m tall, bole up to 50 cm in diameter, often fluted, bark surface rugose or occasionally scaly and flaky, brown, inner bark fibrous, brown; leaves narrowly elliptical or rarely narrowly elliptical-obovate, (10–)15–20(–24) cm × (3–)5–7(–8) cm, apex acuminate, the surfaces concolourous, sparsely pubescent on both sides, more densely so on the main veins, with (14–)16–18(–19) pairs of secondary veins prominent on both sides, reticulation scalariform, obscure on both sides, petiole (0.2–)0.3–0.5(–1.0) cm long; male flowers solitary or in clusters of 3, female flowers solitary; cupule sessile, ovoid-globose to depressed-globose, 2.5–3 cm across, covering the nut completely, set with recurved scales, densely tomentose; nut ovoid to depressed ovoid-globose, densely tomentose, for the greater part free from the cupule. *L. wrayi* is found in primary forest, from sea-level up to 1350 m altitude.

Selected sources 99, 162, 583.

E. Boer (general part),
M.S.M. Sosef (general part, selection of species),
W.C. Wong (properties),
Vu-Cong Quy (wood anatomy)

Litsea Lamk

Encycl. 3: 574 (1792).
LAURACEAE
$x = 12$; $n = 12$ for many species, *L. glutinosa*: $n = 24$

Trade groups Medang: lightweight to medium-weight hardwood, e.g. *Litsea costalis* (Nees) Kosterm., *L. elliptica* Blume, *L. grandis* (Wallich ex Nees) Hook.f.

Medang is used as the trade name for the timber of most *Lauraceae* genera, such as *Alseodaphne, Beilschmiedia, Cinnamomum, Cryptocarya, Dehaasia, Nothaphoebe, Persea* and *Phoebe.*

Vernacular names Medang: bollywood (En). Malaysia: medang padang (Sarawak). Papua New Guinea: litsea. Philippines: batikuling (general). Burma (Myanmar): ondôn, kyese. Thailand: thammang, thang-baiyai. Vietnam: boi loi.

Origin and geographic distribution *Litsea* is a large genus comprising about 400 species. These occur in all tropical and subtropical areas of the world except for Africa. The genus is found throughout the Malesian area and is represented there by about 150 species.

Uses The timber is used for interior finish, panelling, ceilings, partitioning, furniture, cabinet work, boards, rotary veneer and plywood, and packing cases; the heavier timber which may be present in some species is also used for medium-heavy construction, poles, posts, planks, canoes, tool handles, agricultural implements, carving, sculpturing and pattern making.

The fruits of *L. glutinosa* and *L. garciae* S. Vidal are edible. Leaves, bark and wood chips are used in traditional medicine. The seeds of some species contain an oil which is used as a medicine, for the manufacture of soap and hair cream and was formerly used for candle manufacture. The leaves of *L. monopetala* are the principal food of the muga silkworm (*Antheraea assama*) in India and are used for fodder in Nepal. The bark of *L. umbellata* is used for walls of local houses. *L. elliptica* yields safrole used as 'sarsaparilla' in the perfume and flavour-producing industry. The roots of *L. glutinosa* yield fibres used in Thailand for making ropes and for paper pulp.

Production and international trade *Litsea* timber is not traded separately but as medang together with the timber of other *Lauraceae* genera. It probably accounts for only a small proportion of the total amount of medang in trade.

The total export of medang in 1984 from Peninsular Malaysia to Singapore was 1500 m^3 with a value of US$ 62 000, the export from Sabah in 1992 was 52 000 m^3 (about 10% as sawn timber) with a total value of US$ 4.3 million. The minimum price for saw logs in Papua New Guinea in 1992 was US$ 43/m^3.

Properties Medang is a lightweight to medium-weight hardwood. The heartwood is somewhat variable in colour but usually ranges from pale olive-brown or creamy yellow to dark greenish-brown. The sapwood is often not distinctly demarcated from the heartwood (but moderately sharply defined in some species) and ranges from pale straw-coloured to pale yellowish-brown. The density is (355–)370–560(–770) kg/m^3 at 15% moisture content. The grain is straight or slightly to moderately interlocked, texture moderately fine and even.

At 15% moisture content, the modulus of rupture is 38–77 N/mm^2, modulus of elasticity 7250–11 075 N/mm^2, compression parallel to grain 27–35

N/mm², compression perpendicular to grain 3 N/mm², shear 3–7.5 N/mm², cleavage 44–49 N/mm radial and 50–53 N/mm tangential, Janka side hardness 1090–2310 N and Janka end hardness c. 1285 N.

The rates of shrinkage are moderate to high: from green to 15% moisture content 1.1–2.0% radial and 2.7–4.0% tangential, from green to 12% moisture content 1.4–2.7% radial and 3.1–5.1% tangential and from green to oven dry 1.5–4.6% radial and 4.0–8.6% tangential. The wood dries fairly slowly with slight bowing and staining. Boards 15 mm thick take 2.5–4 months to air dry from green to 15% moisture content, 40 mm thick boards 3.5–5 months. In Malaysia kiln schedule H is recommended.

The wood is easy to slightly difficult to saw and easy to plane; the surface produced is smooth to moderately smooth. The nailing properties are rated as excellent.

The wood is generally not durable and is susceptible to fungal and *Lyctus* beetle attack. *L. firma* wood is reported to be resistant to the termite *Nasutitermes exitiosus* but not to *Coptotermes lacteus*. When there is resistance to fungi and insects, this is usually attributed to the presence of monoterpene, a toxic substance present in many *Lauraceae* species. The heartwood is difficult to treat with preservatives, but the sapwood absorbs preservatives readily. The retention by pressure treatment of *L. irianensis* heartwood in Papua New Guinea was 530 kg/m³.

Wood of *L. costalis* contains 68% holocellulose, 42.5% α-cellulose, 28% lignin, 11.5% pentosan and 0.3% ash. The solubility is 4.1% in alcohol-benzene, 5.1% in hot water and 12.7% in a 1% NaOH solution. Wood of *L. firma* contains 51% cellulose, 26% lignin, 11% pentosan, 0.4% ash and 0.05% silica. The solubility is 5.4% in alcohol-benzene, 1.3% in cold water, 4.8% in hot water and 11.3% in a 1% NaOH solution. The energy value is 21 150 kJ/kg.

Description Evergreen, usually dioecious shrubs or small to medium-sized, rarely large trees up to 45 m tall; bole up to 80(–110) cm in diameter, sometimes with short buttresses; bark surface smooth to scaly and irregularly flaky, rarely fissured or dippled, often with horizontal rings or lenticellate, pale grey or pale brown to reddish-brown, inner bark cream to orange or reddish and yellow mottled, often with a strong smell; sapwood white to yellowish or brownish. Leaves alternate, subopposite or opposite, simple, entire, with glandular dots and aromatic when crushed, pinnately veined, often glaucous below; stipules absent. Inflorescence sessile or pedunculate, in leaf axils or cauliflorous on twigs, branches or trunk, consisting of racemes or clusters of umbellules surrounded by an involucre of 4–6 persistent or subpersistent large decussate bracts. Flowers unisexual or rarely bisexual, often 4–6 together in an umbellule, trimerous; tepals 0 or 6, rarely 8, equal or unequal, united in a tube at base; fertile stamens in the male flower 9 or 12, rarely more, in 3 or 4 rows, the 3rd row and 4th row (when present) flanked by glands, anthers 4-celled, all introrse or the basal pair of the 3rd staminal row lateral; ovary rudimentary in the male flower, in the female flower superior, sessile, 1-celled, globose or ovoid, with a single, pendulous, anatropous ovule, style usually thick, often curved, with a conspicuous peltate stigma. Fruit a 1-seeded berry, globose or ovoid to cylindrical, resting on the variably enlarged perianth tube (the perianth lobes deciduous) and supported by the slightly enlarged pedicel. Seed without albumen, with a thin testa; cotyledons large, flat, convex and pressed against each other; embryo minute. Seedling with hypogeal germination (*L. castanea*); cotyledons partially exposed.

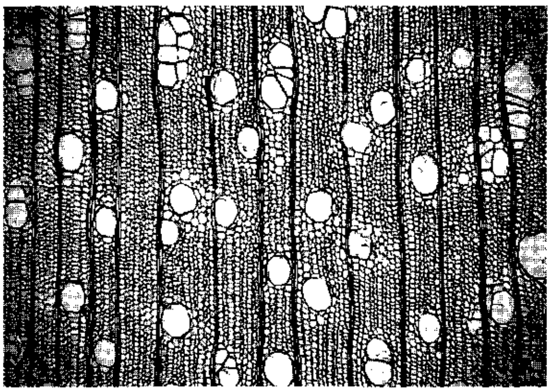
Wood anatomy

– Macroscopic characters:

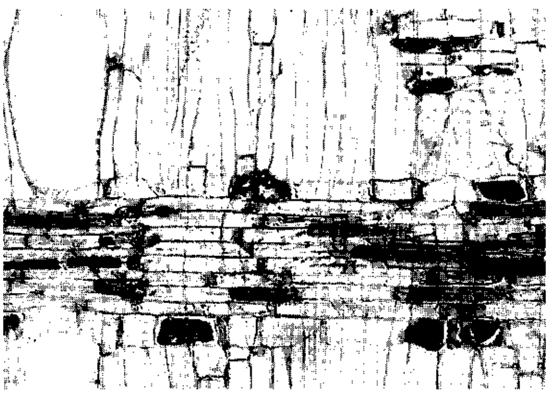
Heartwood greenish-yellow to dark olive-green in most species (drying pinkish in *L. firma*), distinctly or indistinctly demarcated from the paler sapwood. Grain straight to moderately interlocked. Texture moderately fine and even. Growth rings distinct, marked by darker coloured layers of dense fibres; vessels usually visible to the naked eye; parenchyma and rays usually only visible with a hand lens; ripple marks absent.

– Microscopic characters:

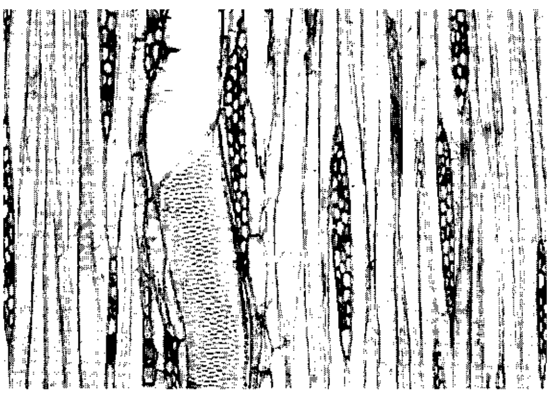
Growth rings distinct, marked by differences in fibre wall thickness and radial fibre diameter. Vessels diffuse, c. 11 (9–12)/mm², solitary and in radial multiples of 2–6, round to oval or slightly angular, average tangential diameter c. 100–150 μm; perforations usually exclusively simple, in some species with a low proportion of scalariform plates; intervessel pits alternate, non-vestured, round to polygonal, 7–12 μm, with slit-like, occasionally coalescent apertures; vessel-ray and vessel-parenchyma pits with strongly reduced borders to simple, mostly elongated and in an oblique or scalariform pattern; no helical thickenings or deposits; thin-walled tyloses present in some of the vessels. Fibres 1080–1520 μm long, all septate or some non-septate, thin-walled to thick-walled,



transverse section (×25)



radial section (×75)



tangential section (×75)

Litsea timoriana

with minutely bordered pits mainly confined to the radial walls. Parenchyma scarce to moderately abundant, scanty paratracheal to vasicentric, aliform with short wings and occasionally confluent, in 2–6-celled strands. Rays 5–8/mm, 2–4 cells wide, c. 0.4 mm high, heterocellular to homocellular, composed of procumbent body ray cells, with 1–2 rows of square to upright or weakly procumbent marginal cells. Crystals present in some species, prismatic in ray cells, occasionally in radial alignment or acicular in the axial and/or ray parenchyma cells (e.g. *L. irianensis* and *L. laeta* (Wallich ex Nees) Benth. & Hook.f.), or as small cubical crystals in the rays (e.g. *L. insignis* (Blume) Boerl.). Silica bodies present in ray and axial parenchyma cells of many species (e.g. *L. grandis*, *L. helferi* Hook.f., *L. ledermannii* and *L. resinosa*). Secretory (oil or mucilage) cells present among the axial parenchyma and occasionally (e.g. *L. nidularis*) associated with the ray margins.

Species studied: *L. angulata*, *L. castanea*, *L. collina*, *L. costalis*, *L. engleriana*, *L. firma*, *L. garciae*, *L. grandis*, *L. helferi*, *L. insignis*, *L. irianensis*, *L. laeta*, *L. ledermannii*, *L. maingayi*, *L. monopetala*, *L. nidularis*, *L. panamanja* (Nees) Hook.f., *L. resinosa*, *L. reticulata* (Meissn.) Benth., *L. robusta*, *L. timoriana*, *L. tomentosa*, *L. umbellata*.

Growth and development Average annual diameter increments for two secondary rain forest species are reported in Luzon: 0.8 cm and 1.9 cm for the 0–5 cm and 5–10 cm diameter classes of *L. glutinosa* respectively, and 2.2 cm for the 10–20 cm diameter class of *L. cordata*.

L. garciae exhibits the architectural growth model of Massart, i.e. an orthotropic, monopodial trunk with rhythmic growth and consequently producing regular tiers of branches, the branches being plagiotropic. *L. glutinosa* in Peninsular Malaysia flowers annually in February and March. The fruits of *L. monopetala* are thought to be dispersed by bats.

Other botanical information Like many other *Lauraceae* genera, *Litsea* is in need of a thorough taxonomic revision. The genus itself is reasonably well-defined, but the lack of a proper key to the Malesian species often leads to misidentification at species level.

Litsea is closely related to *Actinodaphne*, which has its leaves in pseudo-whorls, and to *Neolitsea*, with dimerous flowers. It is divided into 3 subgenera: subgenus *Litsea* with unisexual flowers and 0 or 6 tepals, subgenus *Dodecadenia* (Nees ex Wallich) Kosterm. with bisexual flowers, and subgenus *Octolitsea* Liou-Ho with unisexual flowers and 8 tepals.

Ecology *Litsea* species occur in a wide variety of habitats. Most species are found in well-drained primary and secondary forest, evergreen or sometimes semi-deciduous; some are also encountered in severely degraded vegetation such as bushes and thickets. Some species occur in swamp forest, or rarely in 'kerangas' (heath forest) or on limestone. Most species appear only at low and medium altitudes, but some individual species may ascend up to 1750(–2900) m. They usually constitute elements of the canopy or subcanopy layer, rarely emerging, and occur scattered but may be locally dominant.

Propagation and planting Propagation is generally by seed, but may be possible by root or branch cuttings as well. The number of dry fruits (one fruit contains a single seed) per kg is about 300 for *L. garciae* and 2100 for *L. confusa*. Germination is not very rapid. In *L. castanea* approximately 70% germination is achieved in 45–115 days; 85% germination is achieved in *L. maingayi* in 35–55 days and in 15–45 days in *L. glutinosa*. When fruits are the units of sowing, 95% germinate in 35–100 days for *L. elliptica* and 40% in 35–115 days for *L. umbellata*. Fruits without cup germinate very poorly: 20% in 60–190 days for *L. firma* and 30% in 50–100 days for *L. maingayi*.
L. crassifolia also reproduces vegetatively by root suckers. *L. umbellata* has been successfully planted with other species for erosion control in Central Java at an altitude of 600–800 m and with an annual precipitation of 5000 mm. *L. resinosa* has been planted in a trial plantation in East Java.

Silviculture and management In southern Sulawesi *L. firma* is one of the main species logged under a selective logging system with diameter limit of 50 cm, together with *Santiria laevigata* Blume, *Kalappia celebica* Kosterm., *Vatica flavovirens* v. Slooten, *Calophyllum soulattri* Burm.f. and *Pouteria moluccana* (Burck) Baehni. Natural regeneration is not favourable here. In peat-swamp forest, fast-growing *Litsea* species may become dominant in logged-over forest, such as *L. cylindrocarpa*, *L. gracilipes*, *L. nidularis* and *L. resinosa*. Most of the species coppice freely.

Harvesting Nearly all the larger trees of *L. crassifolia* in kerangas and peat swamp-forest in Sarawak are hollow.

Genetic resources Several species are rare and indiscriminate logging of the trees of such a large and poorly known genus may easily endanger them. In the Philippines *L. leytensis* is considered to be a vanishing timber species.

Prospects The prospects for *Litsea* as timber producer are not clear. More research is needed on wood properties, propagation and planting, and silviculture, to determine the value for the future.

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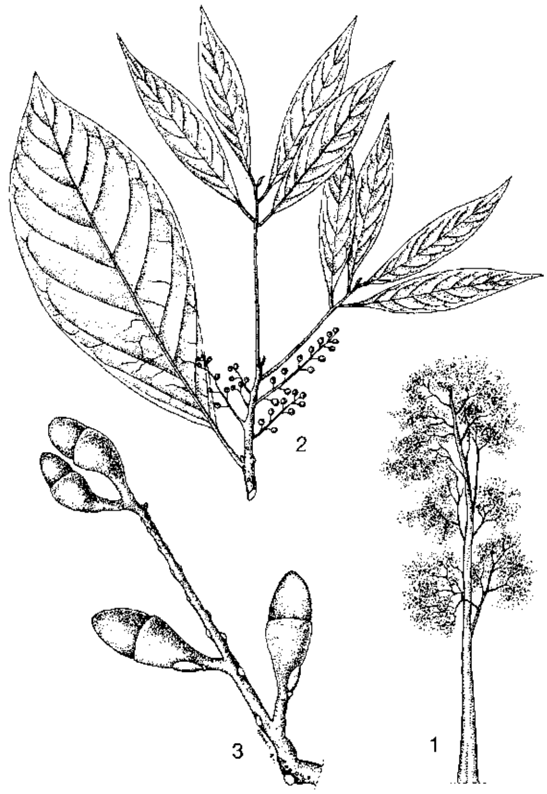
Selection of species

Litsea angulata Blume

Bijdr. fl. Ned. Ind. 11: 563 (1826).

Synonyms *Litsea reinwardtii* Blume ex Meissn. (1864).

Vernacular names Indonesia: huru manggah, huru madang (Sundanese, Java), wuru kunyit (Javanese, Java).



Litsea angulata Blume – 1, tree habit; 2, flowering twig; 3, infructescence.

Distribution Peninsular Malaysia (rare), Java and Borneo.

Uses The wood is locally used for house building.

Observations A small to medium-sized tree up to 18(–24) m tall, bole straight or curved, up to 55 cm in diameter, not buttressed, bark surface smooth, greyish, inner bark pale yellowish; leaves alternate, 10–35 cm × 4–11.5 cm, acute or acuminate, glabrous above, glabrous to rather densely appressed hairy below, midrib sunken above, with 7–14 pairs of secondary veins which are sunken above, tertiary venation obscure on both surfaces, petiole 1–4 cm long; flowers in up to 8 cm long racemes of shortly peduncled umbellules, with 6 tepals and 9–12 stamens; fruit ovoid to oblong, 2–2.5 cm in diameter, seated on a flattened enlarged perianth tube with a straight margin. *L. angulata* is an uncommon species occurring in mixed rain forest, up to 1800 m altitude.

Selected sources 36, 234, 303, 529, 705.

Litsea artocarpifolia Gamble

Kew Bull.: 316 (1910).

Synonyms *Litsea megalophylla* Merr. (1922).

Distribution Peninsular Malaysia, Sumatra, Borneo and western Java.

Uses The wood is reputed to be used as medang.

Observations A small to medium-sized tree up to 25 m tall, bole up to 60 cm in diameter, with buttresses up to 1.5 m high, bark surface smooth or superficially fissured, with horizontal rings, grey to red-brown or pale brown, inner bark pale or orange-brown to pinkish; leaves alternate, 20–40 cm × 9–21 cm, notched at apex or rounded to shortly apiculate, glabrous above, glaucous and pubescent beneath, midrib flattened above, with 14–20 pairs of secondary veins which are sunken above, tertiary venation prominent below, petiole 1–3 cm long; flowers in racemose sessile umbellules, with 6–8 tepals and 9–15 stamens; fruit ovoid, c. 5 cm × 3 cm, the lower half enclosed by a perianth cup with a lobed margin. *L. artocarpifolia* occurs in primary rain forest, often in marshy sites, up to 1600 m altitude. The delimitation of this species remains doubtful as the various descriptions are conflicting. The density of the wood is 380–455 kg/m^3 at 15% moisture content.

Selected sources 140, 183, 316, 322, 529, 705.

Litsea aurea Kosterm.

Reinwardtia 8: 86 (1970).

Vernacular names Malaysia: anau (Iban, Sarawak).

Distribution Sumatra, Borneo (Sarawak) and eastern Java (rare).

Uses The wood is reputed to be used as medang.

Observations A medium-sized to fairly large tree up to 34 m tall, bole branchless for up to 20 m, up to 80 cm in diameter, with buttresses up to 3.5 m high; leaves arranged spirally, 8–27 cm × 4–9 cm, gradually acute, glabrous above, densely minutely sericeous below, midrib flush with the surface above, with up to 22 pairs of secondary veins which are slightly prominent above, tertiary venation indistinct, petiole 1–1.5 cm long; flowers in up to 5 cm long racemes of peduncled umbellules; fruit depressed globose, up to 1.5 cm × 2 cm, seated on a flat cup with a wavy margin. *L. aurea* occurs locally, at 200–900 m altitude.

Selected sources 322, 323.

Litsea calophyllantha K. Schumann

K. Schumann & Lauterb., Fl. Schutzgeb. Südsee 331 (1900).

Distribution New Guinea and New Britain.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole branchless for up to 17 m, up to 50 cm in diameter, bark surface smooth or with warty lenticels, pale grey to grey-brown, inner bark pale yellow; leaves 18–45 cm × 10–20 cm long, obtuse, glabrous on both surfaces, with 10 pairs of secondary veins which are indistinct above, petiole 1.3–3 cm long; flowers in short racemes of umbellules on 8–10 mm long peduncles, with 6 tepals and 9 staminodes; fruit ovoid to ovoid-ellipsoid, up to 0.8 cm × 1.2 cm. The branches are hollow and inhabited by ants. *L. calophyllantha* occurs in lowland forest, sometimes near the beach, or in montane forest with e.g. *Castanopsis*, up to 2200 m altitude.

Selected sources 322, 323, 354, 552.

Litsea castanea Hook.f.

Fl. Brit. India 5: 171 (1886).

Synonyms *Litsea quercina* Gamble (1910).

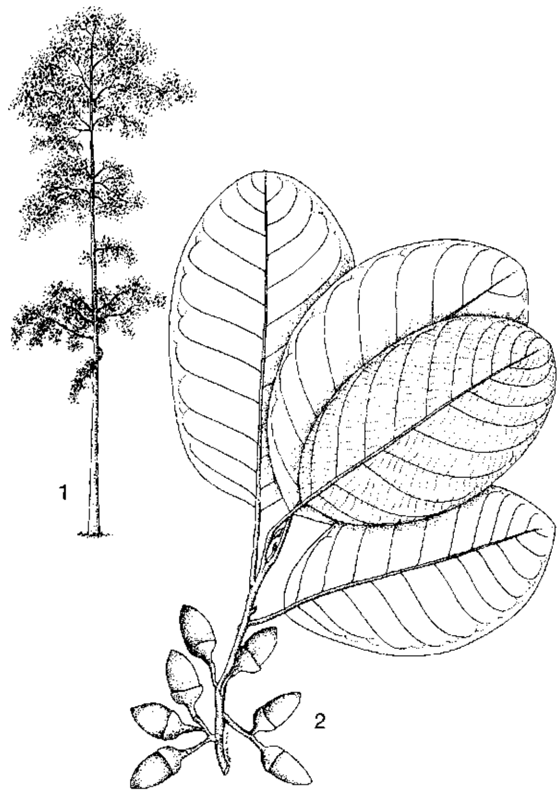
Vernacular names Kelantan laurel (En). Malaysia: bokor-bokor, medang bebokor, medang kunyit (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Borneo and western Java (rare).

Uses The wood is used as medang, in Peninsular Malaysia particularly for local house construction.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 75 cm in diameter, sometimes with short buttresses up to 1 m high, bark surface smooth with horizontal rings, becoming irregularly fissured and flaky, pale grey to reddish-brown, inner bark cream and orange mottled; leaves alternate, 6–17.5 cm × 2.5–10 cm, blunt, rounded or emarginate at the top, glabrous except for the veins beneath, midrib sunken above, with 7–13 pairs of secondary veins which are distinctly sunken above, tertiary venation visible below, petiole 1–3 cm long; flowers in clusters of umbellules on c. 1 cm long peduncles, with 6 tepals and 10–15 stamens; fruit ovoid to cylindrical, c. 3.5 cm × 3 cm, seated on a rimmed perianth cup. *L. castanea* is common in kerangas forest overlying white sands, at low altitudes but sometimes ascending to 700 m. It also occurs in hedges and thickets. The density of the wood is 420–595 kg/m^3 at 15% moisture content.

Selected sources 16, 78, 104, 140, 245, 316, 322, 458, 463, 529, 705.



Litsea castanea Hook.f. – 1, tree habit; 2, fruiting twig.

Litsea collina S. Moore

Journ. Bot. 61, Suppl.: 43 (1923).

Synonyms *Litsea perglabra* Allen (1942), *Litsea perlucida* Allen (1942), *Litsea racemosa* C.T. White (1950).

Distribution Papua New Guinea including New Britain, and the Solomon Islands.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 20 m tall, bark surface finely scaly, dark brown; leaves alternate, 12–21 cm × 6.5–10.5 cm, glabrous, midrib sunken above, with 5–8 pairs of secondary veins which are level with the surface above, tertiary venation densely reticulate and distinct on both surfaces, petiole 1.5–4 cm long; flowers in clusters of shortly peduncled umbellules, with 6 tepals and 12 stamens; fruit ellipsoid, c. 3 cm × 2 cm, seated on a saucer-shaped cup with an undulate margin. *L. collina* occurs in primary rain forest on coastal hills and inland up to 1500 m altitude.

Selected sources 13, 316, 321, 327, 446.

Litsea confusa Koord. & Valeton

Bijdr. boomsoorten Java 10: 161 (1904).

Vernacular names Indonesia: sosowan (Madurese, Java).

Distribution Central and eastern Java.

Uses The wood is reputed to be used as medang.

Observations A large tree up to 45 m tall, bole straight, up to 200 cm in diameter, inner bark darkening orange-yellowish; leaves 9–33 cm × 2.5–10.5 cm, obtuse or acute, glabrous above, densely shortly appressed pubescent below, with 5–12 pairs of secondary veins which are slightly prominent below, tertiary venation not prominent, petiole 1.5–3 cm long; flowers in up to 13 cm long racemes of shortly peduncled umbellules, with (4–)6 tepals and 9–12 stamens; fruit unknown. *L. confusa* is infrequently encountered but is locally common in mixed rain forest and teak forest, at 150–1500 m altitude. See also the table on wood properties.

Selected sources 36, 218, 303, 684.

Litsea cordata (Jack) Hook.f.

Fl. Brit. India 5: 177 (1886).

Synonyms *Litsea perrottetii* (Blume) Fernandez-Villar (1880), *Litsea flexuosa* (Blume) Boerl. (1900).

Vernacular names Malaysia: kedondong butong, serapoh paya, munteh (Peninsular). Philippines: marang (general), bakan, batikuling (Tagalog).

Distribution Peninsular Malaysia, Borneo, the Philippines, Sulawesi and the Moluccas.

Uses The wood is used as medang, e.g. for light construction and novelties.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 60 cm in diameter, with short buttresses or in swampy habitats with stilt roots and pneumatophores, bark surface smooth, lenticellate, pale grey, inner bark yellow-brown, mottled; leaves alternate, 5.5–20 cm × 4–12 cm, base cordate and often unequal, blunt or shortly pointed at apex, glabrous above, brown hairy below, midrib raised or flattened above, with 8–14 pairs of secondary veins which are sunken above, tertiary venation scalariform, prominent below, petiole 1.5–3.5 cm long; flowers in 15 cm long racemes of umbellules, with 6 tepals; fruit ellipsoid to oblong, c. 2 cm × 1 cm, seated on an indistinct perianth cup. *L. cordata* is fairly common in primary and secondary forest along rivers, in swamps, but also in hill forest at low and medium altitudes. The density of the wood is 400–470 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 78, 125, 140, 245, 316, 321, 409, 414, 426, 527, 529, 705.

Litsea costalis (Nees) Kosterm.

Reinwardtia 7: 501 (1969).

Synonyms *Alseodaphne costalis* Nees (1831), *Litsea megacarpa* Gamble (1910).

Vernacular names Elephant laurel (En). Malaysia: medang keladi, medang daun besar, medang pisang (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, not buttressed, bark surface smooth, lenticellate, grey-brown to reddish-brown, inner bark pale yellow to pale orange; leaves alternate, 15–45 cm × 6–20 cm, blunt or shortly pointed, glabrous, midrib flattened or raised above, with 10–15 pairs of secondary veins which are raised on both surfaces, tertiary venation strongly reticulate and distinct above, petiole 2–7 cm long; flowers in 5–15 cm long racemes of umbellules with short peduncles, with 6 tepals and 9–12 stamens; fruit globose, 2–3 cm across, seated on cup- or saucer-shaped enlarged perianth segment. *L. costalis* is fairly common in lowland forest, both primary and secondary, up to 500 m altitude. The density of the wood is 370–475 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 78, 104, 140, 184, 206, 316, 321, 364, 490, 529, 705.

Litsea costata (Blume) Boerl.

Handl. fl. Ned. Ind. 3: 144 (1900).

Synonyms *Litsea kunstleri* Gamble (1910), *Litsea patellaris* Gamble (1910), *Litsea perakensis* Gamble (1910), *Litsea pustulata* Gamble (1910).

Vernacular names Malaysia: medang pisang, medang wangi, medang tembatu (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo.

Uses The wood is reputed to be used as medang.

Observations A small to medium-sized tree up to 20 m tall, bole up to 50 cm in diameter, bark surface smooth, red-brown; leaves alternate, 7–40 cm × 3–14 cm, pointed, rounded or emarginate, glabrous, midrib flattened or slightly sunken above, with 8–14 pairs of secondary veins which are sunken above, tertiary venation faintly visible below, petiole 1–3 cm long; flowers in short, peduncled racemes of umbellules, with 6 tepals and

9–12 stamens; fruit globose, 1–1.5 cm across, seated on a shallow cup-shaped perianth tube. *L. costata* is rather uncommon in lowland and montane forests.

Selected sources 184, 316, 705.

Litsea crassifolia (Blume) Boerl.

Handl. fl. Ned. Ind. 3: 143 (1900).

Synonyms *Tetranthera crassifolia* Blume (1851), *Litsea palustris* Kosterm. (1962).

Vernacular names Malaysia: medang padang (Sarawak).

Distribution Borneo.

Uses The wood is used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 75 cm in diameter, bark surface becoming rough, lenticellate and flaking, purplish-brown, inner bark pink; leaves alternate, 4–10 cm × 2–4 cm, obtuse or rounded to notched, glabrous, midrib sunken above, with 6–8 pairs of secondary veins which are slightly prominent above, petiole c. 0.5 cm long; flowers in short axillary racemes, on an up to 1 cm long peduncle; fruit ellipsoid, up to 1.8 cm × 1.2 cm. *L. crassifolia* may be locally dominant in peat-swamp forest in association with *Dacrydium* and *Casuarina*. It occurs occasionally in kerangas forest at low and medium altitudes. The density of the wood is 350–880 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 56, 77, 316, 321, 433, 546, 576, 703.

Litsea curtisii Gamble

Kew Bull.: 363 (1910).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as medang.

Observations A medium-sized to large tree up to 42 m tall, bole up to 80 cm in diameter, with buttresses up to 4 m high, bark surface smooth but flaking in places, with large lenticels in vertical rows, fawn or pale pink, inner bark pale yellow-brown darkening to pale red-brown; leaves alternate, 20–30 cm × 6–12.5 cm, pointed, glabrous, midrib raised above, with 10–15 pairs of secondary veins which are slightly raised on both surfaces, tertiary venation scalariform, faint below, petiole 1.5–3.7 cm long; flowers in 15–20 cm long racemes of umbellules on short peduncles, with 6–9 tepals and 9(–14) stamens; fruit oblong, 1 cm × 0.5 cm, seated on a saucer-shaped perianth cup. *L. curtisii* is rather uncommon in lowland and hill forest. The density of the wood is 385–405 kg/m^3 at 15% moisture content.

Selected sources 140, 184, 316, 705.

Litsea cylindrocarpa Gamble

Kew Bull.: 318 (1910).

Distribution Peninsular Malaysia and Borneo (Sarawak).

Uses The wood is reputed to be used as medang.

Observations A medium-sized to large tree up to 42 m tall, bole up to 110 cm in diameter, bark surface smooth, with pock marks, grey-brown, inner bark yellow-brown, mottled; leaves alternate, 9–24 cm × 4–10 cm, blunt to rounded, powdery hairy on midrib and secondary veins on both surfaces, midrib raised above, with 6–12 pairs of secondary veins which are sunken above, tertiary venation closely scalariform, faint below, petiole 2–3.5 cm long; flowers in short racemose umbels on 0.5 cm long peduncles, with 8–13 stamens; fruit cylindrical-oblong, 2–2.5 cm × 0.5–0.9 cm, seated on a saucer-shaped perianth cup. *L. cylindrocarpa* is uncommon in lowland forest, but in Sarawak it may be found abundantly in secondary peat-swamp forest.

Selected sources 183, 316, 576, 703, 705.

Litsea densiflora (Teschner) Kosterm.

Reinwardtia 8: 91 (1970).

Synonyms *Actinodaphne densiflora* Teschner (1923).

Distribution Papua New Guinea including New Britain.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 24 m tall, bole branchless for up to 11 m; leaves 6–16 cm × 2–6.5 cm, obtuse, glabrous above, minutely tomentose below, midrib sunken above, with 6–8 pairs of secondary veins which are inconspicuous above, petiole 1–1.5 cm long; flowers in short racemose umbels on a 0.5 cm long peduncle, with 6 tepals and 9 stamens; fruit cylindrical-ellipsoid, up to 2.5 cm × 1 cm, seated on a small and very shallow perianth cup. *L. densiflora* is locally common in primary and secondary forest, sometimes on limestone, up to 1200 m altitude.

Selected sources 316, 322, 635.

Litsea domarensis O.C. Schmidt

C.T. White, Journ. Arn. Arb. 10: 215 (1929).

Distribution Papua New Guinea possibly including New Britain, and the Solomon Islands.

Uses The wood is used for mouldings, interior finish and light construction.

Observations A medium-sized tree up to 25 m tall, bole with spur buttresses; flowers in sessile umbellules in leaf axils and on leafless branches, with 6 tepals; fruit ellipsoid, c. 1.1 cm × 1 cm, seated on an enlarged pubescent cup. *L. domarensis* is an imperfectly known, apparently locally common canopy or sub-stage tree of hill and lower montane rain forest, up to 1000 m altitude. The density of the wood is about 465 kg/m^3 at 12% moisture content.

Selected sources 13, 145, 166, 316.

Litsea elliptica Blume

Bijdr. fl. Ned. Ind. 11: 563 (1826).

Synonyms *Litsea petiolata* Hook.f. (1886), *Litsea nigricans* (Meissn.) Boerl. (1900), *Litsea odorifera* Valeton (1909), *Litsea clarissae* (Teschner) Kosterm. (1968).

Vernacular names Indonesia: trawas, prawas (Sundanese, Java), gogisoro (Moluccas). Malaysia: medang perawas, medang terawas, medang tandok (Peninsular). Philippines: batikuling-surutan (general), magtagbak (Palawan). Thailand: thammang (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, Java, Borneo, the Philippines, Sulawesi, the Moluccas and New Guinea; probably occasionally planted in Java.

Uses The wood is used under cover, e.g. for general construction, but also for carving, sculpturing and pattern making. The aromatic leaves contain etherial oils and are used in traditional medicine against tumours, ulcers, and stomachache, and are applied to stimulate the lacteal glands. They yield safrole used as 'sarsaparilla' in the perfume and flavour-producing industry.

Observations A large tree up to 45 m tall, bole straight, cylindrical, up to 75 cm in diameter, with short buttresses up to 1 m high, bark surface smooth, lenticellate, rarely fissured or scaly, grey-brown, inner bark pinkish, with a strongly aromatic (lemon) smell; leaves arranged spirally, 6–14 cm × 2–7 cm, blunt to acuminate, glabrous, midrib usually sunken above, with 5–8 pairs of secondary veins which are sunken above, tertiary venation densely scalariform, faint below, petiole 1–3.5 cm long, channelled; flowers in shortly peduncled short racemes from leaf axils or on leafless twigs, with 6 tepals and 9–14 stamens; fruit globose to ellipsoid, 0.7–1.3 cm across. *L. elliptica* is widely distributed and occurs in primary and secondary lowland forest, occasionally also in hill and montane forest, usually up to 800 m altitude. The density of the wood, which has a characteristic odour, is 550–665 kg/m^3 at 15% moisture content.

Selected sources 36, 78, 140, 234, 316, 321, 322, 403, 414, 463, 529, 635, 705.

Litsea engleriana Teschner

Bot. Jahrb. Syst. 58: 398 (1923).

Synonyms *Litsea bernhardensis* Allen (1942).

Distribution New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized to large tree up to 43 m tall, bole up to 120 cm in diameter, with buttresses up to 1.2 m high, bark surface smooth to fissured, sometimes scaly with small flakes, pale reddish-brown to pale grey, inner bark brown or orange-brown; leaves alternate, 15–23 cm × 8–14 cm, acute to obtusely acuminate, glabrous above, pubescent below, midrib sunken above, with 8–10 pairs of secondary veins which are sunken above, tertiary venation scalariform, conspicuous below, petiole 3–4.5 cm long; flowers in umbellules in peduncled short axillary racemes, with 6 tepals and 12 stamens; fruit subglobose, c. 1 cm across. *L. engleriana* is locally dominant and occurs in primary and secondary forest, up to 1400 m altitude.

Selected sources 13, 316, 321, 322, 635.

Litsea erectinervia Kosterm.

Reinwardtia 8: 94 (1970).

Synonyms *Litsea ferruginea* auct. non Blume.

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, with buttresses up to 1.5 m high, bark surface dark brown; leaves arranged spirally, 10–31 cm × 4–8 cm, shortly acuminate, reddish-brown hairy below, midrib sunken above, with 8–15 pairs of secondary veins which are sunken above, tertiary venation inconspicuous on both sides, petiole 1–2 cm long; flowers in short racemes of umbellules on up to 8 mm long peduncles; fruit depressed globose, up to 1.7 cm across, embedded for the larger part in a hemispherical cup. *L. erectinervia* is uncommon in lowland forest, up to 100 m altitude.

Selected sources 322, 705.

Litsea euphlebia Merr.

Philipp. Journ. Sci., Bot. 12: 135 (1917).

Vernacular names Philippines: marang, matang-usa (Tagalog).

Distribution The Philippines.

Uses The wood is used as medang.

Observations A small tree up to 12 m tall; leaves alternate, 12–18 cm × 3–5.5 cm, glabrous, with 6–9 pairs of secondary veins which are very prominent on the lower surface, tertiary venation closely reticulate, not prominent, petiole 1–1.5 cm long; flowers in shortly peduncled fascicles of umbellules; fruit ellipsoid, c. 2 cm long, seated on a cup-shaped enlarged perianth. *L. euphlebia* is found in primary forest at low and medium altitudes.

Selected sources 316, 423, 426, 527.

Litsea fenestrata Gamble

Kew Bull.: 360 (1910).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 31 m tall, bole up to 85 cm in diameter, bark surface smooth, with large lenticels, greyish, inner bark yellowish; leaves alternate, 15–35 cm × 8–14 cm, blunt or rounded, glabrous, midrib flattened above, with 10–15 pairs of secondary veins which are slightly sunken above, tertiary venation reticulate, faint below, petiole 1–2.5 cm long; flowers in clusters on the twigs on c. 7 mm long peduncles, with 6 tepals and usually 12 stamens; fruit globose, c. 2.2 cm across, when young completely enclosed in the woody enlarged perianth cup. *L. fenestrata* is uncommon in lowland forest, also in swamp forest, up to 450 m altitude.

Selected sources 184, 316, 705.

Litsea ferruginea (Blume) Blume

Bijdr. fl. Ned. Ind. 11: 561 (1826).

Synonyms *Actinodaphne blumii* (Nees) Nees (1836), *Litsea blumii* (Nees) Hook.f. (1886), *Litsea griffithii* Gamble (1912).

Vernacular names Indonesia: huru meuhmal (Sundanese, Java). Malaysia: lelenga, medang pinang (Peninsular).

Distribution Peninsular Malaysia, Sumatra and western Java.

Uses The wood is used as medang, e.g. for house construction.

Observations A small to medium-sized tree up to 21 m tall, bole up to 50 cm in diameter, with short buttresses up to 1 m high, bark surface smooth, lenticellate, dark grey, inner bark yellow; leaves opposite, 6–21 cm × 3–9 cm, rounded to blunt, glabrous above, reddish-brown hairy below, midrib raised above, with 8–10 pairs of secondary veins which are joined near the margin, tertiary venation faint and inconspicuous on both sides, petiole 0.5–1.5 cm long; flowers in clusters from the twigs; fruit globose, c. 2 cm across, seated on a warty perianth cup. *L. ferruginea* is uncommon in primary lowland and hill forest, up to 1050 m altitude. The density of the wood is about 640 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 234, 316, 322, 705.

Litsea firma (Blume) Hook.f.

Fl. Brit. India 5: 162 (1886).

Synonyms *Litsea sibuyanensis* Elmer (1901).

Vernacular names Blue laurel (En). Indonesia: medang kuning belukar (Sumatra), medang miang (Belitung), medang sekem (Bangka). Malaysia: medang telur, medang kawan (Peninsular). Philippines: bakunib.

Distribution Peninsular Malaysia, Singapore, Sumatra, Borneo, the Philippines and Sulawesi.

Uses The wood is used as medang. It is used under cover, e.g. for house construction.

Observations A medium-sized to large tree up to 42 m tall, bole up to 80 cm in diameter, with buttresses up to 2.5 m high, bark surface smooth to scaly or dippled, lenticellate, yellowish-grey to brown, inner bark yellow; leaves alternate, 6–14 cm × 2.5–6 cm, rounded or blunt, softly hairy below, midrib sunken above, with 7–11 pairs of secondary veins which are sunken above, tertiary venation scalariform, prominent below, petiole 1–2 cm long; flowers in umbellules in short racemes from leaf axils and on leafless twigs; fruit ovoid-oblong, c. 1.5 cm × 1 cm, seated on a cup-shaped perianth. *L. firma* is common in primary and secondary lowland forest, up to 550 m altitude. The density of the wood is 495–570 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 74, 78, 104, 140, 206, 234, 316, 327, 364, 403, 426, 463, 529, 705.

Litsea fulva (Blume) Fernandez-Villar

Blanco, Fl. Filip., ed. 3, Nov. App. 181 (1880).

Synonyms *Tetranthera fulva* Blume (1851), *Tetranthera oppositifolia* Miq. (1853).

Vernacular names Philippines: batikuling (general), limbahan (Manobo).

Distribution Sumatra, Java and the Philippines.

Uses The wood is used as medang, and was formerly highly priced in the Philippines.

Observations A small tree up to 15 m tall, bole often curved and knotty, bark surface greyish, inner bark pale yellowish; leaves opposite or subopposite, 6–19 cm × 2–6 cm, acutely to obtusely acuminate, hairy on the main veins above, entirely hairy below, with 8–13 pairs of secondary veins which are prominent below, tertiary venation reticulate, prominent below, petiole 0.5–1.5 cm long; flowers in clustered almost sessile umbellules, with 4–6 tepals and 9–12 stamens; fruit ovoid, c. 1 cm long, on a small saucer-shaped perianth cup. *L. fulva* is fairly common in primary rain forest at low and medium altitudes, up to 1600 m.

Selected sources 36, 303, 316, 426, 427, 527.

Litsea glutinosa (Lour.) C.B. Robinson

Philipp. Journ. Sci., Bot. 6: 321 (1911).

Synonyms *Litsea chinensis* Lamk (1793), *Litsea glabraria* A.L. Juss. (1805), *Litsea tetranthera* (Willd.) Pers. (1807), *Litsea geminata* Blume (1826).

Vernacular names Indonesia: wuru lilin (Javanese, Java), huru tangkalak (Sundanese, Java), malih (western Kalimantan). Malaysia: malek (Peninsular). Philippines: sablot (general), balongai, porikit (Tagalog). Thailand: mimen (northern), muthaluang (Chanthaburi), thang-buan (Pattani).

Distribution From India through Indo-China towards the Malesian area where it occurs in all parts, and northern Australia; sometimes planted.

Uses The wood is used as medang, mainly in the Philippines, e.g. for house construction and agricultural implements. The fruits have a sweet creamy edible pulp. The seeds contain an aromatic oil which has been used to make candles and soap. The pounded seeds are also applied medicinally against boils. The leaves and the mucilage in the gum from the bark have been used for poultices. The bark also acts as a demulcent and mild astringent in diarrhoea and dysentery. The young leaves are eaten by livestock. Cut leaves release a mucilage which can be mixed with lime and sand to obtain a useful cement for general construction. The roots yield fibres used for rope manufacture and for paper pulp.

Observations A small to medium-sized tree up to 20 m tall, bole straight or curved, up to 60 cm in diameter, not buttressed, bark surface greyish-brown, inner bark yellowish; leaves arranged spirally, 10–30 cm × 3–13.5 cm, blunt or rounded, hairy on main veins above, yellowish hairy below, midrib raised or flattened above, with 6–11 pairs of secondary veins which are not sunken above, tertiary venation prominent below, petiole 1–3.5 cm long; flowers in umbellules arranged in racemes on a 0.7–2.5 cm long peduncle, with 0–3 tepals and 9–15 stamens; fruit depressed globose or globose, 1–2.5 cm across. Several varieties have been distinguished, but their status is uncertain. *L. glutinosa* is found in mixed primary and secondary forest and thickets, up to 1300 m altitude.

Selected sources 36, 68, 78, 125, 234, 303, 316, 321, 426, 463, 527, 528, 705.

Litsea gracilipes Hook.f.

Fl. Brit. India 5: 159 (1886).

Vernacular names Malaysia: medang kasai (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo.

Uses The wood is used as medang, e.g. in house construction.

Observations A medium-sized tree up to 21 m tall, bole up to 40 cm in diameter, with short buttresses or occasionally with stilt roots, bark surface smooth, lenticellate, with horizontal rings, dark brown or reddish-brown, inner bark yellow-brown but soon darkening on exposure; leaves opposite or subopposite, 7.5–12.5 cm × 2.5–5 cm, blunt or pointed, glabrous, midrib sunken above, with 6–8 pairs of secondary veins which are inconspicuous above, tertiary venation reticulate, faint below, petiole c. 0.7 cm long; flowers in umbellules in short racemes, with 4–6 tepals and 10 stamens; fruit cylindrical, c. 1.5 cm × 1 cm, seated on a saucer-shaped perianth cup. *L. gracilipes* is common in freshwater and peat-swamp forest. The density of the wood is about 425 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 245, 316, 427, 703, 705.

Litsea grandis (Wallich ex Nees) Hook.f.

Fl. Brit. India 5: 162 (1886).

Synonyms *Tetranthera multiflora* Miq. ex Zoll. (1854), *Litsea hirta* (Blume) Boerl. (1900), *Litsea ampla* Merr. (1917).

Vernacular names Great laurel (En). Malaysia: medang daun lebar (Peninsular), medang bulu (Sarawak). Philippines: puso-puso (Tagalog), sablot (Iloko), tioh (Bagobo). Thailand: kathang (general), muedaeng (Malay, Narathiwat), sangtong (Yala).

Distribution Burma (Myanmar), Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo and the Philippines.

Uses *L. grandis* is a fairly important source of medang and reportedly used for carving and furniture. Oil from the seeds is used for making hair cream.

Observations A medium-sized tree up to 30 m tall, bole up to 80 cm in diameter, bark surface smooth to cracking and scaly, lenticellate, grey-brown, inner bark pale brown and yellowish mottled; leaves alternate, 8–40 cm × 6–18 cm, rounded to blunt, hairy on the main veins above and throughout below, midrib sunken above, with 8–16 pairs of secondary veins which are sunken above, tertiary venation scalariform, prominent below, petiole 2–5 cm long; flowers in sessile umbellules, with 12–14 stamens; fruit ovoid, c. 1.5 cm × 1 cm, half enclosed in the cup-shaped perianth. *L. grandis* is common in lowland to montane forest, in peat swamps, in Thailand also in bamboo forest, up to 1500 m altitude. The density of the wood is 375–610 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 140, 245, 316, 322, 330, 529, 576, 595, 705.

Litsea irianensis Kosterm.

Bibl. Laurac.: 833 (1964).

Synonyms *Dehaasia novoguineensis* Kosterm. (1955).

Distribution Papua New Guinea.

Uses The wood is used as medang.

Observations A small to medium-sized tree up to 26 m tall, bole up to 60 cm in diameter; leaves alternate, 10–31 cm × 4–14 cm, apex with a long and slender acumen, midrib flattened above, prominent below, with c. 10 pairs of prominent secondary veins, tertiary venation fairly distinct, petiole 1.5–2.5 cm long; flowers unknown; fruit ellipsoid, up to 2.5 cm long, on a fleshy and thickened pedicel. *L. irianensis* occurs in secondary forest up to 1200 m altitude. The density of the wood is 480–560 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 310, 316, 731.

Litsea johorensis Gamble

Kew Bull.: 315 (1910).

Synonyms *Litsea trunciflora* Gamble (1910).

Vernacular names Malaysia: medang kunyit (Peninsular). Thailand: pae-ngu.

Distribution Peninsular Malaysia and Borneo; possibly also peninsular Thailand.

Uses The wood is used as medang, e.g. for house and boat building.

Observations A small tree up to 18 m tall, bole up to 40 cm in diameter; leaves alternate, 10–56 cm × 4–22 cm, pointed to rounded or emarginate, midrib sunken and sparsely hairy above, sparsely hairy or glabrous below, with 10–22 pairs of secondary veins which are sunken above, tertiary venation faint to distinct below, petiole 1.3–3.5 cm long; flowers borne on the trunk in clusters of umbellules on 1–1.5 cm long peduncles, with 6 tepals and 9–12 stamens; fruit ovoid, enclosed for at least half of its length in the enlarged perianth cup. *L. johorensis* is not common and occurs in lowland and montane forest, up to 1200 m altitude.

Selected sources 78, 183, 316, 322, 529, 705.

Litsea ledermannii Teschner

Bot. Jahrb. Syst. 58: 396 (1923).

Synonyms *Actinodaphne caesia* Teschner (1923).

Distribution The Moluccas and New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 32 m tall, bole up to 50 cm in diameter, with buttresses up to 1.5 m high, bark surface smooth, pale brown to reddish-brown, inner bark pale brown to whitish; leaves 7–21 cm × 2.5–6 cm, glabrous, midrib flattened above, with 9–18 pairs of secondary veins which are flattened above, petiole 1–2 cm long; flowers in umbellules in c. 5 cm long racemes, on short peduncles, with 6 tepals and 9–12 stamens; fruit unknown. *L. ledermannii* is locally common, up to 1000 m altitude.

Selected sources 316, 322, 635.

Litsea leytensis Merr.

Philipp. Journ. Sci., Bot. 10: 272 (1915).

Synonyms *Litsea obtusata* (Meissn.) Fernandez-Villar (1880).

Vernacular names Philippines: batikuling (general), balbonera, magarilau (Tagalog).

Distribution The Philippines.

Uses *L. leytensis* is an important source of medang in the Philippines. The wood is especially suitable for carving and pattern making. It has been widely used for ceilings and partitioning, and is easily converted into boards.

Observations A medium-sized tree up to 25 m tall, bole straight, cylindrical, up to 80 cm in diameter, with small buttresses, bark surface pale brown to grey; leaves alternate, 16–30 cm × 5.5–7 cm, blunt to rounded or slightly emarginate, glabrous, midrib raised above, with c. 11 pairs of secondary veins which are prominent above, tertiary venation reticulate, not prominent below, petiole 2–3 cm long; flowers in umbellules arranged in 5–10 cm long racemes on short peduncles on the bare twigs, with 6 tepals and 12 stamens; fruit ellipsoid-ovoid, c. 3 cm × 2 cm, covered up to halfway by the perianth cup. *L. leytensis* has become rare and occurs in forest at low and medium altitudes. The density of the wood is about 420 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 124, 125, 316, 414, 421, 426, 484, 527, 626.

Litsea luzonica (Blume) Fernandez-Villar

Blanco, Fl. Filip., ed. 3, Nov. App. 181 (1880).

Synonyms *Tetranthera luzonica* Blume (1851).

Vernacular names Philippines: dungoi (general), malasiko (Tagalog), pamayabasen (Iloko).

Distribution The Philippines.

Uses The wood is used as medang for general construction.

Observations A small to medium-sized tree; leaves 6.5–12.5 cm × 2–4 cm, acute or obtuse to mucronulate, midrib sunken above, tertiary venation indistinct above, petiole 6–8 mm long; flowers in clusters of 3-flowered umbellules, with 11-12 stamens. *L. luzonica* is still an imperfectly known species which occurs in forest at 100–1000 m altitude.

Selected sources 56, 316, 417, 426, 527.

Litsea machilifolia Gamble

Kew Bull.: 320 (1910).

Synonyms *Alseodaphne kochummenii* Kosterm. (1973).

Vernacular names Malaysia: medang keladi, medang ketukur, dada ruan (Peninsular).

Distribution Peninsular Malaysia and Borneo.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m tall, bole up to 65 cm in diameter, bark surface smooth to pustulate, reddish-brown, inner bark pinkish to reddish; leaves alternate, 6–22 cm × 2–7 cm, distinctly pointed with a long tip, glabrous, midrib prominent above, with 8–15 pairs of secondary veins which are faintly prominent on both surfaces, tertiary venation finely reticulate and faint below, petiole 1–2.5 cm long; flowers in racemes of umbellules on short peduncles, with 6–8 tepals and 9–13 stamens; fruit globose, 1–2 cm across, seated on a swollen and flattened perianth cup. *L. machilifolia* is fairly common in lowland and montane forest, up to 1500 m altitude. The density of the wood is 355–435 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 183, 316, 705.

Litsea magnifica (Miq.) Fernandez-Villar

Blanco, Fl. Filip., ed. 3, Nov. App.: 181 (1880).

Distribution Peninsular Malaysia and Sumatra.

Uses The wood is used as medang.

Observations A small tree; leaves variably crowded at the end of twigs, 23–45 cm × 6–23 cm, apex rounded and shortly pointed, reddish-brown hairy below but becoming glabrous, midrib sunken above, with 15–25 pairs of secondary veins which are sunken above, tertiary venation scalariform reticulate, faint to distinct below, petiole 1–2 cm long; flowers in peduncled umbellules usually from the trunk; fruit ovoid, c. 1 cm long, seated on a perianth cup with smooth to slightly wavy margin. *L. magnifica* is locally frequent in lowland and hill forest. See also the table on wood properties.

Selected sources 364, 705.

Litsea maingayi Hook.f.

Fl. Brit. India 5: 175 (1886).

Distribution Peninsular Malaysia.

Uses The wood is used as medang.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 90 cm in diameter, slightly fluted, sometimes with short buttresses, bark surface smooth to slightly scaly, lenticellate, grey-brown, inner bark pale brown; leaves arranged spirally, 15–40 cm × 3.5–12 cm, pointed with a distinct tip, glabrous, midrib flattened above, with 8–12 pairs of secondary veins which are sunken above and joined into a looped intramarginal vein, tertiary venation scalariform, faint below, petiole (2–)4–6 cm long; flowers in peduncled umbellules arranged in 6–10 cm long racemes, with 6–8 tepals and 12 stamens; fruit oblong, c. 3 cm × 1.5 cm, the lower half enclosed in a perianth cup with wavy margin. *L. maingayi* is uncommon in lowland and hill forest.

Selected sources 245, 463, 529, 705, 734.

Litsea maluensis Teschner

Bot. Jahrb. Syst. 58: 395 (1923).

Synonyms *Litsea gilgiana* Teschner (1923).

Distribution New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 25 m tall, bole up to 90 cm in diameter; leaves 5–11 cm × 2–5 cm, obtuse, glabrous, midrib sunken above, with 4–8 pairs of secondary veins which are sunken above, tertiary venation finely reticulate, petiole 1–2 cm long; flowers in peduncled umbellules in short racemes, with 6 tepals and 9–12 stamens; fruit elongated ellipsoid, seated on a small flat perianth cup. *L. maluensis* is rather uncommon in primary and secondary forest, up to c. 1500 m altitude.

Selected sources 316, 322, 635.

Litsea monopetala (Roxb.) Persoon

Syn. pl. 2: 4 (1807).

Synonyms *Tetranthera monopetala* Roxb. (1798), *Litsea polyantha* A.L. Juss. (1805), *Tetranthera alnoides* Miq. (1853).

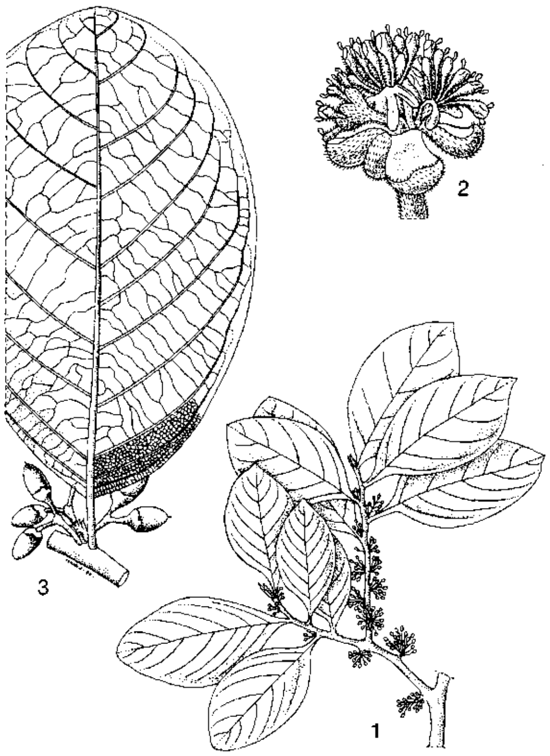
Vernacular names Indonesia: huru koneng, huru manuk (Sundanese, Java), gempur (Javanese, Java). Malaysia: medang busok, bangang (Peninsular). Burma (Myanmar): ondon laukya. Thailand: kathang (peninsular).

Distribution India, Burma (Myanmar), throughout Indo-China, Thailand, Peninsular Malaysia and Java.

Uses The wood is used as medang, e.g. for planks and tool handles. The seeds contain an oil which is used medicinally in India. The leaves are the principal food of the muga silkworm (*Antheraea assama*) in India and are used for fodder in Nepal.

Observations A small tree up to 18 m tall, bole straight to crooked, up to 60 cm in diameter, bark surface longitudinally fissured, dark greyish, inner bark brown mottled; leaves alternate, 4.5–17 cm × 2.5–10 cm, blunt to acute, glabrous above, sparsely hairy below, midrib sunken above, with 6–13 pairs of secondary veins which are sunken above, tertiary venation scalariform, distinct below, petiole 1–2.5 cm long; flowers in peduncled umbellules in short racemes, with (4–)6 tepals and 9–12 stamens; fruit oblong to ellipsoid, 0.7–1.2 cm long, seated on a small flat perianth cup. *L. monopetala* is locally common in mixed lowland and montane evergreen or semi-deciduous forest, up to 1500 m altitude. *L. polyantha* is sometimes regarded as a distinct species. The density of the wood is about 540 kg/m^3 at 15% moisture content.

Selected sources 36, 78, 89, 140, 234, 303, 316, 529, 705.



Litsea monopetala (Roxb.) Persoon – 1, flowering twig; 2, umbellule of flowers; 3, branchlet with leaf and infructescence.

Litsea myristicaefolia (Wallich ex Nees) Hook.f.

Fl. Brit. India 5: 168, 172 (1886).

Vernacular names Nutmeg laurel (En). Malaysia: medang bunga, medang hitam (Peninsular). Burma (Myanmar): pgu thyn try. Thailand: trit (Trang), takhrai (Chanthaburi).

Distribution Peninsular Burma (Myanmar), peninsular Thailand, Peninsular Malaysia and Singapore.

Uses The wood is used as medang, e.g. for house building.

Observations A medium-sized tree up to 27 m tall, bole up to 60 cm in diameter, with short buttresses up to 1 m high, bark surface smooth to scaly, lenticellate, grey-brown, inner bark reddish; leaves alternate or arranged spirally, 8–20 cm × 3.5–7 cm, blunt or rarely pointed, glabrous, midrib sunken above, with 7–10 pairs of secondary veins which are faint or sunken above, tertiary venation reticulate, inconspicuous on both surfaces, petiole 1.3–3 cm long; flowers in clustered umbellules on c. 1.5 cm long peduncles, with 6 tepals and 10–12 stamens; fruit globose, c. 1 cm across, the lower part covered by an obpyriform perianth cup. *L. myristicaefolia* is fairly common in lowland to montane forest, up to 1200 m altitude. The density of the wood is 390–585 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 245, 316, 529, 705.

Litsea nidularis Gamble

Kew Bull.: 365 (1910).

Vernacular names Malaysia: medang tandok, medang sesudu, medang miang (Peninsular).

Distribution India and Peninsular Malaysia.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 30 m

tall, bole up to 120 cm in diameter, with buttresses up to 2 m high, bark surface smooth to dippled, silvery grey-brown, inner bark yellowish-orange, mottled; leaves arranged spirally, 10–30 cm × 4–10 cm, rounded, glabrous, midrib flattened above, with 8–12 pairs of secondary veins which are faint or sunken above, tertiary venation finely reticulate, distinct below, petiole 1.5–3 cm long; flowers in up to 10 cm long racemes of umbellules on c. 0.5 cm long peduncles, with 4–8 tepals and 12(–16) stamens; fruit globose, c. 1.3 cm across. *L. nidularis* is not uncommon in lowland and hill forest, up to 650 m altitude. The density of the wood is about 405 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 184, 316, 529, 703, 705.

Litsea ochracea (Blume) Boerl.

Handl. fl. Ned. Ind. 3: 144 (1900).

Distribution Peninsular Malaysia, Sumatra, Borneo and southern Sulawesi (Salayar).

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 28 m tall, bole up to 85 cm in diameter; leaves alternate, 12–18 cm × 4–8 cm, pointed, glabrous, midrib flattened above, with 7–10 pairs of secondary veins which are sunken above, tertiary venation scalariform, faint below, petiole 1–2 cm long; flowers in peduncled racemes of umbellules, with 9–12 stamens; fruit globose, covered in the lower half by a tuberculate perianth cup with a wavy margin. Two varieties are distinguished: var. *ochracea* and var. *oblanceolata* (Gamble) Kochummen (synonym *L. oblanceolata* Gamble). The latter is rare in Peninsular Malaysia and differs in having oblanceolate leaves and the flowers in sessile umbellules. *L. ochracea* is found in lowland and hill forest.

Selected sources 316, 529, 705.

Litsea penangiana Hook.f.

Fl. Brit. India 5: 171 (1886).

Distribution Peninsular Malaysia.

Uses The wood is used as medang, and because of its small size it is only suitable for e.g. poles and posts. The pounded leaves have been used in traditional medicine.

Observations A shrub or small tree up to 9 m tall, bole up to 15 cm in diameter; leaves alternate, (6.5–)12–24 cm × (3–)5–8 cm, usually blunt, finely hairy on the main veins below, midrib slightly raised to flattened above, with 5–10 pairs of secondary veins which are faint above, tertiary venation reticulate and faint on both surfaces, petiole 1–2.5 cm long; flowers in clustered, almost sessile umbellules; fruit ellipsoid, c. 2 cm × 1.3 cm, covered in the basal half by the perianth cup. *L. penangiana* occurs frequently in hill and montane forest, up to 1200 m altitude.

Selected sources 78, 316, 529, 705.

Litsea philippinensis Merr.

Philipp. Journ. Sci., Bot. 4: 260 (1909).

Vernacular names Philippines: bakan (general), marang, batsan (Tagalog).

Distribution The Philippines.

Uses The wood is used as medang, e.g. for carving and house building.

Observations A small to medium-sized tree up to 20 m tall; leaves alternate, 10–20 cm × 5–10 cm, rounded to acute, glabrous or the midrib pubescent above, glabrous or the main veins pubescent below, with 12–15 pairs of secondary veins which are very prominent below, tertiary venation reticulate, prominent below, petiole 1–2.5 cm long; flowers in umbellules, fascicled or arranged in short racemes, with 6 tepals and 12 stamens; fruit oblong-ovoid, c. 3.5 cm long, seated on an accrescent cup-shaped perianth. *L. philippinensis* is found in primary forest at low and medium altitudes.

Selected sources 316, 414, 418, 426, 527, 595.

Litsea pruriens Kosterm.

Reinwardtia 8: 105 (1970).

Distribution Northern Sumatra and Borneo.

Uses The wood is used as medang.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 60 cm in diameter, with short buttresses up to 1 m high, bark surface smooth, brown to pale brown, inner bark pale brown to whitish; leaves arranged spirally, (2.5–)4.5–8.5 cm × (6–)10–17 cm, shortly acuminate, glabrous except for the main veins above, tomentose below, midrib sunken above, with 8–9 pairs of secondary veins which are sunken above, tertiary venation scalariform, petiole 2.5–4 cm long; flowers in umbellules on 6–7 mm long peduncles; fruit subglobose. *L. pruriens* is still an insufficiently known species occurring near rivers, up to 350 m altitude.

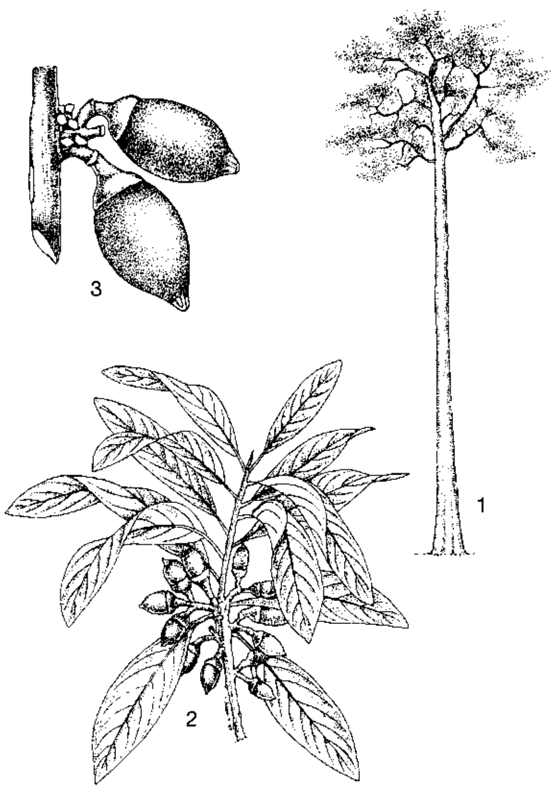
Selected sources 322.

Litsea resinosa Blume

Bijdr. fl. Ned. Ind. 11: 562 (1826).

Synonyms *Litsea pantjara* (Blume) Boerl. (1900), *Litsea monticola* Gamble (1910).

Vernacular names Indonesia: huru pancar



Litsea resinosa Blume – 1, tree habit; 2, fruiting twig; 3, branchlet with fruits.

(Sundanese, Java), nyampu tjombar (Javanese, Java), medang bedaka (Belitung). Malaysia: medang sesudu (Peninsular). Thailand: thammangphokrong.

Distribution Peninsular Malaysia, Java and Borneo; possibly also peninsular Thailand.

Uses The wood is used as medang, e.g. for house building.

Observations A medium-sized to large tree up to 46 m tall, bole up to 150 cm in diameter, sometimes with short buttresses or stilt roots, bark surface smooth with distant fissures, lenticellate, grey, inner bark pale reddish-brown; leaves alternate, 7–25 cm × 2.5–12 cm, usually shortly acuminate, glabrous, midrib flattened above, with 7–12 pairs of secondary veins which are sunken above, tertiary venation scalariform, very faint below, petiole 1–3 cm long; flowers in racemose umbellules on up to 2 cm long peduncles, with 6 tepals and (8–)9–12(–15) stamens; fruit ovoid to ovoid-ellipsoid, 2–3.5 cm × 1–1.5 cm, seated on a saucer-shaped perianth cup. *L. resinosa* is fairly common in lowland and montane forest, especially in swamp forest and peat-swamp forest, up to 2400 m altitude. The density of the wood is about 465 kg/m^3 at 15% moisture content.

Selected sources 36, 78, 140, 218, 234, 303, 316, 529, 703, 705.

Litsea robusta Blume

Bijdr. fl. Ned. Ind. 11: 560 (1826).

Vernacular names Indonesia: huru tangkalak (Sundanese, Java), nyampu gombor (Javanese, Java). Malaysia: medang sangkak (Peninsular). Burma (Myanmar): bmo-kta-slwn.

Distribution Peninsular Burma (Myanmar), Peninsular Malaysia, Singapore and Java.

Uses The wood is used as medang, e.g. for furniture.

Observations A medium-sized to fairly large tree up to 36 m tall, bole straight, up to 85 cm in diameter, bark surface smooth, with many corky lenticels, fawn brown to dark greyish, inner bark greenish-brown to pale brown; leaves arranged spirally, 10–52 cm × 7.5–18(–25) cm, rounded to pointed, glabrous, midrib flattened above, with 16–22 pairs of secondary veins which are prominent above, tertiary venation scalariform reticulate, faint on both surfaces, petiole 1.5–6 cm long; flowers in umbellules in c. 10 cm long racemes, with 5 tepals and 12 stamens; fruit globose to depressed globose, c. 2 cm across, covered in the lower half by the warty perianth cup. *L. robusta* occurs in primary forest, often along streams, at 400–1500 m altitude.

Selected sources 36, 78, 234, 303, 316, 529, 705.

Litsea spathacea Gamble

Kew Bull.: 358 (1910).

Distribution Peninsular Malaysia.

Uses The wood is used as medang, e.g. for house construction and poles.

Observations A small tree up to 15 m tall, bole up to 30 cm in diameter; leaves alternate, 8–29 cm × 4–12 cm, blunt or rarely pointed, glabrous, midrib flattened or sunken above, with 9–14 pairs of secondary veins which are faint above, tertiary venation scalariform reticulate, conspicuous below, petiole 0.5–2.5 cm long; flowers in short or rarely 6 cm long racemes of sessile or shortly peduncled umbellules, with 9–12 stamens; fruit ovoid to ellipsoid, c. 2.5 cm × 1.5 cm, seated on a shallow perianth cup with a wavy margin. *L. spathacea* is common in lowland and hill forest, up to 1000 m altitude. Var. *tomentosa* Gamble is distinguished on the basis of its rusty dense pubescence on the twigs and lower leaf surface; it is rare in Peninsular Malaysia.

Selected sources 184, 316, 529, 705.

Litsea teysmannii Gamble

Kew Bull.: 319 (1910).

Vernacular names Malaysia: medang kelur (Peninsular).

Distribution Peninsular Malaysia, Bangka and Borneo (Sarawak).

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 21 m tall, bole up to 50 cm in diameter, bark surface smooth, lenticellate, grey-brown, inner bark brown; leaves alternate, 7–17 cm × 2.5–6.5 cm, obtuse to abruptly caudate-acuminate, glabrous, midrib sunken above, with 8–12 pairs of secondary veins which are faint on both surfaces, tertiary venation reticulate, distinct below, petiole 1.5–3 cm long; flowers in up to 6 cm long racemes of almost sessile umbellules, with 12 stamens; fruit globose, c. 2 cm across, seated on a rugose saucer-shaped perianth cup. *L. teysmannii* occurs locally common in swamp forest, especially in peat swamps, at low altitude. The density of the wood is about 460 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 183, 316, 427, 529, 705.

Litsea timoriana Span.

Hook., Comp. Bot. Mag. 1: 350 (1836).

Synonyms *Litsea pallida* (Blume) Boerl. (1900), *Litsea tuberculata* (Blume) Boerl. (1900), *Litsea stickmanii* Merr. (1917), *Litsea kauloensis* Teschner (1923).

Vernacular names Indonesia: halaur pantai, halaur putih (Ambon).

Distribution Sumatra, Java, the Lesser Sunda Islands, Sulawesi, the Moluccas, New Guinea and the Solomon Islands.

Uses The wood is used as medang, especially for prahus; in the Solomon Islands also for house building. Bark macerated in water is applied to soothe sore legs.

Observations A small to medium-sized tree up to 20 m tall, bole straight, bark surface smooth, lenticellate, narrowly hoop-marked, brown to greenish, inner bark brown; leaves alternate, 8–23 cm × 2.5–10 cm, obtuse to obscurely acuminate, glabrous, midrib flattened or slightly sunken above, with 5–8 pairs of secondary veins which are slightly prominent above, tertiary venation reticulate, slightly prominent below, petiole 1–2.5 cm long; flowers in solitary or clustered umbellules on a 0.5–1.5 cm long peduncle, with (4–)6 tepals and 9–12 stamens; fruit ellipsoid to oblong with a flattened apex, c. 1.5 cm long, covered up to halfway by a warty perianth cup. *L. timoriana* is generally uncommon but is locally common in mixed forest, also in periodically flooded locations, often at low altitude but sometimes up to 1200 m. The wood apparently has a very low density and splits very easily, but is reported to be fairly durable.

Selected sources 13, 36, 303, 316, 321, 327, 422, 635.

Litsea tomentosa Blume

Bijdr. fl. Ned. Ind. 11: 566 (1826).

Synonyms *Litsea cuneata* (Blume) Boerl. (1900), *Litsea membranacea* Elmer (1908), *Litsea grandifolia* Teschner (1923).

Vernacular names Indonesia: huru meuhmal, huru leksa (Sundanese, Java), wuru lutung (Javanese, Java). Philippines: marabaan (Bagobo), tauako (Igorot). Burma (Myanmar): ava.

Distribution Peninsular Malaysia, Java, Borneo, the Philippines, Sulawesi and New Guinea; possibly also Burma (Myanmar).

Uses The wood is used as medang, e.g. for house construction.

Observations A medium-sized tree up to 27 m tall, bole up to 50 cm in diameter, with short buttresses up to 1.5 m high, bark surface smooth, dark brown, inner bark orange-brown; leaves arranged spirally, 9–50 cm × 3–21 cm, obtuse to shortly acuminate, glabrous above except for the midrib, densely hairy below, midrib flattened above, with 8–18 pairs of secondary veins which are prominent below, tertiary venation reticulate, raised below, petiole 0.5–5 cm long; flowers in short racemes of umbellules on 1–2 cm long peduncles, with 6–9 tepals and 20–24 stamens; fruit ellipsoid, c. 3 cm × 2 cm, seated on a shallow cup-shaped perianth with irregularly toothed margin. *L. tomentosa* occurs infrequently but is widely distributed in lowland and hill forest, up to 1500 m altitude. The density of the wood is 700–750 kg/m^3 at 15% moisture content.

Selected sources 36, 78, 140, 234, 303, 316, 321, 327, 330, 426, 529, 635, 705.

Litsea turfosa Kosterm.

Reinwardtia 7: 353 (1968).

Distribution Borneo.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 27 m tall, bole branchless for up to 17 m, up to 30 cm in diameter, bark surface smooth, lenticellate, pale grey or pale brown, inner bark orange or white and yellow mottled; leaves arranged spirally, 6–16 cm × 3–8 cm, obtuse or rarely shortly obtusely acuminate, glabrous above, densely rufo-lanuginose but glabrescent below, midrib sunken above, with 5–6(–7) pairs of secondary veins which are prominent below, tertiary venation scalariform, faint below, petiole up to 2 cm long; flowers in umbellules on up to 1.5 cm long peduncles; fruit ellipsoid, pointed, c. 0.6 cm long, seated on an up to 4 mm high perianth cup. *L. turfosa* is found in peat-swamp forest, up to 70 m altitude.

Selected sources 318.

Litsea umbellata (Lour.) Merr.

Philipp. Journ. Sci., Bot. 14: 242 (1919).

Synonyms *Litsea hexantha* A.L. Juss. (1805), *Litsea amara* Blume (1826), *Litsea utilis* (Meissn.) Boerl. (1900).

Vernacular names Common laurel (En). Indonesia: huru bodas, ki pecel (Sundanese, Java), wuru emprit (Javanese, Java). Malaysia: isop nanah, medang mayang (Peninsular). Thailand: salot (Chanthaburi), mentru (Khmer-Chanthaburi), satua (Trat).

Distribution From India through Indo-China towards Peninsular Malaysia, Sumatra, Borneo, Java, Sulawesi and northern Australia.

Uses The wood is used as medang, e.g. for house building, boats and tool handles. The leaves are applied to poultice boils. The bark is poisonous because of an alkaloid; it is therefore durable and has been used for outer walls.

Observations A small tree up to 14 m tall, bole up to 35 cm in diameter, bark surface smooth, greyish, inner bark pale brown; leaves alternate, 4.5–18 cm × 2–7.5 cm, blunt to pointed, hairy, midrib sunken above, with 7–15 pairs of secondary veins which are rarely sunken above, tertiary venation scalariform, prominent below, petiole 0.5–1.5 cm long; flowers in clusters or short racemes of peduncled umbellules, with 9 stamens; fruit ellipsoid, 0.7–1.0 cm long, seated on a 4–6-lobed perianth cup. *L. umbellata* is common in lowland forest and thickets, up to 1200 m altitude. The density of the wood is about 770 kg/m^3 at 15% moisture content, but has also been reported to be very low.

Selected sources 36, 78, 104, 140, 234, 303, 316, 321, 322, 463, 529, 705.

Litsea versteeghii Allen

Journ. Arn. Arb. 23: 122 (1942).

Distribution New Guinea.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 26 m tall, bole branchless for up to 20 m, up to 40 cm in diameter, with short buttresses, bark surface smooth to shallowly fissured, greenish-brown, inner bark yellow turning brown; leaves alternate, c. 10.5 cm × 4–5.5 cm, rounded to obtuse, glabrous except for the midrib above, densely pubescent below, midrib sunken, with 5–7 pairs of secondary veins which are sunken above, tertiary venation reticulate, conspicuous below, petiole c. 1.5 cm long; flowers in c. 6.5 cm long racemes of umbellules on c. 1 cm long peduncles; fruit seated on a small flat perianth cup abruptly narrowed into the pedicel. *L. versteeghii* is still an incompletely known species of primary and secondary forest, sometimes on clay soil, up to 2900 m altitude.

Selected sources 13, 316, 323.

Litsea wrayi Gamble

Kew Bull.: 319 (1910).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as medang.

Observations A medium-sized tree up to 25 m tall, bole up to 60 cm in diameter; leaves alternate, 8–17 cm × 2–6 cm, acuminate, glabrous, midrib flattened above, with 10–13 pairs of secondary veins which are raised above, tertiary venation reticulate, faint below, petiole 1.5–2.5 cm long; flowers in clusters or short racemes of umbellules on 4–6 cm long peduncles, with 6 tepals and 12 stamens; fruit globose, c. 1 cm across, covered for more than half by the spotted perianth cup. *L. wrayi* occurs locally in lowland and hill forest, up to 450 m altitude.

Selected sources 183, 316, 529, 705.

I. Soerianegara (general part),
H.C. Sim (properties),
Y.F. Ho (wood anatomy),
M.S.M. Sosef (selection of species)

Mangifera L.

Sp. pl. 1: 200 (1753); Gen. pl. ed. 5: 93 (1754).

ANACARDIACEAE

x = unknown; *M. caesia*, *M. caloneura*, *M. foetida*, *M. indica*, *M. sylvatica*: $2n = 40$

Trade groups Machang: lightweight to medium-weight hardwood, e.g. *Mangifera foetida* Lour., *M. indica* L., *M. laurina* Blume, *M. minor* Blume, *M. monandra* Merr.

Vernacular names Machang: mangowood (En). Indonesia: membacang. Malaysia: asam (Sabah), bachang (Sarawak). Philippines: paho. Burma (Myanmar): thayet. Thailand: mamuang. Vietnam: xo[af]i.

Origin and geographic distribution *Mangifera* consists of about 60 species and is distributed from India and Sri Lanka, through Burma (Myanmar), Indo-China, southern China, Thailand, the Andaman Islands and throughout Malesia, to the Solomon Islands and Micronesia. Western Malesia is richest in species: Peninsular Malaysia, Sumatra and Borneo each have about 30 species. The number of species endemic to one island or archipelago is notably small.

Uses Machang wood is used for light construction or more heavy construction under cover, planking, ceiling, door panels, interior finish, flooring, mouldings, packing boxes, crates, good quality charcoal, gunstocks, and veneer and plywood. The heartwood is often beautifully streaked and is then particularly suitable for high-class furniture and joinery. Locally (e.g. in India) the wood is used for tea chests, canoes, oar blades and implements. In Java, the old wood was formerly used for making 'lumpang' or 'lesung', traditional implements used to dehusk rice. The wood is also used to culture mushrooms.

Many species are primarily planted for their edible fruits (the well-known mangoes), especially *M. indica* and *M. odorata*. The fruits are eaten fresh or as an ingredient of pickles, chutneys, juices and pastes. Seed kernels are sometimes used to feed animals. Young leaves are eaten fresh or cooked as a vegetable. Various parts of the plants (particularly bark, dried flowers and fruits) are used medicinally as astringents and against itch, skin burns and snake bites. The bark yields a dye.

Production and international trade The export of machang is not very important, except from Borneo, from where fairly large amounts are exported. In 1987, the export of round logs of machang from Sabah was 40 000 m^3 with a value of US$ 2.5 million; in 1992, the export was 38 000 m^3 (57% as sawn timber, 43% as logs) with a total value of US$ 5.7 million (US$ 205/m^3 for sawn timber and US$ 77/m^3 for logs). Japan imports small amounts of machang timber from Sabah and Sarawak.

Properties Machang is a lightweight to medium-weight hardwood. The heartwood is pale yellowish-brown or pinkish-brown to dark pinkish-brown or reddish-brown, sometimes with silvery lustre and mottled figure; black streaks are sometimes present in the heartwood. The sapwood is usually indistinctly demarcated from the heartwood, but is sometimes distinctly demarcated when streaked heartwood is present. The density is (410–)450–800 kg/m^3 at 15% moisture content. The grain is straight to interlocked or wavy, texture moderately fine to moderately coarse and even.

At 12% moisture content, the modulus of rupture is 88.5–90(–110) N/mm^2, modulus of elasticity 10 900–14 300(–15 400) N/mm^2, compression parallel to grain 43–51.5(–55) N/mm^2, compression perpendicular to grain c. 6 N/mm^2, shear 9–13 (–14) N/mm^2, cleavage c. 60.5 N/mm tangential and Janka side hardness 4360–4860(–6250) N.

The rates of shrinkage are small to medium: from green to 15% moisture content 0.9–1.2% radial and 1.8–1.9% tangential, from green to 12% moisture content c. 1.8% radial and 3.1% tangential, and from green to oven dry c. 3.0% radial and 4.9% tangential. The wood dries fairly rapidly with slight seasoning defects; it is sometimes subject to cupping or bowing, and it may be liable to staining. Boards 12 mm thick take 2–3 months to air dry, boards 25 mm thick take 2.5–3.5 months and boards 40 mm thick take 3–4 months. The wood kiln dries easily by fairly fast schedules; in Malaysia kiln schedule F is recommended. It is stable in service.

The wood saws fairly well, although excessive tension wood may cause jamming and extreme woolliness in some logs. It is generally easy to plane, with smooth tangential surfaces but often rough radial surfaces. Slight picking-up of grain is common when planing, turning and moulding wavy-grained wood. The wood is difficult to easy to bore and mortises well, but it shows scratches from sanding unless a fine grit is used for the final finish. Filling is required to obtain good results in finishing and polishing. The resistance to splitting when nailed is rated as excellent. A test in Malaysia showed moderately good results for peeling: veneers of 0.8 mm and 1.6 mm could be produced easily, but they had a tendency to curl and wrinkle during drying; the gluability was rated as satisfactory.

Machang wood is classified as non-durable under exposed conditions or in contact with the ground. In graveyard tests in Malaysia untreated stakes of *M. foetida* lasted less than 2 years. The wood is liable to subterranean and drywood termite attack and fungal attack and during seasoning sometimes also to powder-post beetle attack. Both sapwood and heartwood are, however, easy to moderately easy to treat with preservatives. In Malaysia, an absorption of 320 kg/m^3 was obtained for

M. indica wood using an open tank treatment and an equal mixture of creosote and diesel fuel; for *M. foetida* wood the absorption was 128 kg/m^3. Treated wood is very durable.

Wood of *M. altissima* contains 54% cellulose, 31% lignin and 0.7% ash. The solubility is 2.2% in cold water, 5.2% in hot water and 13.5% in a 1% NaOH solution.

The sap from the bark of several species has irritant properties; fruits sometimes also contain an irritant exudate. The main irritating constituent is an allergenic urushiol, 5-heptadecenylresorcinol.

Description Medium-sized to large, evergreen but sometimes deciduous trees up to 45(–54) m tall, usually with straight long clear bole, branchless for up to 25 m and up to 120(–150) cm in diameter; buttresses usually absent (sometimes very small buttresses present, rarely up to 2 m tall); bark surface smooth in young trees, later becoming longitudinally fissured, inner bark with strong turpentine odour, yellowish, pinkish, orange or reddish to brownish, with colourless, white or reddish-brown exudate drying brown or black; crown dense, usually rounded; twigs smooth, cylindrical or sharply angled, dark green (drying blackish or reddish-brown), often with large leaf scars. Leaves arranged spirally, often clustered towards the apex of twigs, simple, entire, usually glabrous, often with long petioles swollen at base; stipules absent; young leaves periodically flushing, pendulous, yellowish to brownish-purple. Inflorescence pseudo-terminal and/or axillary, paniculate, pyramidal or conical in outline; main peduncle often thick and stout (but sometimes not developed and then side branches all crowded at the base of the inflorescence), varying in colour from white to pale green or violet-red. Flowers small, male or bisexual (both types present on the same tree), 4-merous or 5-merous, often sweet scented, usually short-pedicelled, pedicel with articulation at base; sepals free, usually acute and rather stiff, puberulous or glabrous, green, yellow or red; petals imbricate in bud, free or rarely slightly connate at base, much longer than sepals, white, yellowish, pink or red, often changing in colour after anthesis, with ridges (mostly yellow) confluent at base on the inner side (forming a tree-like structure), tips of ridges often free of petal surface and gland-like, petals usually reflexed where ridges end; disk present, extrastaminal, rarely intrastaminal, cushion-shaped, papillose and more or less distinctly divided into 4–5 lobes, or narrow and stalk-like and not distinctly papillose; stamens usually 4–5, rarely 10, often 1–2(–5) fertile and the others reduced, free or filaments united at base, anthers dorsifixed, 2-locular and longitudinally introrsely dehiscent; ovary superior, seated on the disk, asymmetrical, 1-locular with one anatropous ovule, style 1, usually lateral, with small stigma; male flowers with 1–5 fertile stamens (often 1), other stamens staminodal, and with a completely abortive or much-reduced pistil; bisexual flowers slightly larger than male flowers, with 1 or more fertile stamens, staminodes present or absent, and with a well-developed pistil. Fruit a kidney-shaped, globose or cylindrical drupe, with fleshy pulp (in cultivars thick and sweet) and woody or fibrous stone. Seed with plano-convex cotyledons, sometimes strongly folded ('labyrinthine'), albumen lacking. Seedling mostly with hypogeal germination, cotyledons usually non-emergent, hypocotyl very occasionally slightly elongated, first two leaves opposite, subsequent leaves arranged spirally.

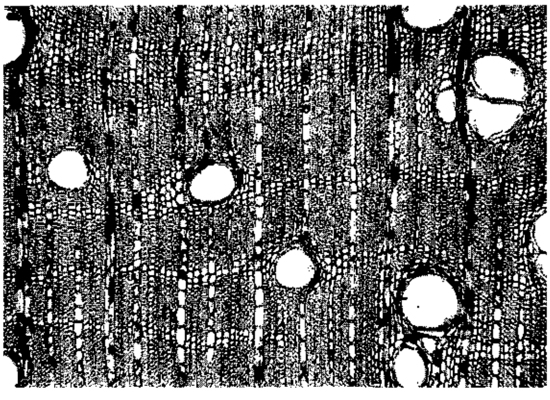
Wood anatomy

– Macroscopic characters:

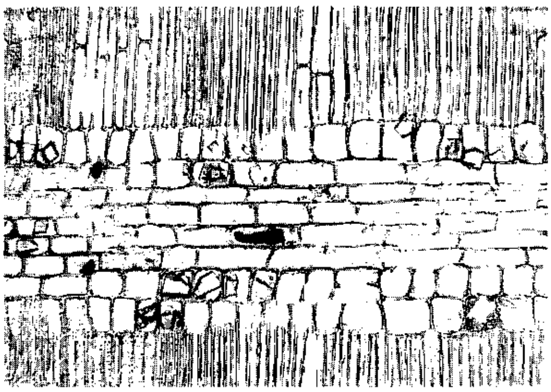
Heartwood pale yellowish-brown to reddish-brown, darkening on exposure, not clearly demarcated from the pale yellowish-brown sapwood. Grain somewhat wavy. Texture moderately coarse; freshly cut wood scentless. Growth rings indistinct or absent; vessels visible to the naked eye, locally filled with a dark red-brown mass, tyloses rather abundant; banded parenchyma distinct; rays only conspicuous (brown deposits in cells) on radial surfaces; resin ducts and ripple marks absent.

– Microscopic characters:

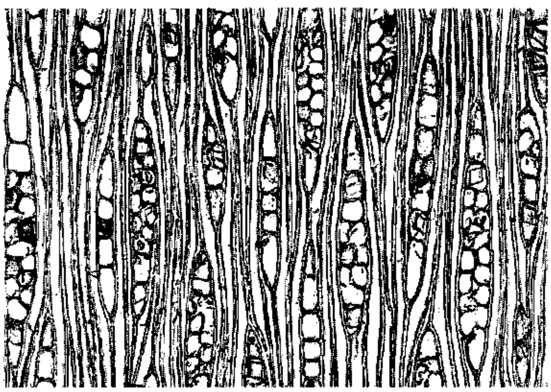
Growth ring boundaries indistinct, marked by marginal parenchyma bands, or absent. Vessels diffuse, 3(–4)/mm^2, solitary and less often in radial multiples of 2–3, rarely in clusters, round to oval, average tangential diameter 100–200 μm; perforation plates simple; intervessel pits dense, alternate, polygonal, 8–11 μm; vessel-ray and vessel-parenchyma pits less numerous, large, half-bordered to almost simple, 8–25 μm; dark reddish-brown deposits locally present; tyloses commonly present. Fibres 600–800 μm long, non-septate, thin-walled to thick-walled, with numerous, small, slit-like, simple pits almost entirely confined to the radial walls. Axial parenchyma paratracheal, banded and rarely apotracheally diffuse; paratracheal parenchyma vasicentric to slightly winged-aliform, vasicentric parenchyma one to several layers thick where vessels are not bordering upon rays; banded parenchyma irregularly



transverse section (×25)



radial section (×75)



tangential section (×75)

Mangifera indica

zonate, 1–8(–20) cells wide, also marginal, in 2–4-celled strands. Rays 6–9/mm, 1–3-seriate (3-seriate rays rarely present), up to 10–15(–25) cells high, almost entirely composed of procumbent body cells and only 1(–3) rows of square and/or upright marginal cells. Crystals prismatic, in ray parenchyma cells, sometimes in axial parenchyma cells; usually one crystal per cell, but in ray parenchyma cells also 2(–3) per cell, especially in marginal cells; yellowish-brown contents present in ray parenchyma cells, less frequently in axial parenchyma cells. Silica absent. Radial intercellular canals absent or present, axial intercellular canals absent.
Species studied: *M. foetida*, *M. gedebe*, *M. indica*, *M. laurina*, *M. mucronulata*, *M. odorata*.

Growth and development The early growth of machang seedlings is rapid. A bare stem of 20–30 cm is formed shortly after germination. An average height of 2–4 m can be attained three years after planting. The crown is usually dense, rounded and dark green. In old trees it may become more open and irregular. Most species are evergreen. They grow in flushes, simultaneously losing most of the older leaves and forming new leaves at the top of the branches. Commonly, flushes on different parts of a crown are out of phase. Some species (e.g. *M. caesia*, *M. pajang*) are deciduous, standing bare for some time before shedding the very large bud scales that envelop new twigs and inflorescences.

The architecture of *M. indica* is according to Scarrone's model: an orthotropic, rhythmically growing, indeterminate trunk bearing tiers of branches; the branches are orthotropic and sympodially branched as a result of terminal or pseudo-terminal flowering. However, in full sunlight the architectural model conforms to Leeuwenberg's model, because of the early abortion of the apical meristem; equivalent orthotropic modules develop, each module determined in its growth.

Individual trees often flower irregularly; some trees do not flower for periods of 10–20 years, sometimes even longer. When flowering, however, trees may produce masses of flowers. Flowering starts at the beginning of the rainy season and fruits ripen at the end of the rainy season. The pollinators of *M. indica* are insects such as flies, nectarivorous bats and possibly thrips. Usually, only a small proportion of the flowers develops into fruits. The fruits are eaten and dispersed by hornbills, monkeys, elephants and porcupines. Bats also feed on the fruits and are said to actually disperse the seeds. The often comparatively large numbers of *Mangifera* trees found in the forest close to villages show that man may serve as a disperser by bringing home the fruits found in the forest and throwing away the stones later. The fruits of *M. gedebe* with their labyrinthine seeds float and can be dispersed by water.

Other botanical information Within the family *Anacardiaceae*, *Mangifera* is classified in the tribe *Anacardieae* together with *Anacardium*, *Androtium*, *Bouea*, *Buchanania*, *Gluta* and *Swintonia*.

Mangifera is subdivided into two subgenera (or considered as sections): subgenus *Mangifera* with large and cushion-like disk and filaments free at base, and subgenus *Limus* (Marchand) Kosterm. with narrow, stalk-like disk and filaments often united at base. *M. caesia*, *M. decandra*, *M. foetida*, *M. lagenifera*, *M. leschenaultii*, *M. macrocarpa*, *M. odorata* and *M. pajang* belong to the latter section.

The delimitation of species within the genus *Mangifera* is often vague. Herbarium specimens are comparatively scarce, as they are difficult to collect from these large trees with long clear boles which often flower and fruit at long intervals. Fruits are difficult to dry and are often lacking in herbarium material. Moreover, several species are unknown in natural forest and exist only in cultivation or semi-cultivation. Perhaps it would be better to consider these species to be cultivars. Other species do occur in the wild but have also been cultivated for centuries; the cultivated specimens sometimes differ considerably from the wild specimens as a result of selection. Some species have naturalized in regions outside their natural area of distribution.

The conception of the species differs considerably between the various taxonomists. The treatment of the species as presented here is mainly based on the new monograph of Kostermans & Bompard (1993) and differs from Prosea 2: 'Edible fruits and nuts' (1991).

The wood of *M. sylvatica* Roxb. is used in India, e.g. for plywood, and that of *M. caloneura* Kurz is used in Indo-China, e.g. for boards.

Ecology Most *Mangifera* species occur in lowland rain forest up to 700 m altitude, but several of them can be found above 1000 m. Some species (e.g. *M. griffithii*, *M. merrillii*, *M. parvifolia*) are more or less confined to wetter locations such as river banks or temporarily inundated land. Trees rarely occur gregariously (e.g. *M. gedebe* in swamp forest), instead they are usually widely scattered in the forest.

Mango (*M. indica*) trees are preferably cultivated up to 600 m altitude in the tropics, although they can be found up to 1200 m. A prominent dry season lasting more than 3 months is necessary for good fruit production. The trees are drought-tolerant, but need a deep soil. Machang trees probably all prefer shade, at least in the early stages of development.

Propagation and planting Machang can be propagated by seed, handled and sown with the enveloping stone. Major fruit-producing species are also propagated vegetatively, e.g. by grafting on rootstock of the same or other *Mangifera* species and by budding. Stones rapidly lose their viability and are considered recalcitrant. At temperatures below 3–6°C seed is damaged by chilling. Desiccation below 30% moisture content will kill seed of *M. indica*. Wet storage of stones of *M. indica* at 15°C is possible, but germinating seed develops roots about 5 cm long and shoots about 8 cm long after 6 months. The germination rate of fresh stones is high, generally over 80%. Germination varies greatly between species and may take up to 5 weeks. Sowing complete fruits or stones with the pulp attached delays germination by up to 7 weeks and germination rate is only 30–50%. Preferably, large and fully developed stones should be sown. Careful removal of the endocarp, releasing the seed, results in earlier and more uniform germination, producing seedlings with a straight stem and roots. However, often this method is not feasible for the commercial production of planting stock. Stones should be sown under shade and seedlings also require a certain amount of shade. Seedlings raised in nursery beds can be transplanted without much difficulty before the taproot has developed to any great extent. However, seedlings raised in baskets or containers are preferable. In India, *M. sylvatica* survives stump planting well (80% survival). There are no reports of machang being planted for timber.

Silviculture and management Natural regeneration of machang is abundant. Because of its dense crown, *M. indica* shades out grasses and will provide an effective firebreak. In Peninsular Malaysia, *M. foetida* is the most important representative of the machang trade group found scattered in natural forest.

Diseases and pests Anthracnose (*Glomerella cingulata*, conidial stage *Colletotrichum gloeosporioides*) is a serious fungal attack of *M. indica*. A longicorn beetle (*Rhytidodera simulans*) bores into the trunk and thick branches; branches may be killed, but the whole tree retains its viability. The larvae of the mango weevil (*Cryptorrhynchus mangiferae*) feed on the pulp and damage the fruits.

Harvesting Machang logs usually show some spongy heart. The darker heartwood of typical machang logs from Peninsular Malaysia of 60 cm diameter was 38 cm in diameter, thus the sapwood on either side was 11 cm thick. The sapwood of *M. altissima* is also rather thick, about 10–15 cm. The sap of the bark of some species, particularly *M. caesia*, is poisonous and may cause serious skin and eye irritation. Therefore, labourers should be protected with gloves and clothing that covers the whole body.

Yield Because machang trees occur scattered, the yield from natural forest is generally low. In a forest in South Kalimantan, the average number of machang trees was 1.1/ha, with an average timber volume of 2.5 m^3/ha.

Genetic resources Although many *Mangifera* species occur very scattered in the forest, they are generally not rare and often have large areas of distribution. Most species do not seem particularly liable to genetic erosion. However, *M. altissima* is considered to be a vanishing timber species in the Philippines. Machang timber is only selectively logged and traded on a larger scale very locally. Several species, as well as cultivars of *M. indica*, have been planted in germplasm collections in Indonesia, Malaysia, the Philippines, Thailand, India and northern Australia.

Breeding No breeding work directed towards timber production and quality is known to be in progress. Polyembryony in mango and apomixis in cultivated *Mangifera* species suggest that it would be feasible to raise genetically identical material. Current breeding objectives are directed towards fruit production in *M. indica*: dwarf tree size, quality of the fruit, regular and good cropping, and resistance to diseases and pests.

Prospects *Mangifera* trees are planted and tended primarily for their fruits. However, they may also yield good-quality timber; the streaked heartwood is especially in demand for furniture and nicely figured veneer. More intensive crop management resulting in higher fruit yield reduces the tree size and the eventual quantity of timber. Therefore, it is unrealistic to aim for a combination of high productivity of fruits and timber. The establishment of timber plantations of machang with limited fruit production might give promising results. Selection and breeding activities combined with proper propagation techniques might result in planting stock suitable for multipurpose plantations.

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Selection of species

Mangifera altissima Blanco

Fl. Filip.: 181 (1837).

Synonyms *Buchanania reticulata* Elmer (1912).

Vernacular names Philippines: pahutan (Sambali, Tagalog), paho (Tagalog, Bikol, Panay Bisaya), pangamangaen (Iloko).

Distribution Northern and central Philippines; locally also cultivated in home gardens for the fruits.

Uses The wood is used for general construction work, sheeting, ceilings, door panels, flooring, furniture and cabinet work, veneer and plywood, and gunstocks. Immature fruit is eaten fresh, pickled or mixed with vegetables.

Observations A medium-sized to fairly large tree with cylindrical bole branchless for up to 20 m and up to 90 cm in diameter, often having small buttresses; leaves obovate-oblong, oblanceolate or narrowly oblong, (9–)14–31 cm × (3–)4–8 cm; inflorescence terminal or axillary, fascicled at base and initially subtended by a crown of velvety scales, very shortly pubescent; flowers 4-merous, petals 3–5 mm long, white or creamy white, with ridges on inner surface closely adjacent with apical, glandular thickenings, disk 4-lobed, one stamen fertile, with much-reduced staminodes; fruit ovoid or ellipsoid, slightly compressed, 5–8 cm × 4–6 cm, green or slightly yellow when ripe. *M. altissima* occurs in wet, evergreen forest at low and medium altitudes, but nowhere abundant. The timber is available in small quantities, especially in Tayabas and Bataan. The heartwood is dark brown with almost black longitudinal bands; the density is about 820 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 124, 125, 162, 328, 414, 527, 626, 673, 742.

Mangifera applanata Kosterm.

The mangoes: 64 (1993).

Vernacular names Indonesia: asem depeh (West Kalimantan), asam kepeng (East Kalimantan), pelipisan (Banjarese, South Kalimantan). Malaysia: lumpingas (Sabah), asem lepeh, asem ka'aper (Sarawak).

Distribution Borneo, locally also cultivated; possibly also in Peninsular Malaysia and Sumatra.

Uses The wood is reputed to be used. The acidic fruit is used as an ingredient in sambal.

Observations A fairly large tree up to 40 m tall, with bole branchless for up to 20 m and up to 120 cm in diameter, having buttresses up to 1 m high, bark surface superficially longitudinally fissured, grey or grey-brown; leaves oblong to ovate-oblong, 8–30 cm × 2.5–9 cm; inflorescence pseudoterminal, lax and pyramidal, glabrous; flowers 4-merous, petals 3–4.5 mm long, yellowish outside, whitish inside, reflexed in the middle, disk larger than ovary, one stamen fertile (rarely two); fruit distinctly flattened, c. 6 cm × 5 cm (in cultivation up to 10 cm × 11.5 cm), greenish-yellow when ripe. *M. applanata* occurs in lowland evergreen rain forest. The heartwood is almost black and hard.

Selected sources 328.

Mangifera caesia Jack

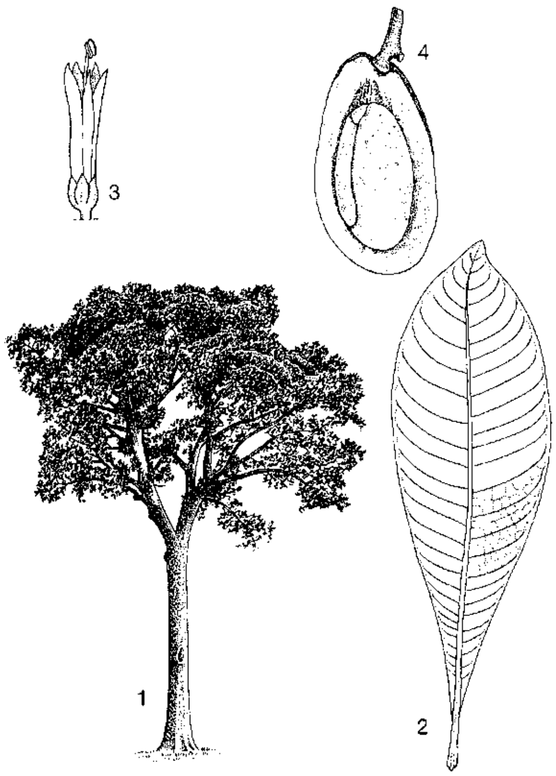
Roxb., Fl. Indica ed. Carey & Wallich 2: 441 (1824).

Synonyms *Mangifera verticillata* C.B. Robinson (1911).

Vernacular names Indonesia: binjai (South Kalimantan), palong, wani (East Kalimantan). Malaysia: binjai (general), beluno, bundo (Sabah). Philippines: baluno (Manobo), bauno (Sulu, Cebu Bisaya), balunut (Sulu). Thailand: bin-ya, lam-yai (peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo; in cultivation and naturalized also in peninsular Thailand, western Java (rare), Bali and the Philippines (Sulu Archipelago and Mindanao); once found in Papua New Guinea.

Uses The wood is used for light construction.



Mangifera caesia Jack – 1, tree habit; 2, leaf; 3, flower; 4, halved fruit.

The fruit is eaten raw or used as an ingredient of sambal or for making a creamy juice.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole up to 75(–115) cm in diameter, buttresses absent, bark surface superficially fissured (strips hard and glossy), grey to greyish-brown; leaves broadly lanceolate to elliptical, 6–42 cm × 3–10 cm; inflorescence pseudo-terminal, densely and many-flowered; flowers 5-merous, petals 5–9 mm long, dark carmine purple with paler margins, the upper third reflexed, with one central ridge, the base connate to the stipe-like and obscurely lobed disk, one stamen fertile, free at base, staminodes 4, knob- or teeth-like; fruit subellipsoid, up to 15 cm × 7 cm, yellowish or whitish-green with suffused reddish parts when ripe. *M. caesia* closely resembles *M. kemanga* Blume, but differs in the longer petiole and the yellowish or whitish-green and smooth fruit. Wild forms have sour fruits but there is a cultivar in Borneo and Bali with sweet, fibreless and tasty fruits. The smell of the fruit pulp is rather offensive, and the white juice of the immature fruit is very irritating to the skin and when ingested. The density of the wood is 410–570 kg/m^3 at 15% moisture content.

Selected sources 77, 104, 125, 162, 328, 463, 465, 673, 705.

Mangifera decandra Ding Hou

Reinwardtia 8: 323, fig. 1 (1972).

Vernacular names Indonesia: kemang badak (Sumatra), konyot, palong besi (East Kalimantan). Malaysia: binjai hutan, belunu hutan (Sabah).

Distribution Sumatra and Borneo (Sarawak, Brunei, Sabah, East Kalimantan).

Uses The wood is reputed to be used. The fruit is edible but sour and fibrous.

Observations A medium-sized, sometimes large tree up to 30(–50) m tall, with bole branchless for up to 20 m and up to 90(–110) cm in diameter, buttresses absent, bark surface initially smooth with longitudinal rows of lenticels, developing into narrow cracks and later regularly fissured, reddish-brown; leaves elliptical-oblong to obovate-oblong or oblanceolate, (17–)27–40 cm × (7–)12–15 cm; inflorescence pseudo-terminal, pyramidal, puberulous; flowers 5-merous, petals 4.5–6 mm long, reddish, without ridges on the inner surface, the base slightly adnate to the rather obscure, cylindrical and stipe-like disk, five stamens fertile but of different lengths, connate at base, staminodes 5, subulate; fruit broadly ellipsoid, up to 16 cm × 10 cm, dull and velvety brown when ripe. *M. decandra* occurs scattered in lowland primary evergreen forest up to 350(–1450) m altitude, sometimes in freshwater swamp forest and secondary forest. The heartwood is pale brown to reddish.

Selected sources 162, 328, 673.

Mangifera foetida Lour.

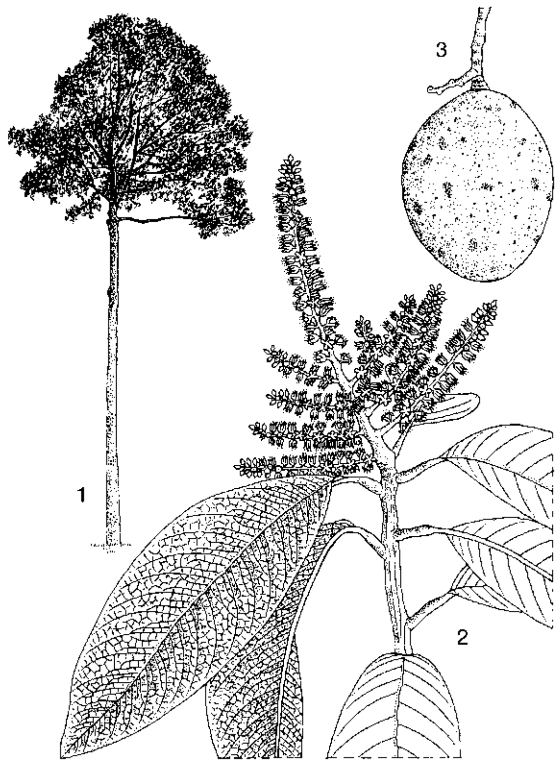
Fl. cochinch.: 160 (1790).

Synonyms *Mangifera horsfieldii* Miq. (1859).

Vernacular names Indonesia: membacang, bacang (general), limus (Sundanese, Java), asem hambawang (Kalimantan). Malaysia: machang (general), bacang, pauh (Sabah). Burma (Myanmar): la-môt. Cambodia: svaay sââ. Thailand: machang (Malay, peninsular), mamut, malamut (Thai, peninsular). Vietnam: xo[af]i h[oo]i.

Distribution Peninsular Malaysia, Sumatra, Java, Borneo and the Moluccas, possibly also Sulawesi; cultivated and sometimes naturalized also in Burma (Myanmar), Indo-China, Thailand and the Lesser Sunda Islands.

Uses The timber is locally used as machang for



Mangifera foetida Lour. – 1, tree habit; 2, flowering twig; 3, fruit.

light indoor construction, temporary constructions and plywood. Streaked heartwood is suitable for the manufacture of furniture. The ripe fruit is edible; it is sweet and tasty, but it has a strong turpentine smell and should be peeled thickly because of the irritant juice present in the skin. The fruit is also used in fruit cocktails. Unripe fruits, washed in salted water or kept for some time in lime water, are sometimes used in vegetable salads and for sour pickles. The irritating sap is used as a lotion for ulcers and to deepen tattoo scars. In flower the tree is a beautiful ornamental.

Observations A medium-sized to fairly large tree up to 40 m tall, with straight bole up to 100 cm in diameter, buttresses absent, bark surface shallowly fissured, whitish-grey to reddish-brown; leaves oblong to elliptical-oblong or elliptical, 12–30 cm × 10–15 cm; inflorescence pseudo-terminal, pyramidal, usually glabrous; flowers 5-merous, petals 6–10 mm long, pinkish, at base violet-red, at apex whitish, with a broad short ridge on the inner surface at the base splitting into 3(–5) branches, disk stipe-like and short, one stamen fertile (rarely two), connate at base with the 2–4 unequal staminodes; fruit subglobose, slightly oblique, up to 14 cm in diameter, glossy and yellowish-green, green or brownish when ripe. *M. foetida* occurs in wet, evergreen lowland forest up to 1000(–1500) m altitude. The density of the wood is 545–785 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 69, 77, 104, 115, 162, 328, 388, 397, 463, 465, 673, 705.

Mangifera gedebe Miq.

Fl. Ind. Bat., Suppl. 1(3): 522 (1861).

Synonyms *Mangifera camptosperma* Pierre (1897), *Mangifera reba* Pierre (1897), *Mangifera inocarpoides* Merr. & Perry (1941).

Vernacular names Indonesia: kedepir (Sumatra, West Java), gedeperan (Sumatra), repeh (East Kalimantan). Malaysia: gedepiak (Peninsular). Burma (Myanmar): thayet pya, thy-ni. Cambodia: reba, riba, svaay miëhs. Thailand: kadupae, mamuang-pan (peninsular). Vietnam: xo[af]i bui, qu[es]o.

Distribution Southern Burma (Myanmar), Indo-China, peninsular Thailand, northern Peninsular Malaysia (rare), Sumatra, western Java, eastern Kalimantan, New Guinea and the Solomon Islands.

Uses The wood is reputed to be used. The fruit is eaten when still young; the pulpy part of ripe fruits consists mainly of fibres.

Observations A medium-sized tree up to 30 m tall, with bole up to 60 cm in diameter, buttresses absent but bole often swollen at the base, bark surface pustular, smooth or cracked to fissured, grey to pale brown; leaves elliptical-oblong, oblong to lanceolate, 5.5–25 cm × 2.5–6 cm; inflorescence pseudo-terminal, rather lax and many-flowered, densely minutely puberulous or glabrescent; flowers 4-merous, petals 3–5 mm long, greenish-white, with 3 (or 5) ridges on the inner surface confluent at their bases, disk cushion-like and short, 4–5-lobed, one stamen fertile, staminodes 3–4, short, free; fruit disk-like, rounded, slightly oblique and distinctly compressed, up to 10.5 cm in diameter, pale green or yellowish-green when ripe; seed with inner integument penetrating the cotyledons forming numerous irregular folds. *M. gedebe* is the only species with labyrinthine seed; the fruit can be dispersed by water. It occurs in lowland rain forest in marshy places, temporarily inundated locations and along rivers, and is locally gregarious. The density of the sapwood is about 520 kg/m^3 at 15% moisture content.

Selected sources 162, 328, 474, 673.

Mangifera griffithii Hook.f.

Trans. Linn. Soc. Lond. 23: 168 (1860).

Synonyms *Mangifera sclerophylla* Hook.f. (1876), *Mangifera beccarii* Ridley (1933).

Vernacular names Indonesia: rawa-rawa (Sumatra, Kalimantan), asem raba (West Kalimantan), romian (South Kalimantan). Malaysia: rawa (Peninsular), bahab, wahab (Sabah).

Distribution Peninsular Malaysia, Sumatra, Borneo; also cultivated.

Uses The wood is reputed to be used. The fruit is edible and has sweet dark orange-yellow pulp.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole branchless for up to 25 m and up to 80 cm in diameter, buttresses absent, bark surface smooth to peeling off in small scales, lenticellate in long vertical rows, sometimes ringed with hoops, pale yellowish-brown to grey; leaves broadly elliptical to elliptical-oblong or obovate-oblong, 8–18 cm × 3–7.5 cm; inflorescence axillary, few-branched, pubescent; flowers 4-merous, petals c. 2 mm long, creamy-white, with 3–5 ridges on the inner surface confluent at their bases, the central ridge with a thick, truncate appendix, disk cushion-like and broad, unequally lobed, one stamen fertile, staminodes minute; fruit cylindrical-oblong or ovoid-oblong, up to 3.5(–4) cm long, glossy and smooth, greyish-purple but turning purplish-black with a rose-red blush near the base when fully ripe. *M. griffithii* prefers temporarily inundated locations along rivers in lowland rain forest. Fruits are produced rather sporadically.

Selected sources 104, 162, 328, 463, 465, 673, 705.

Mangifera indica L.

Sp. pl. 1: 200 (1753).

Vernacular names Mango (En). Manguier (Fr). Indonesia: mangga, mempelam. Malaysia: mangga, mempelam, ampelam. Papua New Guinea: mango (Pidgin). Philippines: mangga (general), paho (Bisaya), mango (Ilokano). Burma (Myanmar): thar-yetthi, thayet thayt-hypu. Cambodia: svaay. Laos: mwàngx. Thailand: mamuang. Vietnam: xo[af]i.

Distribution Mango supposedly originated in India and Burma (Myanmar), but is now cultivated all over the tropics and subtropics.

Uses The wood is used as machang, e.g. for indoor construction; it makes excellent charcoal and is also used to culture mushrooms. Mango is cultivated for the fruits which are eaten fresh when ripe or unripe or processed (in pickles, chutneys, dried slices, canned slices in syrup, juices, pastes etc.). Seed kernels are used as famine food (after long boiling, roasting or soaking) and feed for cattle and poultry. Young leaves are used as vegetable. Bark, kernels and flowers are used in traditional medicine as astringents; various parts of the tree have antibiotic properties. The bark can be used as a yellowish-brown dye for silk.

Observations A medium-sized to fairly large tree up to 40(–45) m tall, with bole up to 120 cm in diameter, bark surface rather smooth, superficially cracked or fissured, greyish-brown; leaves narrowly elliptical to lanceolate, 8–40 cm × 2–10 cm; inflorescence pseudo-terminal, many-flowered and pyramidal, puberulous; flowers 5-merous, petals 3–5 mm long, creamish to pinkish, with 3–5 yellow (later pinkish) ridges on the inner surface, disk cushion-like, 5-lobed or notched, one stamen fertile (rarely two), staminodes minute; fruit very variable in shape, size and colour, subglobose to elongated-oblong and more or less compressed, up to 30 cm long, glossy and smooth, yellowish-green to reddish when ripe. Commercial cultivars of *M. indica* thrive up to 600 m altitude in the tropics, but need a prominent cold or dry season for good floral induction. The density of the wood is 590–800 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 77, 93, 102, 104, 115, 125, 140, 151, 162, 214, 216, 328, 369, 386, 388, 414, 526, 673, 690, 705.

Mangifera lagenifera Griffith

Not. pl. asiat. 4: 414, t. 567, fig. 3 (1854).

Vernacular names Indonesia: lanjut (Sumatra). Malaysia: lanjut (Peninsular, Sarawak), dedahan (Iban, Sarawak). Thailand: mamuang-pom.

Distribution Thailand, Peninsular Malaysia, Singapore, Sumatra and Borneo (Sarawak, Brunei, Sabah); rarely cultivated.

Uses The wood is reputed to be used. The fruit is edible but sour and stringy; it is eaten cooked or uncooked, preserved with salt or sugar in sambals or pickles. The tree is a beautiful ornamental.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole branchless for up to 18 m and up to 80(–100) cm diameter, buttresses usually absent, bark surface initially smooth, later irregularly cracked and slightly fissured, red-brown or grey-brown; leaves obovate-lanceolate to spatulate, (3–)5–13(–15) cm × (1.5–)2–5 cm; inflorescence pseudo-terminal and in the axils of upper leaves, paniculate, sometimes seemingly fasciculate, minutely puberulous; flowers 5-merous, petals 5–7 mm long, purple, without ridges on the inner surface, disk slender and stipe-like, five stamens fertile, connate at base, staminodes small; fruit pear-shaped, up to 11 cm long, green flushed with pink but turning brownish when fully ripe. *M. lagenifera* occurs scattered in evergreen lowland rain forest up to 150 m altitude. The dense crown consists of numerous subcrowns and is dark green. Flowering occurs at long intervals. The density of the wood is about 575 kg/m^3 at 15% moisture content.

Selected sources 104, 140, 162, 328, 673, 705.

Mangifera laurina Blume

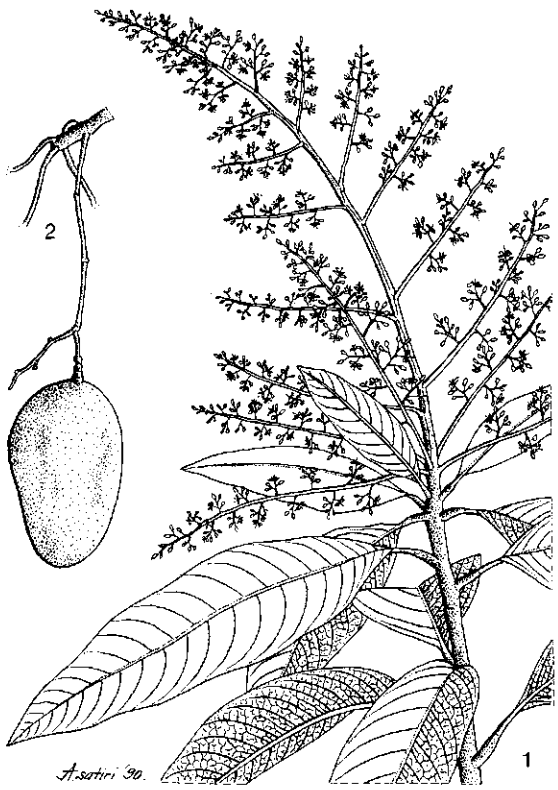
Mus. Bot. Lugd.-Bat. 1: 195 (1850).

Synonyms *Mangifera longipes* Griffith (1854), *Mangifera parih* Miq. (1859), *Mangifera sumatrana* Miq. (1859).

Vernacular names Indonesia: mangga parih (West Java). Malaysia: manga aer (Sabah). Philippines: apali (Tagbanua). Burma (Myanmar): thayet-pya. Thailand: mamuang-kaleng.

Distribution Peninsular Malaysia, Sumatra, Java, Borneo, the Philippines (Palawan), also in Burma (Myanmar), Indo-China, Thailand and possibly in Sulawesi; sometimes also cultivated around villages.

Uses The wood is used as machang. The fruit has only a small amount of flesh which liquifies at



Mangifera laurina Blume – 1, flowering twig; 2, branchlet with fruit.

maturity, so that it can be sucked out. More often the immature fruit is sliced and served in fruit salads with a spicy sauce ('rujak').

Observations A medium-sized to fairly large tree up to 36 m tall, with bole up to 100 cm diameter, bark surface longitudinally cracked, peeling off in small, narrow strips, pinkish-brown to blackish; leaves oblong to lanceolate-oblong or elliptical-lanceolate, (6–)14–30 cm × (2–)3–7 cm; inflorescence pseudo-terminal, lax and widely pyramidal, apically sparingly, minutely puberulous; flowers 5-merous, petals 3.5–5.5 mm long, whitish-green to pale yellowish, with 3–5 ridges on the inner surface, extending half-way along the petal and confluent at base, disk fleshy, 5-lobed, cup-shaped, one stamen fertile, free, staminodes minute; fruit usually obliquely subglobose to oblong-ovoid, up to 10 cm long, yellowish-green when ripe. *M. laurina* occurs in lowland evergreen rain forest up to 150 m altitude. The heartwood is reported to be greyish to pale red but also chocolate brown; the density of the wood is 690–790 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 77, 162, 328, 388, 414, 474, 673.

Mangifera leschenaultii Marchand

Rév. Anacardiac.: 189 (1869).

Synonyms *Mangifera foetida* Lour. var. *leschenaultii* (Marchand) Engl. (1883).

Vernacular names Indonesia: limus tipung (Sundanese, Java).

Distribution Sumatra, western Java, Borneo (Sabah, Kalimantan), Sulawesi, possibly also Peninsular Malaysia; usually cultivated.

Uses The wood is reputed to be used. The fruit is edible; it is larger, sweeter and less fibrous than that of *M. foetida*.

Observations A medium-sized tree up to 30 m tall, with bole up to 100 cm in diameter, bark surface broadly fissured, greyish-brown; leaves oblong to broadly elliptical, 20–40 cm × 10–16 cm; inflorescence pseudo-terminal, glabrous; flowers 5-merous, petals c. 6.5 mm long, outside bright red, inside dark red with a large yellow spot at base, one stamen fertile, staminodes smaller, fused at the base; fruit oblong, up to 16 cm long, pale yellowish-green when ripe with numerous brown lenticels. *M. leschenaultii* closely resembles *M. foetida* but differs in the usually larger leaves, flowers and fruits. It occurs in the lowland, but may be found up to 1000 m altitude. The exudate from the bark and fruit is reported as non-irritant, but this needs to be confirmed.

Selected sources 328.

Mangifera longipetiolata King

Journ. As. Soc. Beng. 65(2): 470 (1896).

Synonyms *Mangifera quadrifida* Jack var. *longipetiolata* (King) Kochummen (1983).

Vernacular names Thailand: mamuang-pa.

Distribution Thailand, Peninsular Malaysia, Sumatra and Borneo; probably extinct in Java.

Uses The wood is reputed to be used. The fruit is probably not eaten as the pulp is juicy but fibrous and with a resinous taste.

Observations A medium-sized to fairly large tree up to 35 m tall, with bole up to 100 cm in diameter, buttresses usually absent but sometimes small buttresses or large superficial roots present, bark surface smooth, cracked or superficially indistinctly fissured, greyish-brown; leaves oblong to elliptical-oblong, 9–25 cm × 6–10 cm; inflorescence pseudo-terminal, rarely axillary, lax, glabrous; flowers 4-merous, petals 3.5–4.5 mm long, cream-white or whitish-yellow, with 3 basal ridges, disk cushion-like, obscurely 4-lobed, one stamen fertile, staminodes small, free at the base; fruit obliquely subglobose, up to 9 cm long, pale greenish-yellow when ripe. *M. longipetiolata* is uncommon and occurs in lowland evergreen rain forest up to 900 m altitude.

Selected sources 328.

Mangifera macrocarpa Blume

Bijdr. fl. Ned. Ind.: 1158 (1826).

Synonyms *Mangifera fragrans* Maingay ex Hook.f. (1876).

Vernacular names Indonesia: gompor (Sundanese, western Java), n'cham busur (East Kalimantan), asem busur (South Kalimantan). Malaysia: machang lawit (Peninsular). Thailand: mamuang-khikwang (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra, western Java (possibly extinct) and Borneo.

Uses The wood is reputed to be used. The fruit is rarely eaten.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole up to 90 cm in diameter, with long spreading branches, bark surface initially smooth, later deeply, narrowly fissured, greyish-brown; leaves linear-lanceolate, 15–51 (–60) cm × 2–3(–5) cm; inflorescence pseudo-terminal, glabrous; flowers 5-merous, petals 9–12 mm long, white, with 1–3 prominent ridges confluent at the base, disk slender, stipe-like, 5-lobed, one stamen fertile, staminodes smaller, free at the base; fruit obliquely oblong-globose or ellipsoid-globose, up to 12 cm long, smooth and glossy, yellowish-green when ripe with few brown lenticels. *M. macrocarpa* occurs scattered in lowland rain forest. Flowering and fruiting occur rarely.

Selected sources 162, 328, 673, 705.

Mangifera magnifica Kochummen

Gard. Bull. Sing. 36: 189 (1984).

Vernacular names Indonesia: putaran, gurbus (Sumatra), asem putar (West Kalimantan). Malaysia: kemang putar, machang pulasan (Peninsular), putaran (Sarawak).

Distribution Peninsular Malaysia, Sumatra, Belitung and Borneo; occasionally cultivated.

Uses The wood is used as machang. The sour fruit is mainly used as an ingredient in sambal.

Observations A fairly large, sometimes very large tree up to 40(–54) m tall, with bole up to 90 cm in diameter, buttresses absent or very small (rarely up to 2 m high), bark surface initially smooth, later fissured or scaly, greyish-brown; leaves elliptical, ovate-elliptical to oblong, (3.5–) 6–26 cm × 4–13 cm; inflorescence pseudo-terminal and axillary, lax and many-flowered, glabrous; flowers 4-merous, petals c. 4 mm long, white, with 3–4 yellow ridges confluent at the base, disk large, cushion-like, obscurely lobed, one stamen fertile, staminodes minute; fruit ovoid to oblong, up to 12 cm long, smooth or roughish, greyish-green when ripe, often with brown spots. *M. magnifica* is locally common in lowland and hill evergreen rain forest, on well-drained soils, up to 1300 m altitude. The heartwood is almost black with brown longitudinal streaks.

Selected sources 328, 705.

Mangifera merrillii Mukherji

Lloydia 12: 104, fig. 11 (1949).

Vernacular names Philippines: pahong-liitan (general).

Distribution The Philippines (Luzon, Palawan, Mindanao).

Uses The wood is used as machang.

Observations A medium-sized tree up to 30 m tall, with bole up to 70 cm in diameter, bark surface scaly with large flakes and numerous small lenticels, pale brown; leaves oblong, 5–10 cm × 1–3 cm; inflorescence pseudo-terminal, fasciculate or with distinct main peduncle, densely pubescent; flowers 4-merous, petals c. 3.5 mm long, white, with 3 prominent ridges at inner surface confluent at the base, disk large, cushion-like, 4-lobed, one stamen fertile, staminodes smaller; fruit ellipsoid and smooth, only known immature. *M. merrillii* is apparently rare. The heartwood is pale brown to dark brown with blackish longitudinal bands.

Selected sources 328, 414.

Mangifera minor Blume

Mus. Bot. Lugd.-Bat. 1(13): 198 (1850).

Vernacular names Indonesia: taipa dare (Sulawesi), wewe bakafo (Moluccas), kusi (Irian Jaya). Solomon Islands: asai.

Distribution The Lesser Sunda Islands, the Philippines (Luzon), Sulawesi, the Moluccas, New Guinea, the Solomon Islands and the Caroline Islands; sometimes cultivated.

Uses The wood is used for light construction, interior finish, mouldings and furniture. The fruit is edible, but the pulp layer is thin and has an astringent taste. The bark is used in traditional medicine, against stomachache and as antidote for snake bites.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole up to 90(–120) cm in diameter, but often much smaller, usually without buttresses, bark surface conspicuously fissured with broad, smooth ridges, pale brown, brown or grey; leaves oblong to elliptical-lanceolate or narrowly elliptical, 12–20 cm × 3–7 cm; inflorescence pseudo-terminal and in axils of upper leaves, lax and many-flowered, glabrous; flowers 5-merous, petals (4–)5–6 mm long, yellowish-white to yellowish-green, with 3–5 distinct ridges confluent at the base, disk shallowly cushion-like, 5-lobed, one stamen fertile (rarely two), staminodes minute; fruit obliquely oblong, often much narrowed and bent at the apex, up to 10 cm long, smooth, green when ripe. *M. minor* grows not only in rain forest, but also in savanna, up to 1300 m altitude, and is locally common. It may flower already when 4 m tall. The heartwood is pale yellow with a silky sheen and blackish streaks. The density is about 610 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 60, 162, 166, 328, 330, 660, 673, 727.

Mangifera monandra Merr.

Publ. Govt. Lab. Philipp. 17: 28 (1904).

Synonyms *Mangifera philippinensis* Mukherji (1949).

Vernacular names Philippines: malapaho (general), kalamansanai (Tagalog), kurig (Sambali, Bataan).

Distribution The Philippines (Luzon, Samar, Leyte, Ticao and Quimaras).

Uses The wood is used for interior finish, furniture, cabinet work and construction under cover. The fruit is usually eaten unripe, because when ripe it becomes difficult to recover the little flesh there is.

Observations A medium-sized to fairly large tree, with bole branchless for up to 20 m and up to 120 cm in diameter, buttresses absent; leaves elliptical to obovate-lanceolate or almost spatulate, 8–19 cm × 2.5–8 cm; inflorescence pseudo-terminal, lax and many-flowered, glabrous; flowers 4-merous, petals 3–4.5 mm long, white, with 5(–7) ridges confluent at the base, disk cushion-like, slightly 4-lobed, one stamen fertile, staminodes much smaller, filaments free; fruit ellipsoid, slightly compressed and inequilateral, c. 3.5 cm long. *M. monandra* occurs scattered in lowland rain forest. The heartwood is greyish to pale red; the density is about 560 kg/m^3 at 15% moisture content.

Selected sources 162, 328, 414, 527, 673.

Mangifera mucronulata Blume

Mus. Bot. Lugd.-Bat. 1(13): 201 (1850).

Synonyms *Mangifera membranacea* Blume (1850), *Mangifera salomonensis* C.T. White (1950).

Vernacular names Indonesia: ponga ma wale (Moluccas), bu-sya, karmesan (Irian Jaya).

Distribution The Moluccas, New Guinea and the Solomon Islands.

Uses The timber is reputed to be used.

Observations A medium-sized (to sometimes very large) tree up to 25(–54) m tall, with bole branchless for up to 15 m and up to 45 cm in diameter, bark surface smooth or superficially fissured, with lenticels, pale grey; leaves elliptical-oblong, 10–29 cm × 5–10 cm; inflorescence pseudo-terminal, initially pubescent but later glabrescent; flowers 4-merous, petals 3.5–5 mm long, cream-white or white, with (3–)5 yellow ridges confluent at the base, disk large, cushion-like, one stamen fertile, staminodes much smaller, filaments free; fruit unknown. *M. mucronulata* occurs scattered, but locally common, in lowland evergreen rain forest. The heartwood is dark brown to blackish.

Selected sources 328.

Mangifera oblongifolia Hook.f.

Fl. Brit. India 2: 16 (1876).

Vernacular names Malaysia: sepam, membachang hutan, machang hutan (Peninsular). Thailand: mamuang-chingrit.

Distribution Thailand, Peninsular Malaysia, Sumatra and Borneo (Sabah, East Kalimantan).

Uses The wood is used as machang, e.g. for construction under cover.

Observations A fairly large tree up to 40 m tall, with bole up to 70 cm in diameter, bark surface broadly to narrowly fissured, pale brown and white-fawn in patches; leaves oblong to elliptical-oblong, 11–39 cm × 3–15 cm; inflorescence pseudo-terminal, lax and broadly pyramidal, apically sparingly pubescent; flowers 5-merous, petals 3–3.5 mm long, yellowish or reddish, with 3–5 yellow ridges inside confluent at the base, disk flat, cushion-like, obscurely lobed, one stamen fertile, staminodes smaller, filaments connate at base; fruit elongated to subglobose, c. 10 cm long, green or yellowish-green when ripe. *M. oblongifolia* occurs in lowland evergreen rain forest up to 700 m altitude. The heartwood is pale pinkish-brown to pale brick-red; the density is 720–815 kg/m^3 at 15% moisture content.

Selected sources 328, 598.

Mangifera odorata Griffith

Not. pl. asiat. 4: 417 (1854).

Synonyms *Mangifera foetida* Lour. var. *bombom*, var. *kawini* and var. *mollis* Blume (1850), *Mangifera foetida* Lour. var. *odorata* (Griffith) Pierre (1897).

Vernacular names Kuwini (En). Kuweni, manguier odorant (Fr). Indonesia: bembem, kaweni (Sundanese, Java), k(u)weni (Malay, Sumatra, Kalimantan; Javanese, Java). Malaysia: kuini (Malay, Sabah, Sarawak), huani or wani (Sabah). Philippines: (h)uani (Cebu, Bisaya), juani (Jolo). Thailand: kinning (Narathiwat), mamuang-chingrit, mamuang-pa (central).

Distribution The origin of *M. odorata* remains unknown; it has not been found in the wild. It is cultivated throughout western Malesia.

Uses The wood is used locally as machang, but is reportedly of poor quality. The fruits are eaten fresh, but must be peeled thickly because of the irritating sap; young fruits are used for making chutney and pickles. A flour made from the seed kernels is used in the preparation of delicacies. The bark and leaves are used in traditional medicine.

Mangifera odorata Griffith – 1, flowering twig; 2, fruit.

Observations A medium-sized tree up to 30 m tall, with straight cylindrical bole up to 80 cm in diameter, bark surface initially smooth, later fissured, grey; leaves oblong-lanceolate to elliptical-lanceolate, 12–35(–40) cm × 4–10(–13) cm; inflorescence pseudo-terminal, pyramidal, rather densely flowered; flowers 5-merous, petals 4–6 mm long, initially white, at the base with a yellow spot (consisting of 3–5 ridges confluent at base) circled by red, gradually discolouring to reddish, disk fleshy, stipe-like, one stamen fertile (rarely two), staminodes smaller and unequal, filaments connate at base; fruit obliquely ovoid, ellipsoid or oblong, up to 13 cm long, yellowish-green with numerous yellow or brown dots when ripe, fragrant. *M. odorata* is cultivated in areas with a fairly heavy rainfall that is equally distributed throughout the year.

Selected sources 104, 162, 328, 463, 465, 673, 705.

Mangifera pajang Kosterm.

Reinwardtia 7: 20, fig. 1a–b (1965).

Vernacular names Brunei: bambangan mombangan. Indonesia: asem payang, alim, n'cham pajay (East Kalimantan). Malaysia: bambangan (Sabah), mawang, alim (Sarawak).

Distribution Borneo (Sarawak, Brunei, Sabah and Kalimantan); commonly cultivated.

Uses The wood is reputed to be used. The fruit is peeled like a banana and eaten fresh; the skin is occasionally dried and used for sambal. In Sarawak, young shoots are sold as vegetable. The tree is a beautiful ornamental when flowering.

Observations A deciduous medium-sized tree up to 33 m tall, with bole up to 70 cm in diameter, buttresses absent, bark surface smooth or superficially fissured, grey or sometimes dark brown; leaves elliptical-oblong to subovate-oblong, (17–)28–45 cm × (7–)10–15 cm; inflorescence terminal and subterminal, erect, pyramidal, glabrous; flowers 5-merous, petals up to 9 mm long, outside pinkish-white, inside purple, becoming yellowish after anthesis, with 3 ridges confluent at base, disk stipe-like, one or two stamens fertile, staminodes smaller and unequal, filaments connate at base; fruit globose to globose-ellipsoid, up to 12(–20) cm long, initially greyish-green with numerous brown lenticels, turning completely brown when ripe. *M. pajang* is rarely found in forest but is common in cultivation; it avoids swampy locations. The bark exudes an irritant sap that blisters the skin.

Selected sources 162, 328, 673.

Mangifera parvifolia Boerl. & Koord.

Koord.-Schum., Syst. Verz. 2(5,2): 31 (1910).

Synonyms *Mangifera havilandii* Ridley (1933).

Vernacular names Indonesia: rawa (Sumatra, Kalimantan), rawa hutan, rawo (Sumatra).

Distribution Peninsular Malaysia (rare), Sumatra and Borneo.

Uses The wood is reputed to be used. The fruit is small but edible when fully ripe; unripe fruits are very acid.

Observations A medium-sized to fairly large tree up to 37 m tall, with bole branchless up to 12 m and up to 80(–100) cm in diameter, bark surface smooth, finely and regularly longitudinally ridged or cracked, reddish-brown; leaves oblong or elliptical (rarely subovate-oblong), 6–16 cm × 2–6 cm; inflorescence pseudo-terminal or axillary, sometimes fascicled, rather few-flowered, very minutely pubescent; flowers 4-merous, petals 3–4 mm long, white, with 3 ridges confluent at base, disk large, cushion-like, 4-lobed, one stamen fertile, staminodes smaller, filaments free; fruit cylindrical or ellipsoid, up to 6 cm long, smooth and blue-black when ripe. *M. parvifolia* grows in forest along rivers and on periodically inundated lands, in peat-swamp forest, but also in forest on well-drained podzolic soils. Trees are reported to flower and fruit at long intervals. The wood is yellowish-white.

Selected sources 162, 328, 673.

Mangifera pentandra Hook.f.

Fl. Brit. India 2: 14 (1876).

Synonyms *Mangifera lanceolata* Ridley (1911).

Vernacular names Malaysia: mempelam bemban, pauh asal, pauh damar (Peninsular). Thailand: mamuang-pa.

Distribution *M. pentandra* is mainly known in cultivation in old orchards in peninsular Thailand, Peninsular Malaysia, Sabah and the Anambas Islands. It is thought to occur wild in northern Peninsular Malaysia.

Uses The wood is reputed to be used. The fruit has only a little flesh, which liquifies at maturity and can then be sucked out. More often the immature fruit is sliced and served in fruit salads.

Observations A medium-sized tree up to 28 m tall, with bole up to 90 cm in diameter, buttresses absent or very short and thick, bark surface initially smooth, later cracked, whitish; leaves oblong or elliptical, 11–25 cm × 3.5–15 cm; inflorescence pseudo-terminal, very densely pubescent but ultimately glabrescent; flowers 5-merous, petals 3–4.5 mm long, white to yellow, with 5 thick, yellow ridges confluent at base, disk large, cushion-like, 5-lobed, 3–5 stamens fertile, unequal, filaments free; fruit oblong, up to 10 cm long, green when ripe. *M. pentandra* resembles *M. indica* but differs in the conspicuous leaf reticulation, the densely hairy panicles and the 3–5 fertile stamens. It occurs in the lowland.

Selected sources 104, 162, 328, 673, 705.

Mangifera quadrifida Jack

Roxb., Fl. Indica ed. Carey & Wallich 2: 440 (1824).

Synonyms *Mangifera spathulaefolia* Blume (1850), *Mangifera langong* Miq. (1862), *Mangifera rumphii* Pierre (1897).

Vernacular names Indonesia: asam kumbang (Sumatra, Kalimantan), asem kipang, rawa-rawa (Kalimantan). Malaysia: rawa (general), rancha-rancha (Sabah). Thailand: mamuang-khan.

Distribution Thailand, Peninsular Malaysia, Sumatra, Java (rare) and Borneo, possibly also the Lesser Sunda Islands, Sulawesi and the Moluccas; locally cultivated around villages.

Uses The wood is reputed to be used. The pleasantly acid fruit is eaten.

Observations A medium-sized tree up to 30 m tall, with often rather short and thick bole up to 150 cm in diameter, bark surface initially smooth, later regularly and superficially longitudinally fissured and becoming rough, greyish to dark brown; leaves elliptical or oblong-spatulate to spatulate, (3–)10–20 cm × (2–)5–9(–10) cm; inflorescence pseudo-terminal, the branches often forming a fascicle, glabrous; flowers 4-merous, petals c. 4 mm long, creamish-white, with 3 stout, dark yellow ridges ending in a gland, disk large, cushion-like, 4-lobed, one stamen fertile, staminodes very small or lacking, filaments free; fruit globose to ellipsoid-globose, up to 8 cm long, black when fully ripe. *M. quadrifida* occurs in lowland rain forest up to 700 m altitude.

Selected sources 104, 162, 328, 463, 465, 673, 705.

Mangifera rufocostata Kosterm.

The mangoes: 116 (1993).

Vernacular names Indonesia: asem kiat (southern Sumatra), asem tanduy (South Kalimantan), n'cham kelau (East Kalimantan). Malaysia: dumpiring (Sabah).

Distribution Sumatra and Borneo, possibly also Peninsular Malaysia; occasionally in semi-cultivation.

Uses The wood is reputed to be used. The very acid fruit is eaten when other fruits are not available.

Observations A large tree up to 45(–53) m tall, with bole branchless for up to 30 m and up to 120 cm in diameter, buttresses very small or absent, occasionally up to 2.5 m high, bark surface deeply fissured, yellowish-brown; leaves oblong to obovate-oblong, 12–30 cm × 4–10 cm; inflorescence pseudo-terminal, very lax, glabrous; flowers 5-merous, petals 4–5 mm long, white to yellowish, disk large, cushion-like, one stamen fertile; fruit obliquely globose, up to 10(–11) cm long, rather rough and dull, brownish-green with numerous brown lenticels when fully ripe. *M. rufocostata* occurs scattered, but sometimes locally fairly common, in evergreen lowland rain forest on well-drained soils, up to 1000 m altitude. The heartwood is blackish.

Selected sources 328.

Mangifera swintonioides Kosterm.

The mangoes: 80 (1993).

Vernacular names Indonesia: asem kelat (southern Sumatra), asem kelau damar, n'cham kelau (East Kalimantan). Malaysia: repat (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sabah, Kalimantan).

Uses The wood is reputed to be used. The very acid, juicy fruit is used as an ingredient in sambal.

Observations A fairly large tree up to 40 m tall, with bole branchless for up to 22 m and up to 80 cm in diameter, buttresses sometimes present and up to 1.5 m high, bark surface smooth to shallowly fissured, pale yellowish-brown; leaves oblong to elliptical-oblong, (8–)12–17 cm × (3–)4–7 cm; inflorescence pseudo-terminal and in axils of upper leaves, short, rather few-flowered, glabrous; flowers 4–5-merous, petals 2–4 mm long, white to greenish-white, with 4–6 ridges confluent at the base, disk large, cushion-like, one stamen fertile; fruit obliquely subglobose, up to 11.5 cm long, roughish and dull, pale greyish-brown with dirty green dots when fully ripe. *M. swintonioides* occurs in lowland evergreen rain forest up to 250 m altitude. It can stand temporary inundation. The heartwood is blackish.

Selected sources 328.

Mangifera timorensis Blume

Mus. Bot. Lugd.-Bat. 1(13): 199 (1850).

Vernacular names Indonesia: upun fui (Timor), pauh puar (Flores), pelem poh (Sumbawa).

Distribution The Lesser Sunda Islands and the Moluccas; also semi-cultivated.

Uses The wood is reputed to be used. The very juicy fruit is edible.

Observations A medium-sized, sometimes fairly large tree up to 30(–40) m tall, with bole up to 80 cm in diameter, bark surface initially smooth, later rough and deeply fissured, dark brown; leaves elliptical-oblong, 11–30 cm × 3–9 cm; inflorescence pseudo-terminal, lax, glabrous; flowers 4-merous, petals 3–3.5 mm long, thick, creamy-white to greenish-white, turning dirty pinkish after anthesis, with 5 prominent, yellow ridges confluent at the base, disk large, 4-lobed, one stamen fertile, staminodes minute or absent; fruit ellipsoid to globose, up to 6 cm long, smooth and glossy, greenish-yellow when ripe. *M. timorensis* occurs rather commonly but scattered in semi-deciduous to evergreen rain forest at 200–1000 m altitude. It is suitable for planting in areas with a prolonged dry season.

Selected sources 162, 328.

Mangifera torquenda Kosterm.

Reinwardtia 7: 21, fig. 2 (1965).

Vernacular names Brunei: pulasan. Indonesia: tayas (Malay, southern Sumatra), kemantan, asam putaran (Kalimantan). Malaysia: kemantan, rade (Sarawak), bunitan bunyitan (Sabah).

Distribution Sumatra and Borneo, possibly also Peninsular Malaysia; cultivated in Kalimantan and southern Sumatra.

Uses The wood is reputed to be used. The fruit is edible; the pulp is pleasantly acid.

Observations A fairly large tree up to 40 m tall, with long clear bole up to 100 cm in diameter, bark surface usually smooth, sometimes slightly rough, shallowly and obscurely fissured, dark brown to pale brown-red; leaves elliptical to elliptical-oblong, 8–21 cm × 3–9 cm; inflorescence pseudo-terminal, dense, with few-flowered branches, sparsely, very minutely puberulous at the base; flowers 4-merous, petals c. 4 mm long, white to pale yellowish, with 3 ridges confluent at the base, disk large, cushion-like, distinctly 4-lobed, one stamen fertile, staminodes minute, filaments free; infructescence axis thick and woody, fruit subglobose, up to 7.5(–10) cm in diameter, smooth, yellow-green with darker dots when ripe. *M. torquenda* occurs scattered in lowland evergreen rain forest up to 800 m altitude, but is locally commonly cultivated, especially in East Kalimantan. The sap from the fruit rind is irritant. The heartwood is dark brown with black bands.

Selected sources 328.

E. Boer (general part),
R.H.M.J. Lemmens (general part, selection of species),
W.G. Keating (properties),
R.W. den Outer (wood anatomy)

Mesua L.

Sp. pl. 1: 515 (1753); Gen. pl. (Ed. 5): 231 (1754).
GUTTIFERAE
x = unknown; *M. ferrea*: $2n = 32$

Trade groups

- Penaga: heavy hardwood, e.g. *Mesua ferrea* L.
- Penaga tikus: medium-weight hardwood, e.g. *Mesua beccariana* (Baillon) Kosterm., *M. nuda* Kosterm. ex Whitmore, *M. paniculata* (Blanco) Kosterm.

Vernacular names

- Penaga: Ceylon ironwood, Indian rose chestnut (En). Indonesia: nagasari (Sundanese, Java). Malaysia: lenggapus, matopus (Peninsular). Burma (Myanmar): ngaw, gangaw. Cambodia: bosneak. Laos: ka thang, may lek. Thailand: bunnak. Vietnam: v[aas]p.
- Penaga tikus. Brunei: taikakang. Malaysia: bintangor batu (Sabah), mergasing (Iban, Sarawak). Philippines: kaliuas.

Origin and geographic distribution *Mesua* consists of at least 42 species and is distributed from India and Sri Lanka, through Burma (Myanmar), Indo-China, Thailand and the Malesian region to northern Australia (Queensland). Western Malesia is an important centre of diversity.

Uses Being a heavy hardwood, penaga is extensively used for heavy construction (posts, beams, rafters, joists, columns) and heavy duty flooring and furniture. It is also used for joinery, cabinet work, staircases, pallets (permanent and heavy duty types), tool handles (heavy impact), agricultural implements, rice pestles, vehicles and boat building. Besides, penaga is often used for telegraphic and power transmission post and cross arms, and in India for railway sleepers. The timber is also suitable for gun-stocks, walking sticks and musical instruments and has also been used as firewood.

Penaga tikus is infrequently used. It is suitable for indoor usage and may be a suitable cabinet timber. Poles of good form may be useful for fences and round sleepers in temporary tracks.

The oil extracted from the seeds is used for lighting and for perfumery. Flowers are used in dyeing for fixing colours. *M. ferrea* is occasionally used in traditional medicine. In Malaysia and India, a mixture of pounded kernels and seed-oil is used for poulticing wounds. The seed-oil is used for treating itch and other skin eruptions, dandruff and against rheumatism. In Java, a decoction of the flowers is drunk by women after childbirth. The fragrant flowers are used to stuff pillows and cushions, and in cosmetic products.

M. ferrea is a common ornamental tree along roadsides and in parks. Its regular, conical, bushy crown with vivid green leaves and showy, fragrant flowers make it an attractive avenue and shade tree. In India, *M. ferrea* is a sacred tree.

Production and international trade Penaga is not produced in large quantities and is generally not traded separately but in mixed consignments of heavy hardwood.

Small amounts of penaga tikus are exported to Japan, but accurate statistics are not available.

Properties Penaga is a heavy and very hard wood. The heartwood is reddish-brown with a purple tinge when fresh, becoming dark red-brown upon exposure. It is sharply demarcated from the sapwood which is pale brown or pale yellow with a greyish tinge and becomes grey or grey-brown upon exposure. The density is 940–1195 kg/m^3 at 15% moisture content. The grain is straight to interlocked, texture rather fine and even. The wood lacks any characteristic odour or taste.

At 16.5% moisture content, the modulus of rupture is 155–171 N/mm^2, modulus of elasticity 19 300–19 500 N/mm^2, compression parallel to grain 79.5–93 N/mm^2, compression perpendicular to grain 16–17 N/mm^2, shear 23 N/mm^2, cleavage 63 N/mm radial and 75 N/mm tangential, and Janka side hardness 14 860–15 530 N.

The rates of shrinkage of penaga are comparatively high: from green to 15% moisture content 4.3% radial and 5.5% tangential. The wood seasons slowly with a slight to moderate amount of end-checking and splitting and a slight risk of degrade, mainly cupping.

Penaga is slightly difficult to difficult to resaw and cross cut, but only slightly blunts the saws. Planing and boring is easy, with a smooth finish; the nailing properties are poor.

Penaga wood is rated as moderately durable to durable, but it is liable to termite attack. It is difficult to treat with preservatives.

Wood of *M. ferrea* contains 49.5% cellulose, 22% lignin, 16.5% pentosan and 0.3% ash. The solubility is 2.0% in alcohol-benzene, 3.0% in hot water and 10.7% in a 1% NaOH solution.

Penaga tikus is a medium-weight and hard wood. The heartwood is pale reddish-brown to yellowish-red or grey-brown with a reddish tinge and is indistinctly demarcated from the pale sapwood. The density is 705–805 kg/m^3 at 15% moisture content. The grain is straight to shallowly interlocked, texture fine or moderately fine and even. The wood does not have any distinct odour or taste. The wood seasons well but is subject to checking and staining. Penaga tikus works well with a smooth finish. The wood is not durable in exposed situations or in contact with the ground.

The kernels contain 75–76% of a yellowish oil, constituted by the glycerides of common fatty acids: stearic, oleic, linoleic and arachidic acids.

Description Small to medium-sized or fairly large evergreen trees up to 36 m tall; bole cylindrical to poorly shaped, up to 95 cm in diameter, often fluted at base; bark surface smooth to adherent scaly, sometimes somewhat dippled, ochrous-brown revealing a bright orange layer below, inner bark firmly fibrous, yellow-brown to pink or red, slowly exuding a clear yellow sticky sap; crown monopodial, later becoming sympodial, branches horizontal to descending, the leaves horizontal or pendulous; flush bright red. Leaves opposite, simple and entire, usually elliptical to narrowly elliptical, glabrous or occasionally glaucous, often shiny; secondary veins numerous, looping, running parallel nearly to the margin, frequently with equally prominent reticulating tertiary veins; sometimes with more or less persistent stipule-like interpetiolar modified leaves (hypsophylls). Flowers terminal or axillary, bisexual, solitary or in an up to 9-flowered open panicle, pedicel with small paired bracts; sepals 4, decussate, suborbicular, persistent and variously enlarged and thickened in fruit; petals 4, white or pink; stamens numerous, free or connate only at the base; ovary superior, 1–2-celled, each cell with 1–2 axillary ovules, style slender with a peltate to 4-lobed stigma. Fruit a capsule, usually globose, often beaked, thinly woody, usually dehiscing with 2(–4) valves before falling, often exuding resinous droplets, seated on or enveloped by the generally persistent sepals, 1–4-seeded. Seedling with hypogeal germination; all leaves opposite.

Wood anatomy

– Macroscopic characters:

Penaga: heartwood reddish-brown with a purple tinge when fresh, becoming dark red-brown upon exposure, sharply demarcated from the pale brown or pale yellow sapwood with a greyish tinge and becoming grey or grey-brown upon exposure. Grain straight to interlocked. Texture rather fine and even; wood somewhat lustrous, without a characteristic odour or taste. Growth rings indistinct or absent; larger vessels visible to the naked eye, occasionally with yellowish-white deposits; parenchyma and rays not distinct without a lens; ripple marks absent.

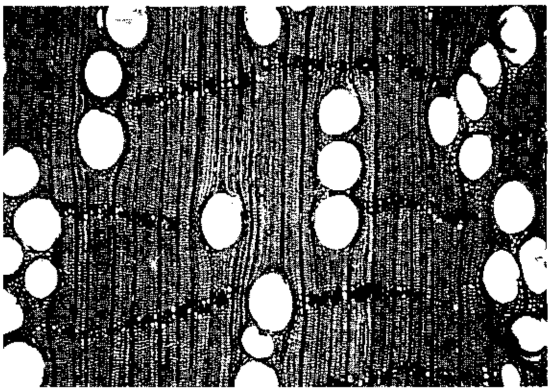
– Microscopic characters:

Penaga: vessels diffuse in a radial to diagonal pattern, 4–6/mm^2, solitary or rarely in oblique radial multiples of 2(–3), round, tangential diameter 100–200(–250) µm; perforations simple; intervessel pits rare or absent; vessel-ray pits large and with strongly reduced borders to simple, rounded or gash-like; faint helical thickenings occasionally present; yellowish-white deposits sometimes present; tyloses abundant. Vasicentric tracheids abundant, sometimes with faint helical thickenings. Fibres 650–1600 µm long, non-septate, thick-walled, with minutely bordered to simple pits mainly confined to the radial walls. Parenchyma abundant, in 2–3 cells wide continuous or interrupted widely spaced apotracheal bands, in about 8-celled strands. Rays very fine and low, 9–12/mm, mostly 1-seriate, the larger ones 300–500 µm high, heterocellular, composed of procumbent central cells and one to two rows of square to upright marginal cells. Prismatic crystals present in chambered axial parenchyma cells; parenchyma with gum-like deposits. Gum ducts absent.

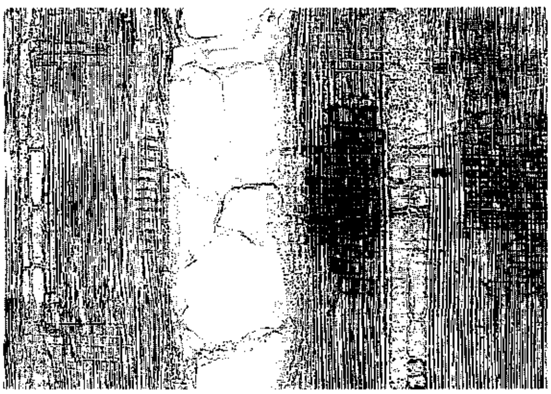
Species studied: *M. ferrea*.

Penaga wood resembles that of bintangor (*Calophyllum*) but is harder and heavier. According to literature from the Philippines, penaga tikus (*M. paniculata* and *M. philippinensis* studied) differs mainly in the sapwood being not distinctly differentiated from the heartwood and the parenchyma being conspicuous on tangential surfaces due to their dark red-brown colour. It has more numerous vessels (22–35/mm^2), and rays 8–17/mm, 1–2(–4)-seriate and up to 1000 µm high.

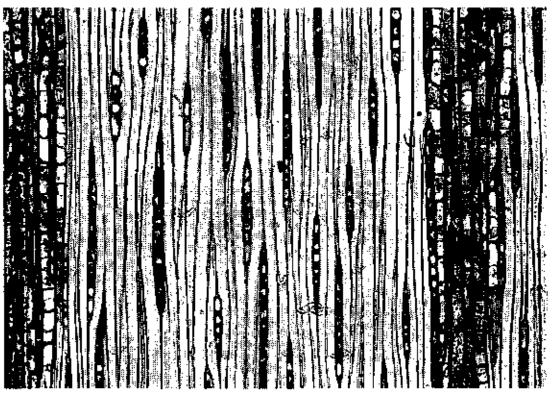
Growth and development During germination of *M. ferrea*, the testa of the seed splits and the radicle emerges from the blunter end. The fleshy cotyledons stay below the ground and within the testa. They remain attached to the seedling for several months. The seedlings will withstand



transverse section (×25)



radial section (×75)



tangential section (×75)

Mesua ferrea

considerable overhead shade, but they are susceptible to suppression by weeds.

M. ferrea grows very slowly. Even under favourable conditions the mean annual diameter increment of mature trees is only 0.3–0.4 cm. In India, an annual diameter increment of 0.5 cm has been recorded for trees in the diameter class 10–20 cm and of 0.8 cm during the first 24 years. In sample plots in Malaysia, 34-year-old trees reached a height of 17.3 m with a diameter at breast height of 24 cm, and 42-year-old trees reached a height of 19.2 m and a diameter of 27 cm. In a plantation established with container-raised seedlings, 8-year-old plants were 6 m tall and the canopy was closed.

Flowering starts when the trees are already fairly old. *M. ferrea* and *M. nuda* flower profusely in 'mast years'; *M. ferrea* flowers in other years too, but not so profusely. It flowers during the dry season and flushes of new leaves are produced just after flowering at the start of the rainy season. The flowers open for one day, starting to open between 3 and 4 a.m. and closing around sunset. Numerous thrips have been observed visiting the flowers of *M. ferrea*.

In India, an endomycorrhizal association has been found in *M. ferrea*.

Other botanical information *Mesua* is closely related to *Mammea* and *Calophyllum* and belongs to the subfamily *Calophylloideae* and the tribe *Calophylleae*. It has been enlarged to include the genus *Kayea* Wallich, and is distinct from the other genera within the tribe by its bisexual flowers, its 1–4-seeded fruits with a thick exocarp and its leaves with distinct intercostal veins.

Several species possess tiny, needle-like, paired, axillary structures which strongly resemble stipules but are probably modified, reduced leaves of the undeveloped axillary shoot.

Ecology *Mesua* is a fairly common component of the understorey and is sometimes also frequent in the main canopy in lowland, hill and occasionally montane evergreen or semi-evergreen forest, up to 2300 m altitude. The species occur usually scattered (*M. ferrea* sometimes gregariously) and are found in a wide variety of habitats; some inhabit poor sites in ridge forest. *Mesua* usually occurs on well-drained land, but sometimes in areas prone to flooding during rainy periods, rarely on limestone. In Borneo, the species occur especially on leached acid soils, in kerangas forest, mixed dipterocarp forest, and along mountain ridges. *M. ferrea* requires a fairly rich, well-drained soil.

Propagation and planting Penaga can be propagated by seed, which can be collected daily from underneath the tree or from the branches. One fruit contains 1–4 seeds. For *M. ferrea*, 1 kg contains 300–500 seeds. Seed is easy to handle in the nursery and germination is good and rapid. For *M. ferrea* 75–90% germination was recorded and seed germinated in 11–24 days. Seed loses its viability fairly rapidly, within 2–3 months. In India, the best storage result was obtained using perforated polyethylene bags stored at 5°C: germination was still 27% after 4 months of storage with an initial germination of 52%. A high degree of moisture and protection from the sun are essential for fair germination and early growth. Seed is planted 1–1.5 cm deep and spaced at 5 cm × 5 cm in the nursery beds; later seedlings are thinned to 10 cm × 10 cm. They grew best on raised beds in the nursery. Seedlings first develop a long taproot and therefore do not tolerate pricking out. In India, *M. ferrea* is planted in the field after 1 year when seedlings are about 30 cm tall or after 2 years when they are about 75 cm tall. In Indonesia, plants of 40–75 cm are recommended for planting out. In Malaysia, 4-year-old plants of *M. ferrea* were still too small to be planted in the field. Stumps do not thrive well, nor does bare-rooted planting stock. Vegetative propagation by means of cuttings did not prove successful. Container-raised seedlings are the best planting stock and should preferably be planted in fairly rich and well-drained sites under light shade. *M. ferrea* is also considered suitable for underplanting in e.g. teak (*Tectona grandis* L.f.) plantations.

Silviculture and management In India, the silviculture of *M. ferrea* is rather well developed. *M. ferrea* sets seed abundantly and natural regeneration is profuse, unless the seedlings are hindered by weeds or climbers. *M. ferrea* tolerates prolonged and intense shade, but it can stand full exposure as well. In a plantation in Peninsular Malaysia, growth of trees subject to full exposure is contorted, but they become straight later. However, when grown in the open, *M. ferrea* may be seriously affected by drought. Saplings coppice well, larger trees coppice fairly well, but the shoots are weak. An estimated rotation period of 150 years is required to arrive at 60 cm diameter for *M. ferrea*.

Diseases and pests Pathogenic organisms and pests recorded for *M. ferrea* are the fungus *Ganoderma lucidum*, causing root and butt rot, and the insects *Phenacaspis dilatata* and *Toxoptera aurantii*, the larvae of which feed on the sap of the leaves, but do not cause serious injuries. The occurrence of these diseases or pests within the South-East Asian region has not been confirmed.

Harvesting Penaga is a shade tree, and therefore selective cutting leaving enough shade for young trees is the only technique possible.

Yield In Peninsular Malaysia, one tree of *M. ferrea* of commercial size is found per 16 ha.

Handling after harvest Logs sink in water and should either be rafted to lighter logs or transported by road.

Genetic resources *M. ferrea* is known as an attractive lawn tree, but apart from a few individuals in arboreta, no specific ex-situ conservation takes place. Still, most *Mesua* spp. are fairly common elements of the Malesian rain forest and do not seem endangered when their habitats are preserved. Some of the rarer and endemic species (e.g. *M. kochummeniana* and *M. nuda* in Peninsular Malaysia) are more vulnerable to loss of genetic diversity.

Prospects Because of its very slow growth, penaga is not popular for plantations and will most likely continue to be harvested solely from the natural forest where regeneration occurs through wildlings. The feasibility for enrichment planting is worth investigating.

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269–284. [10] Whitmore, T.C., 1983. Guttiferae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. A manual for foresters. 2nd edition. Vol. 2. Forest Research Institute Malaysia. Longman Malaysia SDN. Berhad, Kuala Lumpur. pp. 227–236.

Selection of species

Mesua beccariana (Baillon) Kosterm.
Reinwardtia 7: 426 (1969).

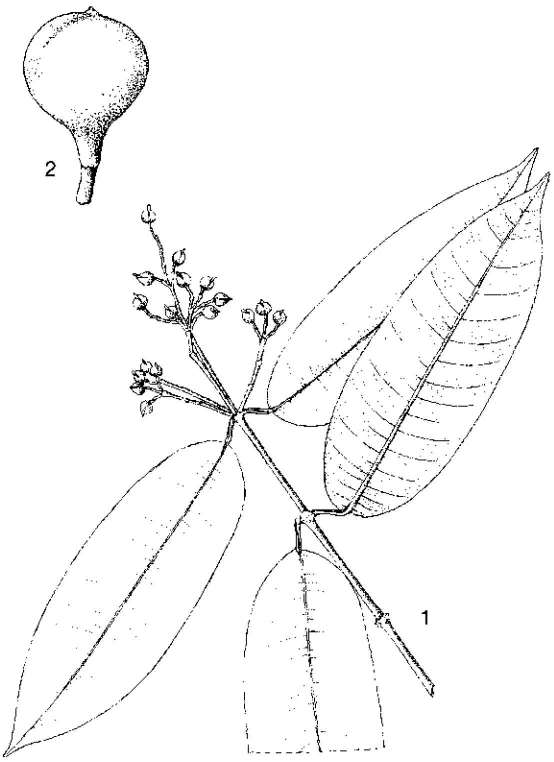
Synonyms *Kayea beccariana* Baillon (1876), *Kayea laevis* Kosterm. (1955).

Distribution Sumatra and Borneo.

Uses The wood is reputed to be used as penaga tikus.

Observations A medium-sized tree up to 30 m tall, bole up to 70 cm in diameter; hypsophylls early caducous; leaves elliptical to oblong, 7–23 cm × 3–10 cm, base rounded to cuneate and slightly decurrent, glabrous, secondary veins 11–17 pairs, tertiary venation much less distinct than the secondary veins below, petiole 12–20 mm long, glabrous; flowers c. 3 together in a panicle up to 10 cm long; fruit up to 3 cm in diameter, sepals caducous. *M. beccariana* is common on a wide variety of soils, from shallow yellow podzolic soils to basalt-derived latosols, and from ridges to alluvial river banks.

Selected sources 26, 310, 319, 706.



Mesua beccariana (Baillon) Kosterm. – 1, flowering twig; 2, fruit.

Mesua elmeri (Merr.) Kosterm.
Reinwardtia 7: 427 (1969).

Synonyms *Kayea elmeri* Merr. (1929).

Distribution Borneo.

Uses The wood is reputed to be used as penaga tikus.

Observations A medium-sized tree up to 30 m tall, bole up to 50 cm in diameter; hypsophylls early caducous; leaves elliptical, 2–13 cm × 1–5.5 cm, base cuneate and shortly decurrent, glabrous, secondary veins 13–14 pairs, tertiary venation almost as distinct as the secondary veins below, petiole 3–18 mm long, glabrous; flowers in a panicle up to 2 cm long; fruit c. 6 mm in diameter, sepals caducous. *M. elmeri* is locally common on yellow leached sandy and clay-rich soils in the lowlands, and on shallow soils on ridges, up to 2000 m altitude.

Selected sources 26, 319.

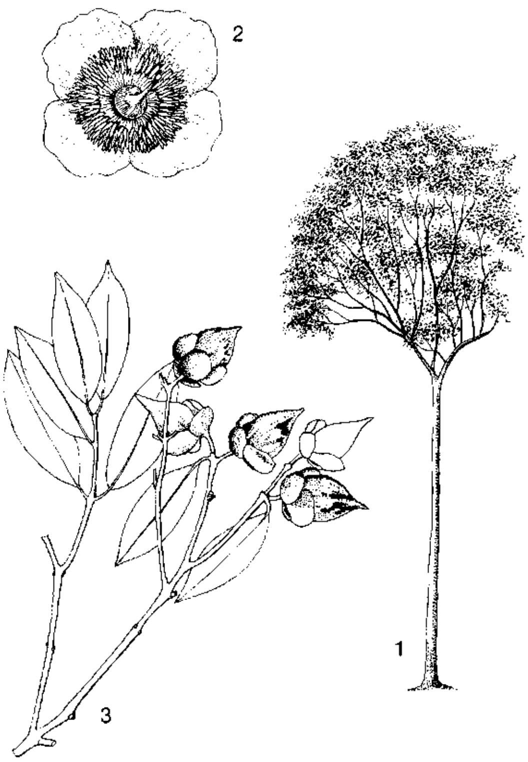
Mesua ferrea L.
Sp. pl. 1: 515 (1753).

Vernacular names Ceylon ironwood, Indian rose chestnut (En). Indonesia: nagasari (Javanese), nagasari gede (Sundanese). Malaysia: penaga, penaga lilin, lenggapus (Peninsular). Burma (Myanmar): ngaw, gangaw. Laos: ka thang, may lek. Cambodia: bos neak. Thailand: bunnak (general), saaraphi-doi (Chiang Mai). Vietnam: v[aas]p.

Distribution India, Sri Lanka, Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia and Singapore; planted as an ornamental or shade tree elsewhere in the Malesian region.

Uses *M. ferrea* is the most important source of penaga timber. Other uses as given for the genus. It is fairly common as an ornamental.

Observations A medium-sized tree up to 30 m tall, bole straight, branchless for up to 20 m, up to 65 cm in diameter, fluted or with small buttresses at base, bark surface elongated, adherent scaly, irregularly fissured, dull brown to grey with a purplish tinge, inner bark brownish-red to red or pinkish, with sparse drops of clear whitish to pale yellow exudate, darkening upon exposure; leaves elliptical, 4.5–12.5 cm × 1–4 cm, base acute, glaucous white below, secondary and tertiary venation



Mesua ferrea L. – 1, tree habit; 2, flower; 3, fruiting twig.

indistinct on both surfaces, petiole 4–8 mm long; flowers solitary or in pairs, up to 9 cm across; fruit ellipsoid, c. 3.5 cm long, seated on the persistent sepals. *M. ferrea* is common in evergreen forest on level or undulating land, also on ridges with shallow soils, from sea-level up to 500 m altitude, but planted up to 1300 m. The density of the wood is 940–1195 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 19, 23, 24, 36, 40, 69, 70, 78, 104, 140, 175, 234, 275, 293, 371, 398, 465, 466, 497, 519, 520, 529, 579, 648, 670, 679, 705.

Mesua ferruginea (Pierre) Kosterm.

Reinwardtia 7: 427 (1969).

Synonyms *Kayea ferruginea* Pierre (1889).

Vernacular names Malaysia: buah sembawang (Peninsular).

Distribution The Andaman Islands, Peninsular Malaysia, Sumatra, Bangka, Borneo and Sulawesi.

Uses The wood is reputed to be used as penaga tikus.

Observations A small to medium-sized tree up to 25 m tall, bole up to 60 cm in diameter; leaves elliptical, 8–12 cm × 3–4.5 cm, secondary veins 10–12 pairs, tertiary venation fine but visible below, petiole 5–12 mm long; flowers 2–4 together in an axillary raceme up to 2.5 cm long; fruit up to 6 cm across, enveloped in 4 loose leathery-fleshy sepals. *M. ferruginea* is locally common in forest along streams and rivers.

Selected sources 319, 529, 705, 706.

Mesua grandis (King) Kosterm.

Reinwardtia 7: 427 (1969).

Synonyms *Kayea grandis* King (1890).

Vernacular names Malaysia: chindarahan gajah, bunuai (Peninsular).

Distribution Peninsular Malaysia and Borneo.

Uses The wood is used as penaga tikus.

Observations A medium-sized tree up to 33 m tall, bole up to 55 cm in diameter, sometimes with steep buttresses up to 1.8 m high, bark surface smooth becoming cracked and fissured or scaly, inner bark meat-red, exuding little clear yellow sap; hypsophylls persistent and heart-shaped; leaves narrowly elliptical-lanceolate, (13–)20–50 (–65) cm × (4.5–)6–12(–15) cm, base usually minutely cordate, sometimes rounded or decurrent, secondary veins 25–60 pairs, sunken above to give the blade a bullate appearance, tertiary veins reticulate, faint, petiole stout, 8–26 mm long; flowers 3 together in a dense cyme up to 2 cm long; fruit up to 5 cm across, completely enclosed in the enlarged persistent sepals. *M. grandis* is very similar to *M. racemosa*, differing only in the size and bullateness of the leaves. It occurs scattered on hills and ridges, especially on basaltic and granitic soils but also on clay-rich fertile soils in mixed dipterocarp forest, rarely on limestone, up to 1300 m altitude. The density of the wood is 705–805 kg/m^3 at 15% moisture content.

Selected sources 26, 140, 319, 529, 705.

Mesua kochummeniana Whitmore

Gard. Bull. Sing. 26: 280 (1973).

Vernacular names Malaysia: penaga bayan, penaga sabut (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as penaga or penaga tikus.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 95 cm in diameter, bark surface scaly, dark grey, inner bark exuding drops of clear yellow sap; leaves ovate-oblong, c. 22 cm × 7 cm, rounded at base, glaucous below, secondary veins c. 5 mm apart, very prominent below, tertiary veins almost as conspicuous as the secondary veins, petiole stout, c. 12 mm long; flowers 3–6 together in a raceme 4–7 cm long and grouped in a terminal inflorescence; fruit at least 3 cm across, enclosed in 2 large woody sepals. *M. kochummeniana* is locally common, often in the drier parts of seasonal swamp forest, also on low hills.

Selected sources 19, 700, 705.

Mesua nuda Kosterm. ex Whitmore

Gard. Bull. Sing. 26: 283 (1973).

Vernacular names Malaysia: penaga lilin, penaga tikus (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as penaga tikus.

Observations A medium-sized tree up to 29 m tall, bole up to 65 cm in diameter, sometimes with steep buttresses or fluted as base, bark surface smooth, later elongated scaly, brown, inner bark with little clear exudate; leaves elliptical, (5–)6–8 cm × (1.5–)2–3 cm, base acute, secondary veins numerous, faint on both surfaces, tertiary venation indistinct, petiole 3 mm long, minutely scaly; flowers in axillary clusters; fruit solitary, up to 4 cm × 2.5 cm, sepals caducous. *M. nuda* is common in lowland and hillside forest, up to 500 m altitude.

Selected sources 700, 705.

Mesua paniculata (Blanco) Kosterm.

Reinwardtia 7: 428 (1969).

Synonyms *Plinia paniculata* Blanco (1837), *Kayea paniculata* (Blanco) Merr. (1904).

Vernacular names Philippines: kaliuas (general), agulasing (Cagayan), malimbatu (Lanao).

Distribution Borneo (Sabah, Brunei), Sulawesi and the Philippines; also reported from Queensland.

Uses The wood is used as penaga tikus; it is durable under cover and is used for interior finish, furniture and cabinet work.

Observations A medium-sized tree up to 30 m tall, bole up to 55 cm in diameter; hypsophylls caducous; leaves narrowly elliptical to lanceolate or oblong-lanceolate, 10–14 cm × 2.5–3.2 cm, base decurrent, secondary veins distant, about 30 pairs, tertiary venation indistinct, petiole 8–10 mm long, glabrous; flowers 1–3 together in an axillary and terminal panicle or raceme 5–7 cm long; fruit ovate to globose, c. 1 cm in diameter, with a short beak, seated on the persistent calyx. *M. paniculata* is fairly common in the Philippines but rare in Borneo, and is found in primary forest along streams, from the lowland up to 1500 m altitude. The density of the wood is 750–785 kg/m^3 at 15% moisture content.

Selected sources 26, 319, 416, 527, 677, 706.

Mesua philippinensis (Planchon ex Triana & Planchon) Kosterm.

Reinwardtia 7: 428 (1969).

Synonyms *Kayea philippinensis* Planchon ex Triana & Planchon (1861).

Vernacular names Philippines: yango (general), bitanhol (Negros).

Distribution The Philippines (from southern Luzon to Mindanao).

Uses The wood is rarely used as penaga tikus; it is durable under cover and is suitable for interior finish, furniture and cabinet work.

Observations A medium-sized tree, bole straight, short, up to 40 cm in diameter. No adequate botanical description of this species seems to be available. *M. philippinensis* occurs in forest along streams at low and moderate altitudes.

Selected sources 414, 527.

Mesua racemosa (Planchon ex Triana & Planchon) Kosterm.

Reinwardtia 7: 429 (1969).

Synonyms *Kayea racemosa* Planchon ex Triana & Planchon (1861).

Distribution Peninsular Malaysia and Borneo.

Uses The wood is used as penaga tikus.

Observations A medium-sized tree up to 24 m tall, bole up to 50 cm in diameter, sometimes buttressed, bark surface smooth, rugose with fine cracks, inner bark with drops of clear yellow exudate; hypsophylls absent; leaves ovate-oblong, 13–21 cm × 4.5–8 cm, base decurrent along the c. 2 cm long petiole, secondary veins 18–25 pairs, tertiary venation faint; flowers 3 together in a short compact raceme; fruit up to 5 cm across, enveloped in the persistent sepals. *M. racemosa* occurs scattered on hillsides, ridges and undulating land, rarely in seasonal swamp, up to 450(–1500) m altitude. The density of the wood is 725–740 kg/m^3 at 15% moisture content.

Selected sources 140, 319, 529, 705.

L. Chua (general part, selection of species),
N. Tonanon (properties),
J.M. Fundter (wood anatomy)

Myristica Gronov.

Fl. orient.: 141 (1755).

MYRISTICACEAE

x = unknown; *M. elliptica*: $n = 21$, *M. fragrans*: $2n = 42$

Trade groups Penarahan: lightweight to medium-weight hardwood, e.g. *Myristica buchneriana* Warb., *M. fatua* Houtt., *M. gigantea* King, *M. iners* Blume, *M. maingayi* Hook.f.
Penarahan timber represents the wood of all genera of the family *Myristicaceae*, hence next to *Myristica* also *Gymnacranthera*, *Horsfieldia* and *Knema*. In the Philippines penarahan is traded mixed with red meranti or as mixed second class timber.

Vernacular names Penarahan: nutmeg, red heart-wood (En). Indonesia: mendarahan (general). Malaysia: darah darah (Sabah), kumpang (Sarawak). Papua New Guinea: nutmeg. Philippines: duguan (general). Burma (Myanmar): mutwinda. Thailand: chan-pa.

Origin and geographic distribution *Myristica* consists of more than 100 species and is distributed from southern India and Sri Lanka, through Burma (Myanmar), Indo-China, Thailand, the whole Malesian area, towards northern Australia, the Solomon Islands, Fiji, Tonga and Samoa. The eastern Malesian region comprises the largest species diversity for the genus.

Uses The timber is often comparatively soft and not durable and when used for construction it should be treated with a suitable wood preservative. It is used for light temporary construction, concrete shuttering, mouldings, pattern making, cladding, interior finish, partitioning, flooring, cheap furniture, carving, cigar boxes, matchboxes and splints, packing cases, crates and plywood. The wood is easy to work and is used for wood carving and in puppet and shoe industries. It is also used as firewood, and in some places it is traditionally used for the fumigation of women after childbirth.
The fruits and nuts traded as nutmeg are produced by *M. argentea* Warb., *M. fatua*, *M. fragrans* Houtt., *M. malabarica* Lamk and *M. succedanea* Blume. *M. fragrans* is widely cultivated and produces the majority of the nutmeg in trade. Apart from its use as spice, nutmeg is generally also used in traditional medicine. Kernels of *Myristica* contain almost 50% fat and were formerly used in pharmaceuticals and cosmetics. The fruits of *M. crassa* King and *M. fragrans* are edible. The red sap from the bark was used as a traditional natural dye.

Production and international trade *Myristica* timber is traded together with the timber of other *Myristicaceae* genera, and no separate production and trade figures are available. In 1983 2800 m^3 of penarahan saw logs with a value of US$ 95 000 was exported from Peninsular Malaysia (2200 m^3 to Singapore and 600 m^3 to South Korea). In 1984 1050 m^3 with a value of US$ 42 000 (US$ 40/m^3) was exported (mainly to Singapore and a small amount of 50 m^3 to Taiwan). The export of penarahan saw logs from Sabah was 10 000 m^3 in 1987 with a value of US$ 610 000, and in 1992 the export of penarahan timber was 7000 m^3 (97% as logs, 3% as sawn timber) with a total value of US$ 510 000 (US$ 71/m^3 for logs, US$ 140/m^3 for sawn timber). The contribution of *Myristica* timber to these totals is probably considerable.

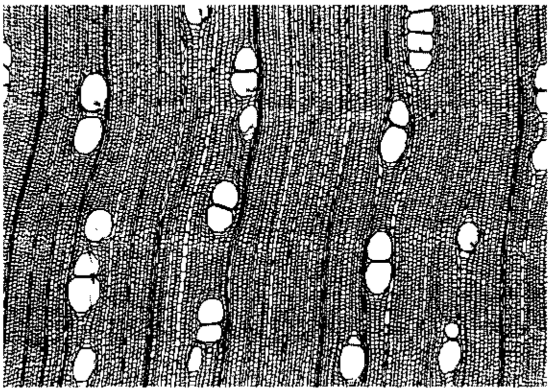
Properties *Myristica* wood is lightweight to medium-weight. The heartwood is pale brown or brown to orange-brown and distinctly or indistinctly demarcated from the yellowish to pale brown sapwood. The density is 400–790 kg/m^3 at 15% moisture content. The grain is straight to slightly interlocked, texture moderately coarse. The wood is more or less lustrous.
At 15% moisture content, the modulus of rupture is c. 71 N/mm^2, modulus of elasticity 8500 N/mm^2, compression parallel to grain 42–43.5 N/mm^2, compression perpendicular to grain 5.5 N/mm^2, shear 9.5 N/mm^2, Janka side hardness 3100 N and Janka end hardness 4200 N.
The rates of shrinkage are moderate to fairly high: from green to 15% moisture content 0.9–3.3 (–3.8)% radial and 2.0–4.1% tangential, and from green to oven dry 1.5–4.6% radial and 5.5–7.2% tangential. The wood dries fairly slowly, with only slight seasoning defects such as cupping, bowing, end checking, splitting and staining. The main source of degrade during seasoning is insect attack. In Malaysia, it takes 2.5–3 months to air dry 15 mm thick boards and about 4 months to air dry boards 40 mm thick. In Papua New Guinea, a kiln schedule with a dry-bulb temperature of 55–71°C gave acceptable results for *M. buchneriana* wood; using this schedule the wood can be dried from 65% to 15% moisture content in 6 days. A reconditioning treatment may prove advantageous.
Generally, the wood is easy to saw, plane, bore, turn, shape, mortise and sand to a smooth to moderately smooth finish, but sometimes boring and turning give moderate or poor results. The resistance to splitting when nailed is rated as good. The peeling properties are good. The veneer dries

with little degrade, but it is susceptible to staining and fungal and borer attack; an antistain and insecticide treatment is recommended. The veneer can be glued satisfactorily to produce plywood.

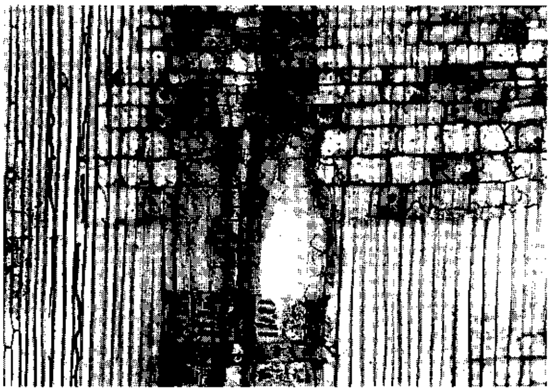
The wood is classified as non-durable, but *M. elliptica* wood has been rated in Indonesia as moderately durable. Tests with stakes (50 mm × 50 mm × 600 mm) of *M. gigantea* wood in Malaysia showed an average service life of only 1 year in contact with the ground. The wood is susceptible to subterranean termite and fungal attack, and indoors it is liable to dry-wood termite and powder-post beetle attack. The heartwood is resistant to preservative treatment but the sapwood usually absorbs preservatives well; an absorption of 320(–450) kg/m^3 can be obtained using an open tank treatment and an equal mixture of creosote and diesel fuel.

Wood of *M. lowiana* contains 50% cellulose, 27% lignin, 15% pentosan, 1.4% ash and 0.5% silica. The solubility is 2.8% in alcohol-benzene, 0.6% in cold water, 7.9% in hot water, and 13.7% in a 1% NaOH solution.

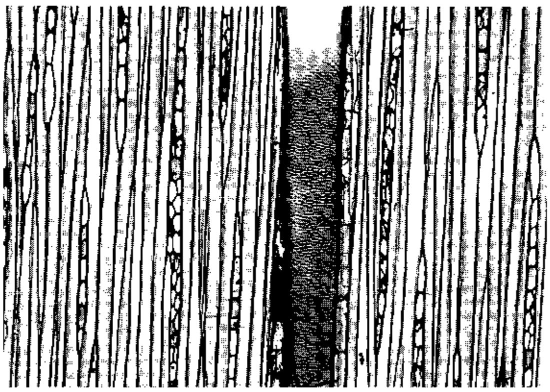
Description Dioecious, small to large evergreen trees up to 35(–45) m tall; bole cylindrical, up to 70(–100) cm in diameter, plank or flying buttresses and stilt roots sometimes present; bark surface usually fissured, sometimes flaking, brownish or occasionally black and brittle, inner bark pinkish to reddish-brown; crown monopodial, often pyramidal with spreading radial limbs; twigs striate, with or without lenticels. Leaves distichous, simple and entire, petiolate, the blades elliptical to elliptical-lanceolate or elliptical-obovate, up to 50 cm long, often glaucous and glabrous or glabrescent or with persistent indumentum of dendroid and/or scale-like hairs below; secondary veins often sunken above, straight or curved, tertiary venation finely reticulate and forming a close network; stipules absent. Inflorescence an axillary panicle with flowers in cymes or subumbels to reduced to short woody knobs, female inflorescence usually less branched or more compact; bracts small, caducous, bracteoles persistent, usually embracing the base of the flower on one side. Flowers actinomorphic, small, pedicelled, often fragrant; perianth elliptical to flask-shaped or campanulate, white to yellow, generally 3-lobed, often with reflexed lobes, glabrous or variously hairy outside, usually glabrous inside; male flowers with an androecium of 6–30 anthers fused with their back to a central column and with their sides to each other; female flowers with a superior, globose to subglobose, 1-celled, glabrous or



transverse section (×25)



radial section (×75)



tangential section (×75)

Myristica globosa

hairy ovary, stigma sessile, minutely 2-lobed. Fruit globose to ovoid, pyriform or oblong, with a thick fleshy wall, orange-yellow, or rusty brown, eventually splitting into 2 halves, 1-seeded. Seed ellipsoid, enclosed in a red to orange aril which is laciniate to the base or nearly so, seed-coat hard; endosperm containing oil and much starch. Seedling with hypogeal germination; leaves arranged spirally.

Wood anatomy

– Macroscopic characters:

Heartwood pale brown or brown to orange-brown, variously demarcated from the yellowish to pale brown sapwood. Grain straight to slightly interlocked. Texture moderately coarse; wood more or less lustrous. Growth rings indistinct; vessels and rays visible to the naked eye; irregularly spaced banded parenchyma often present and visible with a hand lens.

– Microscopic characters:

Growth rings absent or indistinct, if present marked by narrow parenchyma bands and very slight differences in fibre wall thickness. Vessels diffuse, 3–11/mm^2, solitary and in radial multiples of 2–3, round to oval or slightly angular, average tangential diameter 140–200 μm; perforations simple, scalariform and reticulate; intervessel pits non-vestured, alternate to opposite, oval to polygonal, 5–10 μm; vessel-ray and vessel-parenchyma pits mainly large and simple and elongated horizontally, some smaller and half-bordered; helical thickenings and deposits absent; tyloses usually present. Fibres c. 1200 μm long, non-septate, thin-walled, with simple to minutely bordered pits mainly confined to the radial walls. Parenchyma scarce to abundant, only scanty paratracheal to narrowly vasicentric (e.g. *M. elliptica*), or also in zonate, tangential bands of 2–4(–6) cells wide, in 3–6-celled strands. Rays 7–12/mm, 1–3 cells wide, 0.2–1.6 mm high, heterocellular, composed of procumbent to square body ray cells and one row of upright marginal cells. Crystals absent. Oil cells and tanniferous tubes common in the rays.

Species studied: *M. crassa*, *M. elliptica*, *M. iners*.

Growth and development Germination is according to the *Horsfieldia* seedling development type. The testa remains around the cotyledons and is shed together with them. The taproot, hypocotyl and plumule are pushed free from the testa by the elongation of the cotyledonary petioles; the hypocotyl is short and subterranean. The erect main stem of the seedling grows in flushes with dispersed leaves, and develops cataphylls early in the growing season. The leaves produced at the end of the growing season are largest and are close together, forming a pseudo-whorl. The shoot ends in a usually 'open' terminal bud from which the orthotropic growth proceeds in the next season. Branching occurs from the axils of the pseudo-whorled leaves, causing pseudo-verticillate branching from the main stem. The branches are usually more or less horizontal or somewhat drooping; they ramify to various degrees and in the periphery of the crown may carry twigs with inflorescences. The branch phyllotaxis is distichous. The general growth form of *Myristicaceae* is according to Massart's architectural model (e.g. *M. fatua* and *M. fragrans*). Strong erect-growing renewal shoots may be produced after severe damage to the crown, showing dispersed phyllotaxis.

M. elliptica and *M. maingayi* are normally stilt-rooted when growing in swamps, but do not produce stilts on well-drained soils. *Myristica* shows ramiflory in canopy trees. In many *Myristicaceae* the flowers are pollinated by bees. For *M. malaccensis* the period from flowering to fruiting is 7 months, which is slightly shorter than for cultivated nutmeg (*M. fragrans*; 9 months). The fruits are commonly dispersed by birds, including pigeons and hornbills.

Other botanical information The vernacular names are generally derived from the word blood, referring to the blood-red sap that exudes when the bark is slashed.

Species of freshwater swamp or peat-swamp forest often have stilt roots. These do not seem to develop when the same species grow in drier conditions, and hence are not a helpful character for identification.

Ecology Most species are found scattered in lowland tropical evergreen rain forest up to 800 m altitude. They are nearly always elements of the second storey, although some may occasionally reach the canopy top. Quite a number of species are found in freshwater swamp or peat-swamp forest, but others prefer well-drained fertile places such as hillsides and ridges. Generally they do not tolerate waterlogging or excessive drying out of the soil. Few species are found on limestone, or along the coast. The latter prefer a rocky or sandy substratum, with the exception of *M. hollrungii* which grows in the mud of the inner mangrove zone. Several species extend into the montane forest zone, and in New Guinea some are confined to montane forest up to 2200 m altitude.

Propagation and planting *Myristica* is usually propagated from seed collected from under the tree. The seed dries out easily and cannot be stored, and loses its viability in about one month. Seed of *M. crassa* without aril has about 45% germination in 1.5–3.5 months and seed of *M. malaccensis* has about 75% germination in 1.5–4 months. Attempts have been made to propagate nutmeg by budding and cuttings, but these have failed so far. Shade appears to be beneficial in the early growth stages. Planting for timber in South-East Asia is not known.

Silviculture and management When one-year-old seedlings of *M. andamanica* Hook.f., a timber species from the Andaman Islands, were planted at an average height of 30 cm the survival was 90%; partial overhead shade proved essential.

Diseases and pests The foliage of *M. malaccensis* is invariably galled; the galls develop within two weeks after leaf renewal. Living trees are rarely, if ever, attacked by borers.

Harvesting In general, logs are remarkably free from natural defects, except for a very small area around the pith in which heart rot and compression failures or cross breaks occur. Occasionally, trees are slightly hollow and sometimes freshly sawn logs are apt to split longitudinally. Trees are liable to ambrosia beetle attack soon after felling.

Yield The yield of *Myristica* wood from natural forest is generally low as the trees occur scattered. In natural forest near Samarinda, East Kalimantan, the timber volume of *Myristica* is about 1.85 m^3/ha.

Genetic resources As in most other larger genera, the distribution and frequency of the various species differ considerably. Some occur over large areas and are common, but others are rare or occur very locally. Clearly, the latter category is more vulnerable. *Myristica* does not seem to be particularly liable to genetic erosion because it is rarely selectively logged for timber, and the timber is not in great demand.

Breeding Dioecy implies out-breeding and should be taken into account when attempting any breeding work.

Prospects Penarahan may be promising for local enrichment planting in logged-over areas, e.g. in the Moluccas and Irian Jaya where many species occur naturally. However, more information is needed on aspects such as silviculture, propagation and planting.

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Selection of species

Myristica bifurcata (Sinclair) W.J. de Wilde

Blumea 35: 239 (1990).

Synonyms *Myristica lancifolia* Poiret var. *bifurcata* Sinclair (1968).

Vernacular names Indonesia: au-au, pongamagasara (Moluccas).

Distribution The Moluccas and western New Guinea (Vogelkop peninsula).

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized to fairly large tree up to 40 m tall, buttresses small or absent, bark fissured, dark brown or grey; leaves chartaceous, 8–18 cm long, papillose and glabrous below except for the glabrescent midrib, secondary veins about 15 pairs, flat or sunken above; male inflorescence ramified or on thick spur shoot; male flowers 2.5–5 mm long, densely shaggily hairy, female flowers about 5 mm long; fruit oblong-ellipsoid, 3–4 cm long, tomentose. *M. bifurcata* is locally common in well-drained forest on volcanic or clayey soil, also overlying serpentine, up to 750 m altitude. Two subspecies are recognized. Subsp. *bifurcata* has 0.5–0.8 mm long hairs on flowers and fruits and 4–5 mm long male flowers, and is found on Morotai and the Vogelkop peninsula. Subsp. *sulaica* W.J. de Wilde has 0.1–0.2 mm long hairs on flowers and fruits and about 2.5 mm long male flowers, and occurs in the northern Moluccas.

Selected sources 138, 568.

Myristica buchneriana Warb.

Bot. Jahrb. Syst. 13: 311 (1891).

Vernacular names Indonesia: gaa gala (Irian Jaya). Papua New Guinea: ilis (Jal, Madang), madut (Sempi, Madang), nogumur (Kaigorin).

Distribution Eastern Irian Jaya and Papua New Guinea.

Uses *M. buchneriana* is an important source of penarahan timber in Papua New Guinea.

Observations A small to medium-sized tree up to 30 m tall, bark fissured, dark brown or greyish-brown; leaves chartaceous, 14–21 cm long, glabrous and glaucous below or sometimes sparsely covered with minute yellow scales and hairs, secondary veins 12–18 pairs, sunken above; male inflorescence on thick spur shoot; male flowers 8–10 mm long, appressed rusty tomentose outside, female flowers about 8 mm long; fruit ellipsoid to obovoid, about 4 cm long, rusty tomentose. *M. buchneriana* occurs frequently on ridge tops at 300–1300 m altitude. The density of the wood is about 600 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 60, 145, 166, 474, 568, 718.

Myristica crassa King

Ann. Roy. Bot. Gard. Calc. 3: 293, pl. 117 (1891).

Synonyms *Myristica suavis* King (1891).

Vernacular names Malaysia: penarahan, pala bukit, pala hutan (Peninsular). Thailand: prae ledong.

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore and Sumatra.

Uses The wood has been used as penarahan for house building.

Observations A small to medium-sized tree up to 18 m tall, bole up to 30 cm in diameter, with few weak stilt roots, bark shallowly fissured, brown; leaves coriaceous, 18–40 cm long, glabrous, faintly glaucous below, secondary veins 15–22 pairs, sunken above; inflorescence sometimes bisexual, on thick spur shoot; male flowers 4–7 mm long, puberulous, female flowers 4–7 mm long; fruit ovoid-globose, 2.5–4.5 cm long, minutely rusty puberulous. *M. crassa* is uncommon in lowland and hill forest. The density of the wood is 485–530 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 436, 529, 567, 568, 705.

Myristica crassipes Warb.

K. Schumann & Lauterb., Fl. Deutsche Schutzgeb. Südsee: 326 (1900).

Distribution New Guinea.

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized tree up to 27 m tall, bole sometimes spurred at base; leaves chartaceous, 4–15 cm long, yellowish to glaucous below due to minute scales, becoming glabrous, secondary veins 14–20 pairs, sunken above; male inflorescence on thick spur shoot; male flowers 5–10 mm long, rusty tomentose outside; fruit ellipsoid to obovoid-ellipsoid, 5.5–7 cm long, rusty tomentulose and slightly warty. *M. crassipes* occurs in primary and secondary forest on ridges and slopes, up to 1500 m altitude.

Selected sources 165, 568, 718.

Myristica elliptica Wallich ex Hook.f. & Thomson

Fl. Brit. India 1: 162 (1855).

Synonyms *Myristica calocarpa* Miq. (1858), *Myristica sycocarpa* Miq. (1858).

Vernacular names Swamp nutmeg (En). Indonesia: sungkit-sungkit (Sumatra). Malaysia: penarahan arang ayer (general), tabah, tajam penggali (Peninsular). Thailand: chan-muang (Nakhon Si Thammarat).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo (Sarawak and Kalimantan) and intervening islands.

Uses The wood is used as penarahan. The nut is used for nutmeg.

Observations A small to medium-sized tree up to 33 m tall, bole up to 95 cm in diameter, with buttresses or stilt roots in wet habitats, bark smooth or rough, reddish-brown to grey-brown or pale brown; leaves chartaceous, 12–18(–28) cm long, glabrous and slightly glaucous below, secondary veins 12–17 pairs, faint and slightly raised above; male inflorescence 2–2.5 cm long with short branches; male flowers 8–9 mm long, glabrous to appressed puberulous, female flowers 8–9 mm long; fruit obliquely oblong, 7–8 cm long, glabrous.

M. elliptica is closely related to *M. simiarum*. It occurs in seasonal and permanent swamp areas, on river banks, less frequently in undulating country at low and medium altitudes. The density of the wood is 445–540 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 140, 436, 470, 474, 528, 567, 568, 705.

Myristica fatua Houtt.

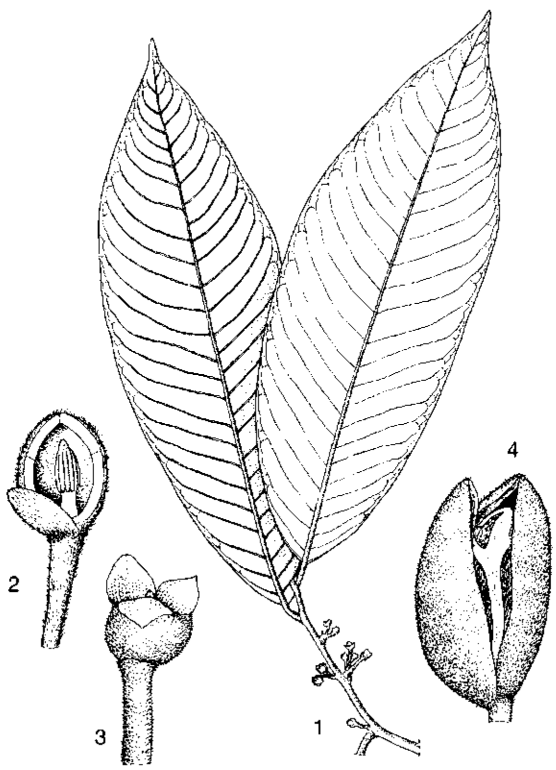
Nat. hist. pl. 2(3): 337 (1774).

Synonyms *Myristica tomentosa* Thunb. (1782), *Myristica spadicea* Blume (1826), *Myristica plumeriifolia* Elmer (1911).

Vernacular names Indonesia: hai (Seram), pala utan (Ambon), pala laki-laki (Banda). Philippines: uyat-uyat (Yakan).

Distribution South-eastern Kalimantan, Sulawesi, the Philippines and the Moluccas.

Uses The wood has been used as penarahan, e.g. for house building. The nut has been used medicinally against headache, or pounded with senna (*Cassia*) as a purgative.



Myristica fatua Houtt. – 1, twig with male flowers; 2, sectioned male flower; 3, female flower; 4, dehisced fruit showing seed and aril.

Observations A small to medium-sized tree up to 20 m tall, bole with low buttresses and stilt roots; leaves chartaceous to slightly coriaceous, (20–)25–35 cm long, pale yellow to whitish due to minute scales below, secondary veins 20–25 pairs, sunken above; male inflorescence on lateral spur shoot; male flowers 7–8 mm long, rusty appressed tomentose outside, female flowers about 6 mm long; fruit oblong, 5–7.5 cm long, shortly tomentulose. *M. fatua* is a very variable species, formerly divided into many varieties. Most of these are now regarded as distinct species. It is found in well-drained forest, on clay or volcanic soil, up to 500 m altitude.

Selected sources 138, 145, 216, 234, 544, 568, 718.

Myristica fusca Markgraf

Bot. Jahrb. Syst. 67: 158 (1935).

Distribution New Guinea (locally).

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized tree up to 30 m tall, bole with buttresses up to 1 m high, bark surface scaly, black; leaves chartaceous, 18–28 cm long, shortly rusty tomentose below, secondary veins 20–28 pairs, sunken above; male inflorescence on thick spur shoot; male flowers 15–17 mm long, densely tomentose or lanose outside, female flowers about 10 mm long; fruit ellipsoid, about 7 cm long, densely rusty tomentose but glabrescent. *M. fusca* occurs in primary rain forest, at 100–800 m altitude. The density of the wood is 520–710 kg/m^3 at 15% moisture content.

Selected sources 474, 568, 718.

Myristica gigantea King

Ann. Roy. Bot. Gard. Calc. 3: 288, pl. 110 (1891).

Vernacular names Malaysia: penarahan arang, penarahan arang bukit (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as penarahan.

Observations A large tree up to 45 m tall, bole occasionally with plank and flying buttresses and stilt roots, bark surface usually closely fissured, black and gritty; leaves coriaceous, 7–10 cm long, glabrous, slightly glacous below, secondary veins 12–18 pairs, sunken above; male inflorescence a short panicle; male flowers 4–5 mm long, shortly rusty tomentose; fruit ovoid, 5.5 cm long, minutely tomentose and with a reddish-brown persistent scurf. *M. gigantea* is common on flat land and hillsides, up to 700 m altitude. The density of the wood is 625–690 kg/m^3 at 15% moisture content, but dark-coloured corewood may have a density of about 865 kg/m^3. See also the table on wood properties.

Selected sources 140, 436, 567, 568, 641, 705.

Myristica globosa Warb.

Monogr. Myrist.: 540, t. 19, fig. 1–2 (1897).

Synonyms *Myristica baeuerlenii* Warb. (1897), *Myristica salomonensis* Warb. (1897), *Myristica schumanniana* Warb. (1900).

Distribution Papua New Guinea to the Solomon Islands.

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized to fairly large tree up to 35 m tall, bole with buttresses or prop roots, or both, bark surface densely fissured or distinctly flaking; leaves chartaceous, 8–17 cm long, glabrous, glaucous or greyish below, secondary veins 13–18 pairs, sunken above; male inflorescence on thick spur shoot; male flowers 5 mm long, short tomentose to puberulous outside, female flowers 6 mm long; fruit subglobose, 1.5–2.5 cm across, pale greyish or rusty-brown tomentose. *M. globosa* is found in evergreen rain forest, from sea-level up to 1200 m altitude.

Selected sources 138, 568, 718.

Myristica guatteriifolia A.DC.

Ann. Sci. Nat. Bot. 4(4): 30 (1855).

Synonyms *Myristica littoralis* Miq. (1858), *Myristica riedelii* Warb. (1897), *Myristica palawanensis* Merr. (1918).

Vernacular names Sea-shore nutmeg (En). Indonesia: ki mokla (Sundanese). Malaysia: penarahan (Peninsular). Philippines: duguan-mabolo, palawan duguan (Filipino), alanagni (Sulu).

Distribution Burma (Myanmar), southern Vietnam, Peninsular Malaysia, Sumatra, Java, Bali, Borneo and the Philippines.

Uses The wood is used as penarahan in the Philippines, and is sometimes used in Sabah. The oil of the seeds has been used for lamps.

Observations A small to medium-sized tree up to 26 m tall, bole straight, cylindrical, up to 45 cm in diameter, without buttresses, bark surface irregularly flaky, brown to greyish-brown; leaves coriaceous, 15–30 cm long, sparsely tomentose to subglabrous below and with stellate scaly hairs, secondary veins 15–20 pairs, sunken above; male inflorescence branched, 2–8 cm long; male flowers 4–7 mm long, densely rusty tomentose, female flowers 5–7 mm long; fruit broadly ellipsoid, 5 cm long, rusty tomentose. *M. guatteriifolia* is not uncommon in evergreen to deciduous forest and beach forest, up to 400 m altitude. The density of the wood is 500–650 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 140, 234, 303, 436, 474, 544, 567, 568, 705.

Myristica hollrungii Warb.

Monogr. Myrist.: 490, t. 19, fig. 1–2 (1897).

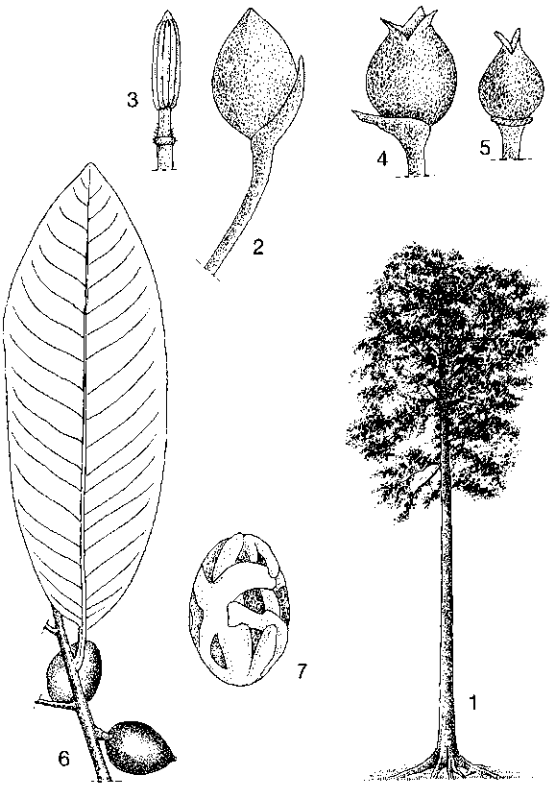
Synonyms *Myristica albertisii* Warb. (1897), *Myristica euryocarpa* Warb. (1900).

Vernacular names Mangrove nutmeg (En).

Distribution New Guinea, New Britain and New Ireland.

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized to fairly large tree up to 36 m tall, bole slender, with stilt roots, bark surface finely vertically fissured and flaking, dark greyish-brown; leaves thinly coriaceous, 20–35 cm long, glabrous, pale or glaucous below,



Myristica hollrungii Warb. – 1, tree habit; 2, male flower; 3, androecium; 4, female flower; 5, pistil; 6, fruiting twig; 7, seed with aril.

secondary veins 16–22 pairs, flat or slightly sunken above; male inflorescence on short, single or branched, thick shoot; male flowers 5 mm long, pale tomentulose to subglabrous, female flowers 5 mm long; fruit oblong to oblong-ovoid, 3–3.5 cm long, slightly scurfy but glabrescent. *M. hollrungii* is common in lowland rain forest, along water courses, in swamps, or mangrove vegetation, usually at low altitude, rarely up to 900 m.

Selected sources 568, 718.

Myristica iners Blume

Bijdr. fl. Ned. Ind. 2, 11: 575 (1828).

Synonyms *Myristica vordermanii* Warb. (1897), *Myristica heritieriifolia* Pierre ex Lecomte (1909).

Vernacular names Indonesia: kayu luo, ki laka, laka (Sundanese). Malaysia: penarahan arang (general). Thailand: chan-daeng (Trang), chan-pa (Trat), phrao-ledong (Surat Thani).

Distribution Southern Vietnam, Cambodia, Thailand, Peninsular Malaysia, Sumatra, Java and Borneo.

Uses The wood is used as penarahan.

Observations A medium-sized to large tree up to 45 m tall, bole cylindrical, up to 100 cm in diameter, sometimes with stilt roots, bark surface fissured, black and gritty; leaves thinly chartaceous, 12–20 cm long, glabrous, dull pale green below, secondary veins 12–15 pairs, distinct above; male inflorescence an axillary panicle of 2–2.5 cm long with flowers borne in sub-umbels; male flowers 7–8 mm long, rusty puberulous outside, female flowers campanulate; fruit oblong to ovoid-oblong, 5–8.5(–10) cm long, minutely scaly but glabrescent. *M. iners* is common in evergreen rain forest, in Peninsular Malaysia especially in red meranti-keruing forest, on fertile moist soil. The density of the wood is 490–570 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 198, 199, 234, 303, 401, 436, 470, 474, 567, 568, 574, 705.

Myristica lepidota Blume

Rumphia 1: 183, t. 57 (1837).

Vernacular names Indonesia: kaibita-bita, kapieta (Aru Islands), maramea (Taire, Mimika, Irian Jaya).

Distribution The Moluccas and western New Guinea.

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 50 cm in diameter, sometimes with small buttresses, bark surface fissured; leaves chartaceous, 9–14 cm long, with woolly pale cinnamon or grey-brown tomentum below, secondary veins 10–12 pairs, faint and sunken above; male inflorescence on thick spur shoot; male flowers 2–2.5 mm long, densely rusty tomentose, female flowers 3 mm long; fruit obovoid, 2.5–3 cm long, cinnamon-brown tomentulose. Two subspecies are distinguished: subsp. *montanoides* (Warb.) W.J. de Wilde (synonym: *Myristica montanoides* Warb.) is characterized by an early glabrescent lower leaf surface, and is found in the north-eastern Moluccas and the Vogelkop peninsula; subsp. *lepidota* occurs in the southern Moluccas and south-western New Guinea. *M. lepidota* occurs in primary or secondary rain forest in flat to hilly country, on sandy or clayey alluvial soils or on loamy soils, up to 600 m altitude.

Selected sources 138, 568, 718.

Myristica lowiana King

Ann. Roy. Bot. Gard. Calc. 3: 293, pl. 120, fig. 2, 3, 4 (1891).

Synonyms *Myristica hackenbergii* Diels (1926).

Vernacular names Malaysia: penarahan arang gambut (general), kumpang kiong (Iban, Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as penarahan.

Observations A small to medium-sized tree up to 25 m tall, bole up to 60 cm in diameter, usually with few stilt roots and flying buttresses, bark narrowly fissured, black and gritty, inner bark pink, slightly laminated; leaves stoutly coriaceous, 19–30 cm long, glabrous, pale green below, secondary veins 17–20 pairs, sunken above; male inflorescence ramified with 2 or 3 short branches and 3–5 cm long; male flowers 4–5 mm long, rusty stellate tomentose, female flowers 5 mm long; fruit ovoid, 6–8 cm long. *M. lowiana* is a peat-swamp forest species, rarely found on dry land. The density of the wood is 485–600 kg/m^3 at 15% moisture content.

Selected sources 77, 140, 401, 436, 562, 567, 568, 576, 641, 705.

Myristica maingayi Hook.f.

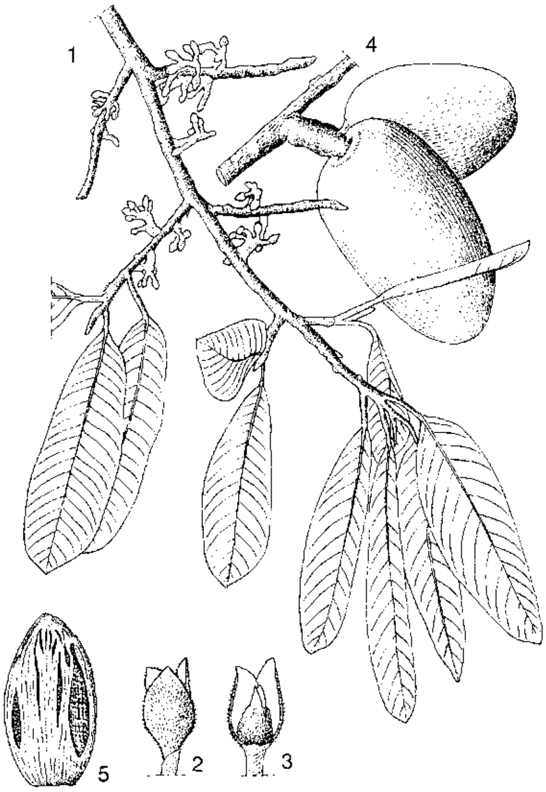
Fl. Brit. India 5: 104 (1886).

Vernacular names Maingay's nutmeg (En). Malaysia: penarahan arang bukit (general).

Distribution Peninsular Malaysia.

Uses The wood is used as penarahan.

Observations A medium-sized to large tree up to 45 m tall, bole often with plank and flying but-



Myristica maingayi Hook.f. – 1, twig with female flowers; 2, female flower; 3, sectioned female flower; 4, fruits; 5, seed with aril.

tresses and stilt roots, bark surface closely fissured, black and gritty; leaves coriaceous, 12–28 cm long, glabrous, pale green below, secondary veins about 20 pairs, sunken above; male inflorescence branched, 10–16 cm long; male flowers 4–6 mm long, rusty tomentose, female flowers 9 mm long; fruit oblong-ovoid, 8.5–10.5 cm long, sparsely reddish-brown scurfy but soon glabrescent. *M. maingayi* is common on hillsides and crests, seldom in flat country, up to 300 m altitude. See also the table on wood properties.

Selected sources 104, 436, 528, 567, 568, 641, 705, 741.

Myristica malaccensis Hook.f.

Fl. Brit. India 5: 104 (1886).

Vernacular names Malaysia: penarahan arang (general).

Distribution Peninsular Malaysia (rare), Borneo.

Uses The wood is reputed to be used as penarahan.

Observations A small to medium-sized tree up to 20 m tall, bole up to 50 cm in diameter, but usually smaller, with stilt roots, bark surface scaly with small squarish scales in several layers, black and gritty; leaves coriaceous, 15–25(–33) cm long, glabrous, pale green and slightly glaucous below, secondary veins 15–20 pairs, sunken above; male inflorescence branched, 7–10 cm long, bracteoles with ciliate margins; male flowers 2.5–5 mm long, tomentulose with greyish hairs, female flowers 3.5–6 mm long; fruit oblong, 5–7 cm long, glabrous. *M. malaccensis* is related to *M. iners* but differs in the scaly, not fissured, bark and slightly in leaf characteristics. It is uncommon in Peninsular Malaysia but common in Sarawak and Brunei, and occurs particularly on low hills.

Selected sources 410, 465, 567, 568, 705.

Myristica markgraviana A.C. Smith

Journ. Arn. Arb. 22: 66 (1941).

Distribution Papua New Guinea.

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized tree up to 30 m tall, older specimens develop buttresses, bark surface finely fissured, flaking vertically in rectangular strips when old, medium to dark brown; leaves chartaceous to thinly coriaceous, 16–23 cm long, with minute silvery or cinnamon scales and a brown tomentum of branched hairs below, secondary veins 12–15 pairs, sunken above; male inflorescence a 3–6 cm long panicle; male flowers 7–10 mm long, densely tomentose or lanose with branched hairs, female flowers 7 mm long; fruit ellipsoid to ovoid-globose, 3–5 cm long, densely minutely tomentose. *M. markgraviana* is found in rain forest on slopes and ridges, at 200–900 m altitude.

Selected sources 568, 718.

Myristica maxima Warb.

Monogr. Myrist.: 385 (1897).

Vernacular names Malaysia: penarahan arang (general).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses The wood is used as penarahan.

Observations A medium-sized to fairly large tree up to 35 m tall, bole usually with buttresses up to 3 m high, rarely with stilt roots, bark surface smooth, slightly scaly, or rarely closely fissured, dark greyish-brown, inner bark pinkish-white; leaves coriaceous, 25–50(–54) cm long, glabrous and glaucous below, secondary veins

23–30(–33) pairs, sunken above; male inflorescence a 10–18 cm long panicle; male flowers 5–8 mm long, tomentulose outside, female flowers 8–9 mm long; fruit oblong, 7–9 cm long, minutely rusty pubescent. *M. maxima* occurs in low undulating land and on hillsides. The density of the wood is 400–570 kg/m^3 at 15% moisture content.

Selected sources 436, 474, 567, 568, 705.

Myristica papyracea Sinclair

Gard. Bull. Sing. 23: 133 (1968).

Distribution Borneo.

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized to fairly large tree up to 37(–43) m tall, bole sometimes with stilt roots, bark flaking with papery strips, dark grey; leaves coriaceous, 23–40 cm long, glabrous, pale green below, secondary veins 20–25 pairs, sunken above; male inflorescence with short branches, 2–5 cm long; male flowers 6–7 mm long, dark brown tomentulose outside, female flowers 6–7 mm long; fruit oblong, 8–9 cm long, glabrous. *M. papyracea* is found on slopes and along rivers.

Selected sources 568.

Myristica philippensis Lamk

Hist. Acad. Roy. Sci. Paris 1788: 161 (1791).

Synonyms *Myristica luzonica* Blanco (1837), *Myristica bracteata* A.DC. (1856).

Vernacular names Philippines: duguan (general), tambalau (Tagalog), mundara (Iloko).

Distribution The Philippines.

Uses The wood has been used for temporary construction.

Observations A small tree up to 15 m tall, bole short, up to 80 cm in diameter, often with small buttresses, bark surface fissured, blackish-brown; leaves firmly chartaceous to coriaceous, 18–45(–50) cm long, glabrous, glaucous or pale green below, secondary veins 18–30 pairs, sunken above; male inflorescence a 6–10 cm long panicle; male flowers 5–8 mm long, pale brown to greyish tomentulose outside, female flowers 6–9 mm long; fruit oblong to subglobose, 5–8 cm long, variably tomentulose and eventually glabrous. *M. philippensis* is common and occurs up to 300 m altitude. The density of the wood is 475–660 kg/m^3 at 15% moisture content.

Selected sources 125, 527, 568.

Myristica simiarum A.DC.

Ann. Sci. Nat. Bot. 4(4): 29 (1855).

Vernacular names Indonesia: dahan-ritek, lawoting-ritek (Sulawesi), kena-poa (Sula Islands). Philippines: tanghas (Filipino), paria (Tagalog), pokipok (Iloko).

Distribution Borneo (north-eastern Kalimantan and Sarawak), Sulawesi, the Moluccas (Bacan and Sula Islands), and the Philippines.

Uses The wood is used as penarahan, e.g. for house construction.

Observations A small to medium-sized tree up to 30 m tall, bark fissured, sometimes flaking, reddish or greyish-brown; leaves chartaceous, 10–17 cm long, glaucous and glabrescent below, secondary veins 8–11 pairs, slightly raised above; male inflorescence a 3–5 cm long panicle; male flowers 4–6 mm long, densely appressed dark rusty tomentose or pilose outside, female flowers 4–6 mm long; fruit globose to subglobose, 1.5–2 cm across, glabrous. *M. simiarum* has been divided into 3 subspecies: subsp. *simiarum* (synonym: *Myristica elliptica* Wallich ex Hook.f. & Thomson var. *simiarum* (A.DC.) Sinclair) occurs in the Philippines; subsp. *celebica* (Miq.) W.J. de Wilde (synonyms: *Myristica celebica* Miq., *Myristica elliptica* Wallich ex Hook.f. & Thomson var. *celebica* (Miq.) Sinclair) has broadly ellipsoid to ovoid fruits of 3–3.5 cm long and is found in the southern Philippines, Sulawesi, and the Moluccas (Bacan and Sula Islands); subsp. *calcarea* W.J. de Wilde has densely pubescent leaves and occurs on limestone in north and north-eastern Kalimantan. *M. simiarum* occurs in forest on sandy and stony soil, at low and medium altitudes.

Selected sources 125, 138, 567, 568.

Myristica sulcata Warb.

Monogr. Myrist.: 538, t. 19, fig. 1–2 (1897).

Synonyms *Myristica anceps* Warb. (1897), *Myristica undulatifolia* Sinclair (1968).

Vernacular names Indonesia: mong (Muyu, Irian Jaya), sikwahi (Irian Jaya), krikket (Mandobo at Awemko, Irian Jaya).

Distribution New Guinea.

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized to large tree up to 43 m tall, bole straight, branchless for up to at least 20 m, sometimes buttressed, bark surface shallowly fissured and flaking, medium to dark brown or greyish-brown, inner bark reddish-brown; leaves 14–26(–32) cm long, medium green and slightly glossy or silvery cinnamon below, with small appressed scales but glabrescent below, secondary veins 15–28 pairs, sunken above; male inflorescence on a thick spur shoot; male flowers 4–5 mm long, densely brown tomentose outside, female flowers 3–4 mm long; fruit subglobose to oblong, 3.5–4 cm long, tomentulose but glabrescent. *M. sulcata* is found in primary and secondary rain forest on slopes or low-lying country, up to 700 m altitude. The density of the wood is about 540 kg/m^3 at 15% moisture content.

Selected sources 474, 568, 718.

Myristica villosa Warb.

Monogr. Myrist.: 419, t. 14, fig. 1-3 (1897).

Vernacular names Indonesia: gampusu (Dayak, East Kalimantan).

Distribution Borneo.

Uses The wood is reputed to be used as penarahan.

Observations A medium-sized tree up to 30 m tall, bole sometimes with stilt roots, bark surface rough and flaking in thin pieces, dark reddish-brown with blackish patches; leaves coriaceous, 24–36 cm long, appressed velvety cinnamon brown or greyish-brown tomentose below but soon glabrescent, secondary veins 20–25(–32) pairs, sunken above; male inflorescence on lateral spur shoot; male flowers 7–10 mm long, densely appressed pale brown villose-tomentose outside; fruit ovoid, 4.5–6 cm long, velvety tomentose. *M. villosa* is found at low and medium altitudes. The density of the wood is 690–790 kg/m^3 at 15% moisture content.

Selected sources 77, 474, 568.

H. Sangat-Roemantyo (general part),
A. Martawijaya (properties),
P. Nimiago (wood anatomy),
M.S.M. Sosef (selection of species)

Nageia Gaertner

Fruct. sem. pl.: 191 (1788).

PODOCARPACEAE

x = 10, 12, 13; *N. vitiensis*: $2n$ = 20, *N. wallichiana*: $2n$ = 20

Trade groups Podocarp: lightweight to medium-weight softwood, e.g. *Nageia vitiensis* (Seem.) O. Kuntze, *N. wallichiana* (Presl) O. Kuntze.
The timber is traded as podocarp together with that of the genera *Dacrycarpus, Podocarpus* and *Prumnopitys*.

Vernacular names Podocarp (En, Fr). Indonesia: jamuju (general). Malaysia: podo (general). Papua New Guinea: brown podocarp. Philippines: malaalmaciga (general). Burma (Myanmar): thitmin. Thailand: phayamai (general).

Origin and geographic distribution *Nageia* consists of 12 species which occur in South America, Africa, southern India, Indo-China to southern Japan, and throughout Malesia towards New Caledonia and Fiji. Within Malesia 4 species are found; 3 of them are present in Borneo.

Uses The wood of *Nageia* is used for house construction, light framing, interior trim, moulding, furniture, boats, canoes, carving, cases, drawer sides, matchsplints, matchboxes, veneer and household utensils. Furthermore it is used as other woods of the podocarp trade group for high-grade construction, beams, oars, spars, masts and flooring. The beautiful foliage makes *Nageia* trees attractive ornamentals.

Production and international trade In Papua New Guinea, podocarp timber attracts high prices, but only comparatively small amounts of this timber are exported. The export of logs of all podocarp species has been banned.

Properties *Nageia* yields a lightweight to medium-weight softwood which varies from not strong to moderately strong. The heartwood is pale pinkish-brown to pale yellowish-brown, sometimes with an orange tinge, often not clearly demarcated from the paler, straw-coloured sapwood. The density is 410–920 kg/m^3 at 15% moisture content. The grain is straight, texture fine and even; wood usually with little or no figure, glossy.
A test of *N. vitiensis* wood from Fiji showed the following mechanical properties at 12% moisture content: the modulus of rupture 72 N/mm^2, modulus of elasticity 7865 N/mm^2, compression parallel to grain 42.5 N/mm^2, compression perpendicular to grain 7 N/mm^2, shear 10 N/mm^2, cleavage 25.5 N/mm radial and 32 N/mm tangential, Janka side hardness 2780 N and Janka end hardness 5230 N.
The rates of shrinkage are moderate: for *N. wallichiana* wood from green to 12% moisture content 1.8% radial and 6.2% tangential. The wood seasons well with little warping and checking. It is easy to work and takes a high finish, and glues, carves and moulds well. The nail-holding capacity is comparatively low. The peeling properties of *N. vitiensis* wood are good but the yield is often low as the veneer is often brittle and may split during handling.
Wood of *N. wallichiana* is rated in Papua New Guinea as non-durable and not suitable for exteri-

or use unless treated with preservatives. In the Philippines, however, it is considered as durable for interior use and when exposed to the weather or in contact with the ground. Wood of *N. vitiensis* is reported to be liable to blue stain, and to attacks of termites, pinhole borers, longhorn beetles and marine borers. *Nageia* wood is not susceptible to *Lyctus* attack. The heartwood is moderately easy and the sapwood is easy to treat with preservatives; however, *N. vitiensis* heartwood is reported to be resistant.

Description Dioecious, small to large trees up to 54 m tall or rarely shrubs; bole cylindrical, branchless for up to 30 m, up to 130 cm in diameter; bark surface smooth with scattered lenticels, peeling off in irregularly shaped plates. Leaves decussate, sometimes mixed with some spirally placed leaves, bifacially flattened, comparatively broad, distinctly narrowed into a decurrent base; adult leaves usually smaller than the juvenile ones but otherwise similar, twisted at the base so as to appear distichous, leaves on the left side of the shoot with the abaxial surface facing up, those on the right side with the adaxial surface facing up. Fertile structures axillary, produced on a scaly shoot, part of the fruit-bearing shoot becoming enlarged and fleshy and forming a receptacle in some species, otherwise a part of the shoot remaining attached to the seed when it falls. Pollen cones solitary or grouped, cylindrical to ovoid; apex of microsporophyll lanceolate to triangular. Seed-bearing structure 1–2(–5), subterminal, with a single fertile inverted ovule and several sterile bracts; seed remaining inverted, smooth, completely covered by the fertile scale, elongated into a curved beak at the apex, the usually persistent leathery covering becoming more or less fleshy when ripe.

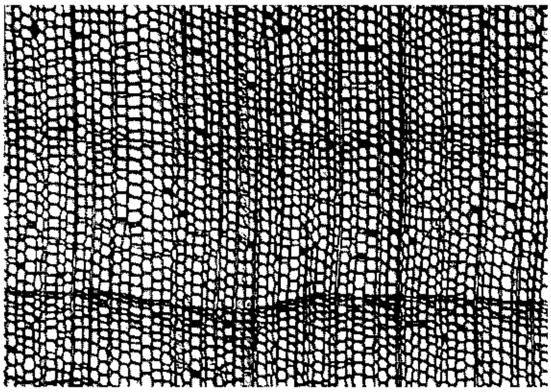
Wood anatomy

– Macroscopic characters:

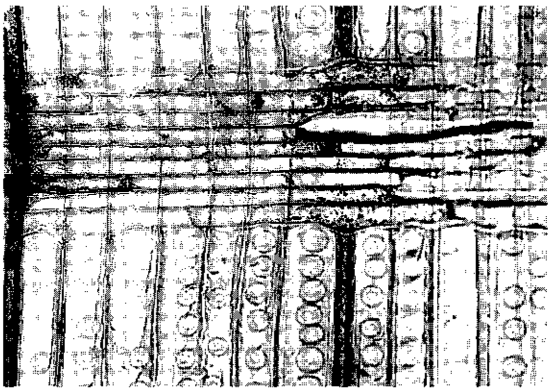
Heartwood pale yellowish-brown, sometimes with an orange tinge, or pinkish-brown, often not clearly demarcated from the paler sapwood. Grain straight, texture fine and even; wood with little or no figure, sometimes with contrasting bands of pale yellow and brown in *N. vitiensis*. Growth rings indistinct; diffuse parenchyma sometimes evident to the naked eye; rays very fine, not visible to the naked eye.

– Microscopic characters:

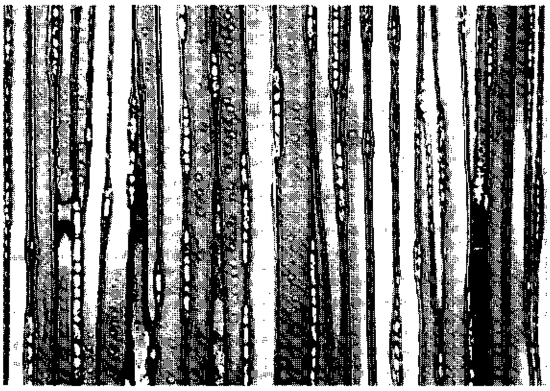
Tracheids polygonal, square to rounded in cross-section, radially aligned, tangential diameter approximately (15–)40–60 μm, (2.5–)4–6(–9) mm long; intertracheid pits in 1(–2) rows, mainly in



transverse section (×25)



radial section (×150)



tangential section (×75)

Nageia motleyi

radial walls, mostly in a single row, opposite when in more than one row, large and rounded, 20–24 μm in diameter, rarely flattened, when crowded crassulae present; pits on tangential walls rare and smaller, more numerous in *N. vitiensis*. Parenchyma diffuse, moderately abundant, with smooth end walls. Rays (4–)6–8(–9)/mm, predominantly uniseriate, biseriate rays rare, (1–)4–15(–20) cells high (sometimes up to 40 cells high in *N. motleyi*), biseriate part, when present, rarely up to 4 cells high; ray cells with smooth end walls; ray-tracheid pits half-bordered, cupressoid to taxodioid, medium-sized, 10–15 μm in diameter, 1–2(–3) per crossfield, crossfields of marginal cells usually containing no pits or larger single pits, often with reduced border. Ray tracheids absent, resin ducts absent. Reddish-brown extraneous material present in parenchyma cells.
Species studied: *N. motleyi*, *N. vitiensis*, *N. wallichiana*.
Wood of *Agathis*, *Falcatifolium*, *Phyllocladus*, *Podocarpus* and *Prumnopitys* is similar to that of *Nageia*. *Agathis* differs by having alternate intertracheid pits. Parenchyma is absent in *Phyllocladus* and *Prumnopitys*. However, *Falcatifolium* and *Podocarpus* are very similar.

Growth and development In natural forest in Java, 3-year-old seedlings of *N. wallichiana* were 25 cm tall. In an arboretum in Peninsular Malaysia, one 40-year-old *N. motleyi* tree was 18 m tall and 25 cm in diameter.
In Java, *N. wallichiana* flowers in October–November and has mature seeds in March–June; in Sumatra, seeds are full-grown in February, and in Kalimantan in November–January.

Other botanical information *Nageia* is divided into three sections: *Nageia* (distributed from India to New Guinea and New Britain), *Afrocarpus* (Buchholz & Gray) de Laubenf. (in Africa only) and *Polypodiopsis* (Bertrand) de Laubenf. (occurring in the Moluccas, New Guinea, New Caledonia, Fiji and South America). The latter 2 sections have been treated as genera and given the names *Afrocarpus* and *Retrophyllum*, respectively. This conception is supported to some extent by the basic chromosome numbers of $n = 10$, 12 or 13 for *Nageia* s.s., $n = 10$ for *Retrophyllum* and $n = 12$ for *Afrocarpus*. As it is not yet clear whether this view will be generally accepted, it seems best to treat *Nageia* here in a conservative and hence broad sense.
Species of *Nageia* can be confused with *Agathis*, but their leaves are flexible and do not snap when bent, their buds are pointed and the inner bark lacks the characteristic sugary, white, resinous exudate of *Agathis*.

Ecology *Nageia* occurs scattered and is often common but seldom dominant in primary lowland and lower montane rain forest and in secondary forest including peat-swamp forest. It may be associated with other conifers such as *Agathis*, *Araucaria* or *Podocarpus*, or with *Fagaceae* genera, *Anisoptera*, *Cinnamomum* or *Sloanea*. It is found from near sea-level up to 2100 m altitude. Less often it occurs in heath forest (kerangas). *Nageia* species generally thrive best on peat but they are also found on sandy soils.

Propagation and planting *Nageia* can be propagated by seed. There are approximately 900 dry fruits of *N. wallichiana* per kg.

Silviculture and management In natural forest seedlings of *N. wallichiana* are generally found close to the mother tree, but natural regeneration is not very abundant. There is no difference between natural regeneration in open sites and in locations under forest cover. Established seedlings grow very slowly, less than 25 cm in 3 years. *Nageia* is recommended for mixed stands with fast-growing timbers in montane forest. No plantations have been established using *Nageia* species.

Yield In western Buru, the Moluccas, the number of trees per ha of *N. vitiensis* with a diameter at breast height of 35–49 cm averages 0.7 which equals to 1.0 m^3.

Genetic resources No information is available on the collection and the conservation of genetic resources of *Nageia*. *N. motleyi*, *N. vitiensis* and *N. wallichiana* are all widespread and locally common (although usually scattered) and do not seem to be in direct danger of genetic erosion. The fourth Malesian species, *N. maximus* (de Laubenf.) de Laubenf., a shrub or small tree, occurs only very locally in Sarawak and might become endangered.

Prospects As the wood quality of podocarp timber (including *Dacrycarpus*, *Podocarpus* and *Prumnopitys* as well as *Nageia*) is excellent, the prospects for increased use are promising, although only small quantities may reach the market. *N. wallichiana* is reported to have high-value export potential for veneers and furniture in Irian Jaya.

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Selection of species

Nageia motleyi (Parl.) de Laubenf.

Blumea 32: 210 (1987).

Synonyms *Podocarpus beccarii* Parl. (1868), *Podocarpus motleyi* (Parl.) Dümmer (1914), *Decussocarpus motleyi* (Parl.) de Laubenf. (1969).

Vernacular names Indonesia: kayu cina, marimbu (Kalimantan), kebal ayam (Sumatra). Malaysia: podo kebal musang (Peninsular), medang buloh (Sarawak). Thailand: sangching, phayamai (peninsular), rayo-kayu (Malay, peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo (Sarawak, Kalimantan).

Uses The wood is used as podocarp.

Observations A large tree up to 54 m tall, bole straight, without buttresses, up to 75 cm in diameter; leaves oblong to elliptical, 3–5(–7.5) cm × 1.5–2.2(–2.8) cm, with many veins; pollen cones solitary and sessile; seed-bearing structure solitary, receptacle becoming fleshy; seed globose. *N. motleyi* occurs scattered in primary and secondary rain forest and is generally found in mixed peat-swamp forest, but also on well-drained slopes, up to 500(–1000) m altitude. The density of the wood is 550–660 kg/m^3 at 15% moisture content.

Selected sources 117, 127, 132, 162, 190, 404, 466, 474, 476, 575, 685, 705.

Nageia vitiensis (Seem.) O. Kuntze

Revis. gen. pl. 2: 800 (1891).

Synonyms *Podocarpus vitiensis* Seem. (1862), *Podocarpus filicifolius* N.E. Gray (1962), *Decussocarpus vitiensis* (Seem.) de Laubenf. (1969).

Vernacular names Red podocarp (En). Indonesia: mugo (Kapauko, Irian Jaya). Papua New Guinea: lehil (New Britain).

Distribution The Moluccas, New Guinea, New Britain, the Solomon Islands (Santa Cruz group) and Fiji.

Uses The wood is used as podocarp. It is regarded as a valuable timber tree, especially on Fiji.

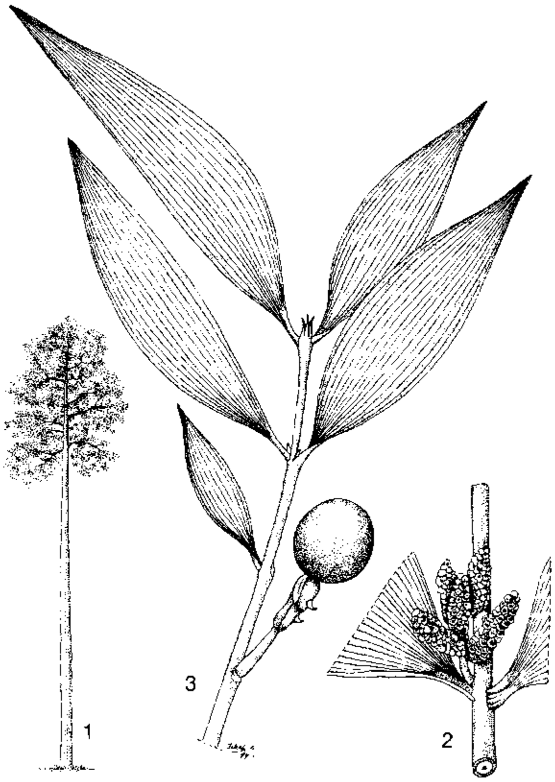
Observations A medium-sized to fairly large tree up to 43 m tall, bole up to 130 cm in diameter; leaves linear-lanceolate to ovate, 1.5–2.5 cm × 0.3–0.5 cm, with a single indistinct midrib; pollen cones solitary or clustered on scaly shoot; seed-bearing structure solitary, receptacle not fleshy, remaining attached to the globular seed upon falling. *N. vitiensis* occurs scattered and is locally common in primary rain forest, in New Guinea sometimes frequent in *Agathis-Quercus* forest, from sea-level up to 1800 m altitude. The density of the wood is 410–475 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 61, 117, 127, 132, 162, 190, 213, 268, 289, 474, 476, 685, 715.

Nageia wallichiana (Presl) O. Kuntze

Revis. gen. pl. 2: 800 (1891).

Synonyms *Podocarpus wallichianus* Presl (1844), *Podocarpus blumei* Endl. (1847), *Decussocarpus wallichianus* (Presl) de Laubenf. (1969).



Nageia wallichiana (Presl) O. Kuntze – 1, tree habit; 2, twig with pollen cones; 3, twig with mature seed.

Vernacular names Brown podocarp (En). Indonesia: bali (Kalimantan), kayu cina (Sumatra, Sulawesi), ki bima (Java). Malaysia: podo kebal musang gunong (Peninsular), mengilan (Sabah), manggilan (Dusun, Sarawak). Philippines: malaalmaciga (Tagalog), almaciga nga lalaki (Sibuyan), makapola (Negros). Burma (Myanmar): thitmin. Thailand: phayamai (south-eastern), khunmai (peninsular).

Distribution Southern India, Burma (Myanmar), Indo-China, Thailand and throughout Malesia except for central and eastern Java, and in the Lesser Sunda Islands only on Flores.

Uses *N. wallichiana* is an important source of podocarp timber; the wood is used for house construction, mouldings, interior finish, furniture, veneer and sometimes for making canoes.

Observations A large tree up to 54 m tall, bole branchless for up to 30 m, up to 100 cm in diameter; leaves elliptical to ovate, 6–14(–23) cm × 2–5(–9) cm, with many veins; pollen cones grouped on a common peduncle; seed-bearing structure solitary, receptacle becoming fleshy; seed globose. *N. wallichiana* occurs scattered and is often common in primary lowland and montane rain forest. It is reported from peat-swamp forest but more often from drier hillsides and ridges, usually on sandy soils, from sea-level up to 2100 m altitude. The density of the wood is 505–920 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 77, 104, 117, 127, 129, 132, 135, 140, 145, 162, 166, 190, 213, 218, 234, 268, 332, 333, 404, 474, 476, 477, 527, 575, 589, 653, 685, 690, 705, 715.

E. Boer (general part),
M.S.M. Sosef (general part, selection of species),
R.H.M.J. Lemmens (properties),
J. Ilic (wood anatomy)

Nothofagus Blume

Mus. Bot. Ludg.-Bat. 1: 307 (1850).
FAGACEAE
$x = 13$; $2n = 26$ for several non-Malesian species

Trade groups New Guinea beech: heavy hardwood, e.g. *Nothofagus perryi* v. Steenis, *N. pullei* v. Steenis, *N. starkenborghii* v. Steenis.

Vernacular names New Guinea beech: southern beech, Antarctic beech (En). Indonesia: diri (Kapauku language, Wissel Lakes, Irian Jaya), snokko, pemmem (Manikiong language, Arfak, Irian Jaya).

Origin and geographic distribution *Nothofagus* comprises 37 species and is distributed in southern South America (11 species), New Zealand (4), New Caledonia (5), Australia and Tasmania (3) and New Guinea (14). Fossil pollen records of *Nothofagus* date back to the Upper Cretaceous and indicate that the genus was once more widespread in Gondwanaland. It probably became separated during the breaking up of that land mass, resulting in the development of several sections and subsections within the genus.

Uses The wood of New Guinea beech is used for general and heavy construction, house posts, furniture, scantlings, panelling, tool handles, joinery, window frames and sills, turnery, flooring, fence posts, bridge decking, sleepers, boat building and sliced veneer.

In Papua New Guinea, small-diameter logs have been found to be suitable for shiitake mushroom cultivation. Several species are planted as ornamental trees along roads and in villages.

Production and international trade Timber of New Guinea beech fetches high prices, and in Papua New Guinea the export of logs is banned to encourage local processing.

Properties New Guinea beech is a heavy hardwood. The heartwood is brown to pinkish-brown, golden-brown or red-brown and clearly demarcated from the creamy-yellow to pale brown sapwood. The density is 800–1020 kg/m^3 at 15% moisture content. The grain is generally straight, rarely slightly interlocked, texture is fine to moderately fine and uniform. The timber often has a distinct flame-like figure on back-sawn material. The wood has no distinct taste or odour and is non-siliceous.

Tests of samples from New Guinea beech (unidentified species) from Papua New Guinea showed the following mechanical properties at 12% moisture content: the modulus of rupture 127.5 N/mm^2, modulus of elasticity 19 115 N/mm^2, compression parallel to grain 69 N/mm^2, shear 11–18.5 N/mm^2, cleavage 77.5 N/mm radial and 96.5 N/mm tangential, and Janka radial hardness 6185 N.

The rates of shrinkage are high: 3.7% radial and 8.4% tangential from green to 12% moisture content. Seasoning is rather difficult; back-sawn boards are prone to face checking, particularly in material near the pith, and end splitting. Splitting from board edges in association with crossed grain may be severe. Warping, in the form of cup and twist, develops to a generally moderate extent, occasionally pronounced in back-sawn boards. Kiln drying of 25 mm quarter-sawn stock from green to 12% moisture content requires 13–14 days; preliminary air drying to 25% moisture content reduces kiln drying to 4 days. A tentatively recommended kiln schedule for quarter-sawn stock is at a dry bulb temperature of 50–70°C. After drying, a high humidity treatment should be given to relieve drying stresses.

New Guinea beech can be sawn reasonably well, preferably to produce quarter-sawn material, thus reducing degrade upon drying. It is easily worked with machine and hand tools and a smooth finish is readily obtained, but it has a tendency to picking up if the grain is wavy. It shapes and polishes well, requiring little filling, and is excellent for turning. It peels, slices, and glues readily. Preboring is necessary in nailing. The wearing properties are satisfactory.

The heartwood is moderately durable and liable to termite and borer attack. The sapwood is susceptible to *Lyctus* borer attack. The heartwood is highly resistant and the sapwood is permeable to moderately resistant to preservative treatment.

Description Medium-sized to large, evergreen (in Malesia), monoecious trees up to 50 m tall; bole straight, cylindrical, up to 150(–250) cm in diameter, sometimes with short buttresses or spurred; bark surface very rough, peeling off in large irregular scales, prominently pustular and craterous, pale grey-brown. Leaves alternate, distichous (in Malesia), simple, entire or rarely crenate, dotted with glands below, pinnately veined; stipules peltately attached, soon caducous, inner side with many glandular trichomes around the attachment (colletors). Inflorescence axillary, cymose, male inflorescence borne lower on the twig than female one. Male flowers solitary or 3 together, sessile to short-peduncled or with short pedicels; perianth tubular, later irregularly rupturing; stamens 12–18, exserted, filaments usually basally connate. Female flowers solitary or 3 together, surrounded by a cupule, sessile, green; ovary inferior, flat and usually narrowly 2-winged or shouldered, 2-celled, usually glabrous, style short, with 2 stigmatic arms. Cupule flattened, 2-valved, with 1 or more lamellae, rarely vestigial or absent. Fruit an indehiscent, flat, ovoid, 1-seeded nut, apiculate by the style base. Seed with a membranous testa; cotyledons thin, folded, with fatty reserve. Seedling with epigeal germination.

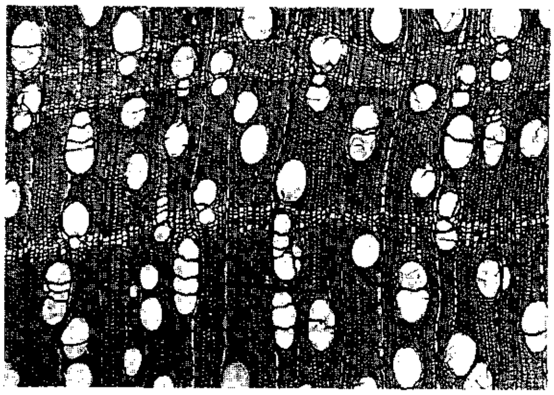
Wood anatomy

– Macroscopic characters:

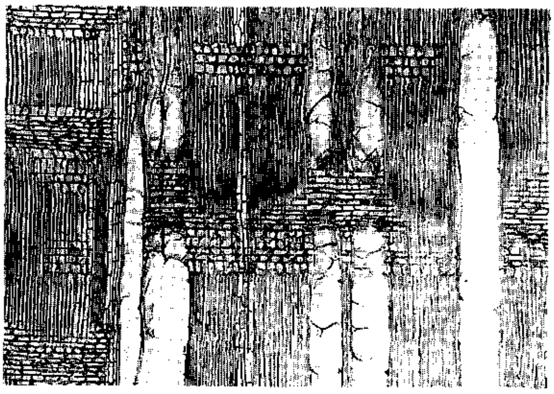
Heartwood golden-brown, brown to red-brown, clearly demarcated from the creamy-yellow to pale brown sapwood, usually grading into an intermediate zone. Grain usually straight, rarely slightly interlocked. Texture moderately fine, uniform; wavy figure sometimes evident on back-sawn material; wood lustrous. Growth rings indistinct; vessels indistinct to visible to the naked eye, evenly distributed; parenchyma with irregular spaced bands, sometimes discontinuous, frequently appearing wavy in transverse section; rays not visible to the naked eye, although visible on quarter-sawn surface; ripple marks absent.

– Microscopic characters:

Growth rings inconspicuous. Vessels diffuse, evenly distributed, 9–16/mm^2, solitary (40–60%) and in radial multiples of 2–4(–6), with few clusters, solitary vessels mostly oval, average tangential diameter 90–165 μm, maximum tangential diameter 190 μm; perforation plates simple, horizontal to oblique; intervessel pits moderately coarse, alternate to opposite, occasionally tending to scalariform, non-vestured, 7–10 μm; vessel-ray pits with



transverse section (×25)



radial section (×75)

tangential section (×75)

Nothofagus grandis

strongly reduced borders, often appearing simple, rounded to irregular and elongated, often scalariform; helical thickenings present in vessel tips, scarce to consistent, not observed in *N. perryi*; tyloses abundant. Fibres 1200–1480 μm long, occasionally septate, moderately thick-walled, pits indistinctly bordered, mainly confined to the radial walls. Tracheids absent. Parenchyma apotracheal, mainly in irregularly spaced bands of 2–6(–9) cells wide, sometimes discontinuous, frequently wavy; diffuse parenchyma occasionally present, sparse to absent, in 4–8-celled strands. Rays 9–16/mm, 1–2(–3)-seriate, up to c. 0.7 mm high, weakly to markedly heterocellular, uniseriate rays composed of square to upright cells, multiseriate rays with up to 5 rows of square to upright marginal cells and procumbent central cells (Kribs type heterogeneous II). Prismatic crystals present in parenchyma strands, individual cells sometimes enlarged containing a large crystal; extraneous reddish-brown deposits moderately common in ray cells. Silica absent. Horizontal intercellular canals absent. Elements non-storied.

Species studied: *N. brassii, N. grandis, N. perryi.*

Wood of some species of *Nothofagus* may resemble *Homalium*, but it can easily be differentiated from the latter by the definite pinkish colour and the presence of coarser intervessel pitting and large vessel-ray pits.

Growth and development A *N. pullei* tree in the lower montane rain forest of Papua New Guinea of 1.8 m in diameter is reportedly about 550 years old.

Ectotrophic mycorrhizae have been recorded for *Nothofagus* in South America, New Zealand and Australia. It is likely that they are also associated with New Guinea beech in New Guinea. Seed dispersal is very restricted; seeds cannot cross even moderately wide seaways.

Other botanical information The Malesian species of *Nothofagus* can be readily recognized by their gland-dotted leaves, peltately attached stipules and 2-merous female flowers arranged in few-flowered heads. When still present, the shape of the stipules is helpful in identifying individual species.

The genus *Nothofagus* was until recently usually subdivided into two sections: the deciduous section *Nothofagus*, restricted to South America and Tasmania, and the evergreen section *Calusparassus* (Hombr. & Jacq.) Krasser, occurring almost throughout the range of the genus. The deciduous or evergreen nature of the species proved, however, to be not congruent with other morphological features. Recently, *Nothofagus* has been subdivided into 4 subgenera. The new classification also agrees with the traditional pollen types distinguished within *Nothofagus*. All Malesian and New Caledonian species belong to subgenus *Brassospora* Philipson & M.N. Philipson. This subgenus had a much wider distribution 50–80 million years ago, including New Zealand and Tasmania. It has been suggested that the New Guinea species are derived from species adapted to the lowland tropical environment of the late Tertiary, and that the creation of high-altitude environments provided the opportunity for the extension of the species ranges and the subsequent development of high-altitude species. It has been further hypothesized that the restriction of high-altitude species to single mountain ranges and the more widespread distribution of low-altitude species are functions of the poor seed dispersal mechanisms of the genus.

Ecology In New Guinea, *Nothofagus* species are usually dominant or co-dominant elements of the canopy layer of primary or sometimes old secondary forest in the montane forest zones, at (750–)1000–3100 m altitude; in New Caledonia even down to 100 m. The species prefer high precipitation, 1500–5000 mm annually, and cloudiness, and are found in areas with a mean daily temperature of up to 23°C. Severe frost damage may occur following prolonged dry and cloudless periods.

Nothofagus does not seem to have a specific soil preference, but is generally absent from localities with regular and sustained water deficits. At lower altitudes, *Nothofagus* is almost restricted to ridge crests, where trees may become gnarled or dwarfed. When in pure stands, these often consist of a mosaic of patches dominated by a single size class.

At lower altitudes, associated species include *Castanopsis* and *Lithocarpus* species. At higher altitudes, associations with *Phyllocladus hypophyllus* Hook.f. are common, and in some wet habitats associations with *Dacrydium* and *Libocedrus* species have been observed. New Guinea beech forest is a very extensive forest type in the highlands of Papua New Guinea. It is found in the intermediate montane zone. Above this zone a transition into gymnosperm-dominated forest occurs, which reaches up to the timber line.

Propagation and planting *Nothofagus* may be propagated by seed, but wildlings are more widely used for ornamental plantings. Fruits should be dried before seed extraction and seed should be stored dry. Although trees produce seed in abundance, seed viability is extremely low: less than 1% for *N. grandis*, *N. pullei* and *N. rubra*.

Silviculture and management The occurrence of patches of trees of the same size class is an interesting phenomenon in the composition of natural *Nothofagus* forest. Hence, natural regeneration also occurs in patches. Seed predation under natural conditions appears to be exceptionally high. In mature natural forest, 50–1000 seedlings per ha are found and these are mostly found on mossy substrates, especially fallen trees. *Nothofagus* seedlings grow slowly under the canopy of mature trees where only 5–8% of the daylight penetrates, but they outgrow seedlings of other species when light becomes available. Much of the regeneration arises from root suckers from fallen trees or from damaged or suppressed seedlings or saplings. Suckers may spread horizontally for several metres and produce several shoots and associated root systems.

N. pullei is reported as not to regenerate under its own cover, whereas *N. rubra* can. Successful colonization of new sites from seed may be limited in the absence of suitable ectotrophic mycorrhizae. Logging implies the formation of large gaps because of the even-aged nature of patches within the natural forest. This has led to problems in Papua New Guinea with vigorous climbing bamboo growth smothering natural regeneration. Within even-aged patches, synchronized dieback and eventual death has been observed. Patches can be a few trees to a few ha in size. On Mount Giluwe, Papua New Guinea, nearly pure *N. pullei* forest appears to be characterized by a cycle of patch mortality followed by good regeneration of the same species to form canopy trees which may in turn suffer extensive mortality. No single cause for the patch dieback has been determined, and several hypotheses have been formulated to define the causes, including pathogens (*Armillaria*, *Phytophthora*), pinhole borers, nutrient deficiency, lightning, senility and water stress. *N. grandis* suffers from similar localized dieback. Within the dead patches, young trees, be it from suckers or from seedlings, appear to be healthy and grow well. No forest plantations of New Guinea beech have been established.

Diseases and pests The synchronized dieback of patches of even-aged trees is insufficiently understood. The pathogens isolated include *Phytophthora cinnamomi* and *Armillaria* sp., but their contribution to tree mortality is unknown. In New Guinea, pathogens of New Guinea beeches are remarkably limited. Seed predation is very serious;

caterpillars of a tortricid moth have been recorded on cupules of *N. grandis* and *N. rubra*, but it is not known to what extent. They are responsible for seed destruction under natural conditions.

Harvesting Apart from felling under the selective felling system with a diameter limit of 50 cm, small diameter logs have been used for shiitake mushroom cultivation on a small scale.

Yield The volume of harvestable New Guinea beech timber in the lower montane forest zone of Papua New Guinea is estimated at 45–60 m^3/ha.

Handling after harvest As the sapwood is susceptible to *Lyctus* borer attack, logs should be converted as soon as possible.

Genetic resources There is very little pressure on land where natural stands are located; thus genetic resources of species with a wide distribution (e.g. *N. grandis*, *N. pullei*) are safeguarded. Species occurring scattered and only locally (e.g. *N. nuda* v. Steenis and *N. womersleyii* v. Steenis) may be more vulnerable with regard to the conservation of their genetic base.

Breeding Hybrids have been recorded for *Nothofagus* species in New Zealand and South America, but there is no observation to confirm this for New Guinea.

Prospects After logging, *Nothofagus* forest regenerates well, while there is very little pressure on the land. The suitability of *Nothofagus* logs as a substrate for shiitake mushroom cultivation is expected to result in an increased interest in the management of the natural stands for smaller diameter logs.

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Selection of species

Nothofagus brassii v. Steenis

Blumea 7: 146 (1952).

Synonyms *Nothofagus recurva* v. Steenis (1952).

Distribution New Guinea.

Uses The wood is used as New Guinea beech.

Observations A large tree up to 45 m tall, sometimes a dwarfed shrub, bole up to 100 cm in diameter, bark surface rough, fissured, scaly, brown; leaves elliptical-oblong to ovate, (2.5–) 3.5–9 cm × 1.5–4 cm, entire, midrib ridged to at least halfway, with 7–9 pairs of secondary veins, petiole 4–7 mm long, stipules rhombic, 5–10 mm × 2.5–3 mm; male flowers in sessile or almost sessile triads, female flowers 3 together; cupule present, distinctly widening when mature and then about 15 mm across, 4–5-lamellate, on a peduncle 5–15 mm long; nut 6–10 mm × 4–6 mm, distinctly winged apically. *N. brassii* is locally common or dominant in montane forest, at 1550–2700 m altitude.

Selected sources 25, 162, 236, 501, 662.

Nothofagus carrii v. Steenis

Blumea 7: 147 (1952).

Vernacular names Indonesia: dierie, didame (Kapauku language, Wissel Lakes, Irian Jaya), taro (Enga language, Western Highlands, Irian Jaya).

Distribution New Guinea.

Uses The wood is used as New Guinea beech.

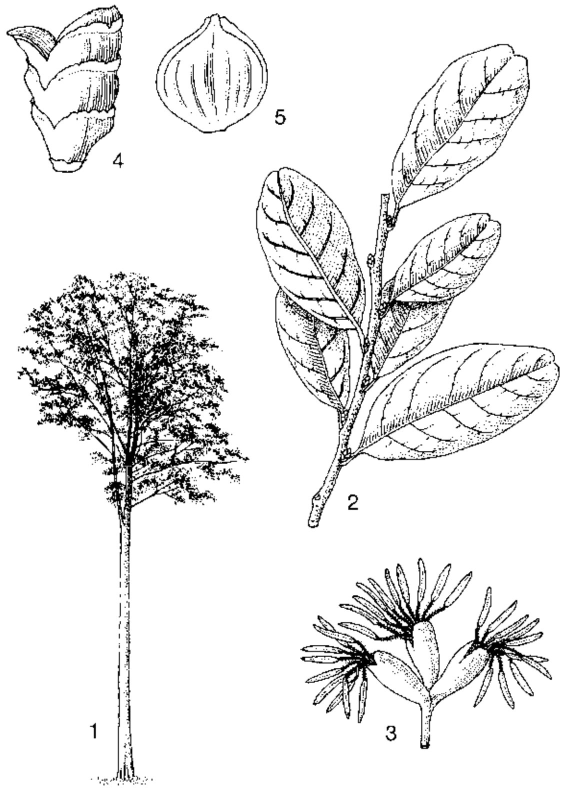
Observations A large tree up to 45 m tall, bole branchless for up to 24 m, up to 130 cm in diameter; leaves obovate or rarely elliptical, 2–6 cm × 1–3 cm, entire, midrib ridged in the lower half, with 5–7 pairs of secondary veins, petiole 2.5–5 mm long, stipules ovate, 2–2.5 mm × 1.2–1.8 mm; male flowers sessile in triads on a peduncle 1–3 mm long, female flowers solitary; cupule reduced to a lamellar flap much smaller than the flower, on a peduncle 1–1.5 mm long; nut elliptical to ovoid-oblong, 7–11 mm × 4–5 mm. *N. carrii* occurs in montane forest or shrubby vegetation on ridge tops, at 1900–2850 m altitude.
Selected sources 25, 145, 162, 236, 501, 662.

Nothofagus flaviramea v. Steenis

Nova Guinea, n.s. 6: 281, fig. 1 (1955).
Vernacular names Indonesia: diedame (Kapauku language, Wissel Lakes, Irian Jaya), essamene (Arguni language, Fak Fak, Irian Jaya), snokko (Arfak, Irian Jaya).
Distribution New Guinea.
Uses The wood is used as New Guinea beech.
Observations A large tree up to 45 m tall, bole branchless for up to 25 m, up to 150 cm in diameter; leaves ovate-oblong, 5–12 cm × 2.7–5 cm, entire, midrib sulcate and ridged, with 8–10 pairs of secondary veins, petiole 5–10 mm long; male flowers in more or less sessile triads, female flowers solitary; cupule sessile, consisting of 2 tiny flaps without lamellae; nut obovoid-apiculate, 9–10 mm × 6–7 mm. *N. flaviramea* occurs in montane, sometimes mossy forest on slopes and spurs, at 750–2450 m altitude. It is locally common and may be dominant or co-dominant with *Castanopsis acuminatissima* (Blume) A.DC. or *Araucaria* spp.
Selected sources 25, 145, 162, 236, 501.

Nothofagus grandis v. Steenis

Blumea 7: 147 (1952).
Vernacular names Indonesia: diri (Kapauku language, Wissel Lakes, Irian Jaya), taro (Enga language, Wabag, Irian Jaya).
Distribution New Guinea, rare in the western part, common in the eastern part.
Uses The wood is used as New Guinea beech. The tree is also planted as an ornamental around villages. When people feel sick due to the smell of the dead after a funeral, they eat crushed leaves together with the fern *Pteridium aquilinum* Kuhn, mixed with fish.
Observations A large tree up to 45 m tall, bole branchless for up to 25 m, up to 150(–250) cm in diameter, sometimes with small buttresses; leaves elliptical-oblong, 4.5–10 cm × 2–5 cm, entire, midrib red and ridged to at least halfway, with 7–9 pairs of secondary veins, petiole 3–10 mm long, stipules elliptical, 5–7 mm × 3.5–4 mm; male flowers in triads on a peduncle 2–9 mm long, female flowers solitary; cupule broadly elliptical, 13–17 mm × 8–14 mm, with (2–)3–4 lamellae, sessile or on a peduncle 1–4 mm long; nut rhomboid or mostly orbicular, 7–10 mm × 9.5–10 mm. *N. grandis* is one of the commonest *Nothofagus* species of Papua New Guinea and occurs in montane forest at 1350–2600 m altitude, often as the dominant species or sometimes associated with *Phyllocladus hypophyllus* Hook.f.
Selected sources 25, 85, 145, 162, 236, 239, 501, 662.



Nothofagus grandis v. Steenis – 1, tree habit; 2, twig with leaves; 3, male inflorescence; 4, mature cupule; 5, nut.

Nothofagus perryi v. Steenis

Blumea 7: 146 (1952).
Distribution Papua New Guinea.
Uses *N. perryi* is an important source of New Guinea beech; the wood is used e.g. for general

building. The tree is also planted along roads and in gardens.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 160 cm in diameter, usually with buttresses; leaves ovate-oblong, 4.5–11 cm × 2–4.5 cm, shallowly crenate towards the apex, ridge on midrib extending to three quarters or almost to the top, with 6–8 pairs of secondary veins, petiole 4–6 mm long, stipules c. 7 mm × 3 mm; male flowers in triads on peduncles 4–12 mm long, female flowers unknown; cupule 10–15 mm × 11–18 mm, 3-lamellate, on a peduncle 15–25 mm long; nut ovoid, 5–8 mm × 5–6 mm. *N. perryi* is locally abundant, co-dominant or dominant in montane forest, at 1600–2100 m altitude. It is also reported from limestone, in ridge forest associated with *Araucaria*, *Castanopsis* or *Lithocarpus* species.

Selected sources 25, 145, 162, 236, 501, 662.

Nothofagus pseudoresinosa v. Steenis

Blumea 7: 147 (1952).

Distribution Papua New Guinea.

Uses The wood is used as New Guinea beech.

Observations A large tree up to 45 m tall, bole sometimes over 100 cm in diameter, sometimes shortly flanged; young parts and lower leaf surfaces with waxy or resinous exudate; leaves elliptical-oblong, 2.5–5.5(–9) cm × 1.2–2.5(–5) cm, entire, ridge on midrib up to halfway, with 8–9 pairs of secondary veins, petiole 5–10 mm long, stipules elliptical, 4–6 mm × 1.5–2 mm; male flowers solitary, female flowers unknown; cupule elliptical to obovate-oblong, (5–)6–7 mm × (2–)3 mm, with 1–2 lamellae, sessile; nut ovoid, 7–8 mm × 4–5 mm. *N. pseudoresinosa* is locally common and dominant or co-dominant in montane forest on ridges and in valleys, at 2300–3100 m altitude.

Selected sources 25, 145, 162, 236, 501, 662.

Nothofagus pullei v. Steenis

Blumea 7: 146 (1952).

Synonyms *Nothofagus cornuta* v. Steenis (1952).

Distribution New Guinea.

Uses *N. pullei* is an important source of New Guinea beech; the wood is used e.g. for local bridge construction. The tree is also planted in villages and garden areas.

Observations A large tree up to 50 m tall, bole up to 100 cm in diameter; leaves broadly elliptical to elliptical-oblong, 1–4.5 cm × 0.7–2.8 cm, entire, ridge on midrib up to about halfway, with 5–7(–8) pairs of secondary veins, petiole 1–3 mm long, stipules tardily caducous, elliptical, 4–5 mm × 2 mm; male flowers solitary, female flowers solitary; cupule 2.5–5 mm × 2 mm, with a single lamella, often laciniate at apex, sessile or on a peduncle 1 mm long; nut acute-orbicular to elliptical, 5–6 mm × 3.5–5 mm. *N. pullei* is very variable occurring often gregariously or dominant on ridges and slopes, sometimes on limestone, at (1650–)2000–3000 m altitude.

Selected sources 25, 85, 145, 162, 236, 501, 662, 664.

Nothofagus resinosa v. Steenis

Blumea 7: 147 (1952).

Vernacular names Indonesia: garuwa (Kapauku language, Wissel Lakes, Irian Jaya).

Distribution New Guinea.

Uses The wood is used as New Guinea beech.

Observations A large tree up to 50 m tall, bole up to 105 cm in diameter, bark surface scaly, grey; young parts and lower leaf surfaces with waxy or resinous exudate; leaves elliptical to broadly elliptical, 4–10 cm × 2–5 cm, finely undulate towards the apex, midrib ridged to at least halfway, with 8–10 pairs of secondary veins, petiole 5–10 mm long, stipules ovate to elliptical, 5 mm × 3 mm; male flowers solitary, almost sessile, female flowers solitary; cupule absent; nut broadly elliptical, 9–10 mm × 6.5–7.5 mm. *N. resinosa* is locally common and sometimes dominant in montane forest, at 2400–2850 m altitude.

Selected sources 25, 145, 162, 236, 501, 662.

Nothofagus rubra v. Steenis

Blumea 7: 147 (1952).

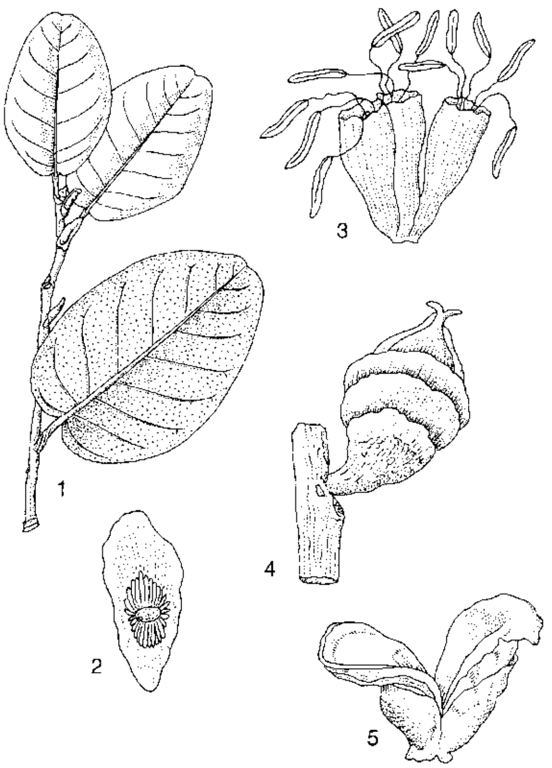
Synonyms *Nothofagus bernhardii* v. Steenis (1952), *Nothofagus decipiens* v. Steenis (1952), *Nothofagus dura* v. Steenis (1952), *Nothofagus eymae* v. Steenis (1952).

Vernacular names Indonesia: diri (Kapauku language, Wissel Lakes, Irian Jaya), snokko (Manikiong language, Arfak), pemmem (Hattam language, Arfak).

Distribution New Guinea and the d'Entrecasteaux Islands.

Uses *N. rubra* is an important source of New Guinea beech. The tree is also locally planted.

Observations A large tree up to 45 m tall, bole up to 100(–120) cm in diameter, bark surface fissured, scaly, dark brown to grey; leaves ovate-oblong to elliptical, 2.5–9.5 cm × 1.5–4.5 cm, entire, midrib ridged well over halfway, with 5–7 pairs of secondary veins, petiole 2–5 mm long, stipules elliptical to oblong, 4–9 mm × 2–4 mm; male flowers



Nothofagus rubra v. Steenis - 1, twig with leaves; 2, stipule; 3, male inflorescence; 4, female flower enclosed by cupule; 5, mature cupule.

in more or less sessile triads, female flowers solitary; cupule variable, 7–10 mm × 7–14 mm, 2–3-lamellate, sessile or on a peduncle up to 7 mm long; nut orbicular to broadly ovoid, 4–6 mm in diameter. *N. rubra* is locally common, dominant or co-dominant in montane forest, sometimes in mossy or boggy forest, also on exposed ridges and then often a gnarled shrub, at 1700–2850 m altitude, but in the d'Entrecasteaux Islands at 750–850 m. The density of the wood is about 970 kg/m^3 at 15% moisture.

Selected sources 25, 145, 162, 236, 280, 501, 662, 664, 715.

Nothofagus starkenborghii v. Steenis

Blumea 7: 347 (1952).

Vernacular names Indonesia: senoko (Manikiong language, Ransiki, Irian Jaya). Papua New Guinea: katula (New Britain, Pomio).

Distribution New Guinea and New Britain.

Uses The wood is used as New Guinea beech, e.g. for house posts, bridge decking and fence posts.

Observations A large tree up to 45 m tall, bole up to 100 cm in diameter, sometimes with spur-buttresses, bark surface with thin sheets or large scales, pale grey-brown; leaves elliptical or rarely obovate, 3–8 cm × 1.2–3.5 cm, entire, midrib grooved but without a ridge above, with 6–10 pairs of secondary veins, petiole 5–10 mm long, stipules elliptical to broadly elliptical, acute, 4–7 mm long; male flowers in shortly stalked triads arranged in glomerules, female flowers in triads; cupule orbicular to obovoid, 11–15 mm × 10–11 mm; nut unknown. *N. starkenborghii* is locally common and may occur in pure stands, also on limestone, at (600–)1200–2400 m altitude.

Selected sources 25, 145, 162, 236, 501, 662.

F. Arentz (general part, selection of species),
W.G. Keating (properties),
J. Ilic (wood anatomy),
M.S.M. Sosef (selection of species)

Ochanostachys Masters

Hook.f., Fl. Brit. India 1: 576 (1875).

OLACACEAE

$2n$ = unknown

Trade groups Petaling: medium-weight to heavy hardwood, a single species, *Ochanostachys amentacea* Masters in Hook.f., Fl. Brit. India 1: 577 (1875), synonyms: *Petalinia bancana* Becc. (1883), *Ochanostachys bancana* (Becc.) Valeton (1886).

Vernacular names Petaling (Indonesia, Malaysia). Indonesia: petikal (Sumatra), ampalang, empilung (Kalimantan). Malaysia: mentalai (Peninsular), petikal (Sarawak), tanggal (Dusun, Sabah).

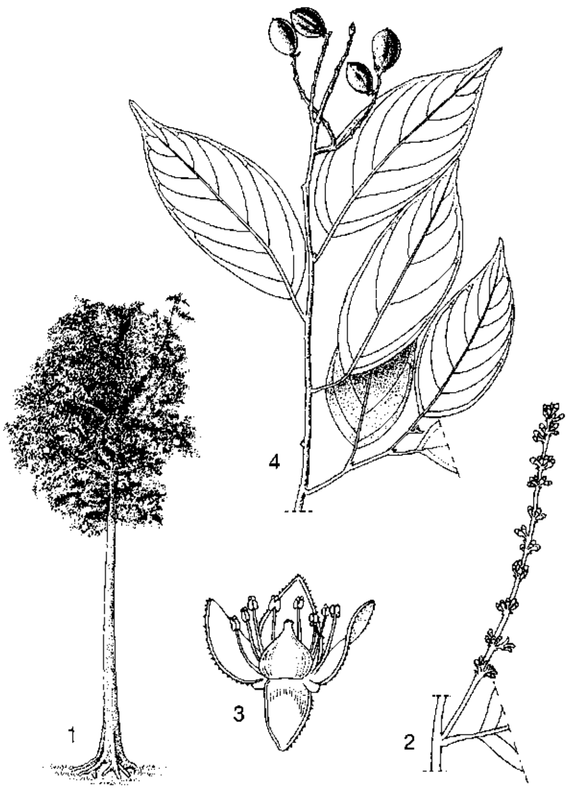
Origin and geographic distribution *Ochanostachys* is a monotypic genus occurring in Peninsular Malaysia, Sumatra, Borneo and intervening islands. It is probably erroneously reported from the Nicobar and Andaman Islands.

Uses Petaling timber is used for house posts and other heavy construction purposes such as bridge bearers for logging roads and railways, for telephone poles, foundation piles, fence posts, flooring and tool handles. Because it has no figure it is less suitable for furniture or indoor work such as staircases, but the wood has been observed to be used as such. Utilization for pallets, boxes, and crates has also been reported. The high elasticity of the wood makes it suitable for gymnasium equipment, such as horizontal bars. Petaling has

been used for underplanting in forest plantations to reduce weed growth.
The seeds are edible when cooked or roasted. A decoction of the bark has been used medicinally against fever and after childbirth. Rheumatic fever has been treated by applying a paste of the roots with bark of *Koompassia* or by a bath prepared by using petaling leaves along with *Koompassia* bark and coriander (*Coriandrum sativum* L.) seed.

Production and international trade Petaling is generally too scarce to be of economic importance as an export timber. It is probably often traded in mixed consignments with other heavy or medium-weight hardwoods. On the local market it is popular for house posts. The amounts exported are insignificant. In 1983, about 3400 m^3 of sawlogs were exported from Peninsular Malaysia, with a value of US$ 120 000 (US$ 35/m^3), and in 1984 it was 3500 m^3 with a value of US$ 140 000 (US$ 40/m^3); the export was mainly to Singapore.

Properties Petaling is a medium-weight to heavy hardwood. The heartwood is red-brown to purplish red-brown or purplish-grey, darkening upon exposure, usually only moderately sharply demarcated from the dark brownish-yellow to pale red-brown sapwood. The density is 730–1105 kg/m^3 at 15% moisture content. The grain is interlocked, texture rather fine and even.
In green condition, the modulus of rupture is 96 N/mm^2, modulus of elasticity 8525 N/mm^2, compression parallel to grain 45.5–49 N/mm^2, compression perpendicular to grain 6 N/mm^2, shear 7.5 N/mm^2, cleavage 54 N/mm radial and 70.5 N/mm tangential, Janka side hardness 4310–6590 N and Janka end hardness 6115 N. At about 15% moisture content, the compression parallel to grain is 56–65 N/mm^2, compression perpendicular to grain 6–6.5 N/mm^2, shear 10 N/mm^2, and Janka side hardness 6360–6625 N. See also the table on wood properties.
The rates of shrinkage from green to 15% moisture content are 1.9% radial and 3.8% tangential. Petaling seasons slowly to very slowly with slight defects. Slight cupping, bowing, end checking or splitting and surface checking have been observed. It takes about 3.5 months to dry 2.5 cm thick boards to the air-dry condition, but periods of 6 and 9 months for drying 1.5 cm and 3.8 cm thick boards, respectively, have also been reported.
Petaling timber can be planed and sanded with very good results, whereas shaping, turning, boring and mortising give good results. The resistance to splitting in nailing is rated as poor. Petaling wood can be peeled into 1.5 mm thick veneer without pretreatment at a 90° peeling angle with good results. Gluing with urea-formaldehyde produces plywood that meets the Indonesian, Japanese and German standards.
Petaling wood is durable to moderately durable, except in water; stake tests show an average service life in contact with the ground of 3.2 years under tropical conditions. The heartwood is considerably resistant to termite attack and also to soft-rot fungus (*Chaetomium globosum*) and white-rot fungus (*Coriolus versicolor*). The treatability of the heartwood with preservatives is rather variable, from average to extremely difficult. Using a 2.5 hour treatment schedule with 3% copper-chrome-arsenic preservative, petaling heartwood absorbed 206 l/m^3. The sapwood is liable to powder-post beetle attack but is easily treated with preservatives.
Petaling wood contains 47.5% cellulose, 30% lignin, 10.5% pentosan, 0.1% ash and 0.1% silica.



Ochanostachys amentacea Masters – 1, tree habit; 2, branchlet with inflorescence; 3, flower; 4, fruiting twig.

The solubility is 2.2% in alcohol-benzene, 3.3% in cold water, 4.8% in hot water and 20.5% in a 1% NaOH solution.

Description A medium-sized to sometimes large evergreen tree up to 30(–50) m tall; bole straight or rather poorly shaped, branchless for up to 15(–20) m, up to 60(–80) cm in diameter, fluted and often with short buttresses at base; bark surface with distant roundish to oblong thin adherent scales, mottled with purplish shades of pale brown, yellowish-brown or dark brown, inner bark finely fibrous, mottled yellowish to orange-brown-fawn, with droplets of white latex and separated from the cambium by a purplish line; crown dense and dark with many small branches. Leaves arranged spirally, simple and entire, ovate or elliptical to oblong, (5–)6–13 cm × (2.5–)3–7 cm, broadly cuneate to rounded at base, apex short-bluntly acuminate, pinnately veined with (4–)5 (–8) pairs of secondary veins, tertiary venation scalariform; petiole (1–)1.5–2(–3) cm long, with an apical knee; stipules absent. Flowers bisexual, actinomorphic, arranged interruptedly, either solitary or 2–4 together in a simple or sometimes 1–2-branched, up to 12 cm long spike from the leaf axils, c. 3 mm long, green to whitish-yellowish, almost sessile; calyx 4–5-toothed; petals (3–)4(–5), united at the very base; stamens (1–)2(–3) before each petal; ovary superior, depressed-ovoid, glabrous, with a short cylindrical style. Fruit a subglobose to ovoid pendulous drupe, (1.5–)2–2.5 (–3) cm in diameter, turning yellow when ripe, with a thin pericarp and woody endocarp, 1-seeded. Seed subglobular. Seedling leaves similar in form to those of the mature tree.

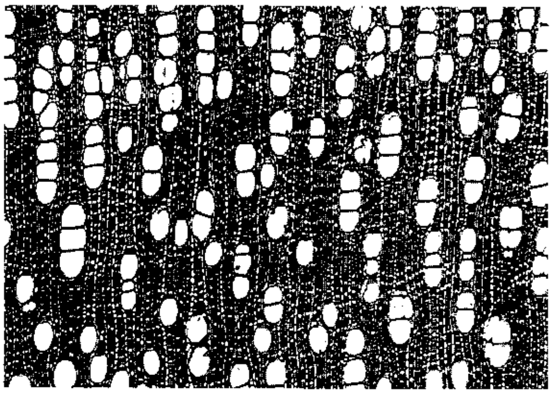
Wood anatomy

– Macroscopic characters:

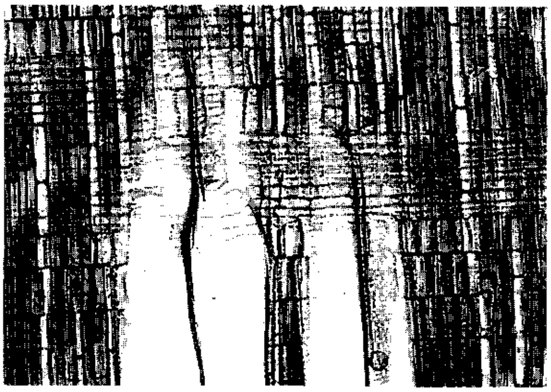
Heartwood red-brown to purplish red-brown or purplish-grey, darkening on exposure, usually only moderately sharply demarcated from the sapwood (dark yellow-brown or pale red-brown). Grain interlocked. Texture rather fine and even; wood odourless and featureless. Growth rings indistinct; vessels visible to the naked eye, small to medium-sized, in radial multiples; parenchyma and rays only visible with a lens; ripple marks absent.

– Microscopic characters:

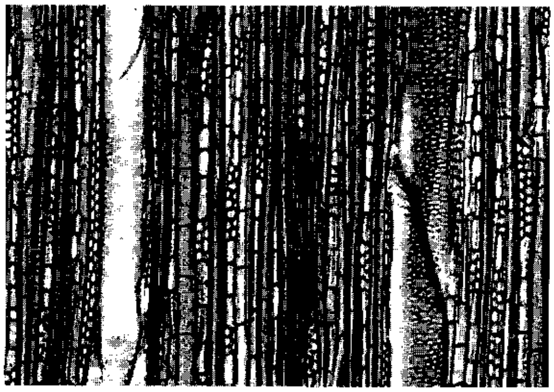
Growth rings faint. Vessels diffuse, 10–40/mm², solitary (10–45%) and in radial multiples of 2–4 (–7), round to oval or slightly angular in cross-section, average tangential diameter 85–110 μm; perforations scalariform with up to 10 bars per perforation; intervessel pits alternate, in narrow vessels occasionally opposite to scalariform, rounded,



transverse section (×25)



radial section (×75)



tangential section (×75)

Ochanostachys amentacea

polygonal or elongated, 10–16 μm in diameter; vessel-ray and vessel-parenchyma pits large, half-bordered to simple, solitary, occasionally forming together a reticulate or scalariform pattern; helical thickenings absent; thin-walled tyloses rarely present. Fibres 1450–2900 μm long, very thick-walled (walls 8–12 μm thick), with minutely bordered pits with slit-like apertures mainly confined to the radial walls. Parenchyma fairly common to abundant, predominantly apotracheal, diffuse and in small aggregates, scarcely paratracheal, occasionally forming uniseriate rows between the rays, in (4–)8–16(–20)-celled strands. Rays 12–18/mm, mainly uniseriate with small 2–3-seriate central parts, (200–)1250–1950(–4200) μm high, composed of procumbent or weakly procumbent cells in the multiseriate parts, and square to upright cells in the uniseriate margins and in uniseriate rays (Kribs type heterogeneous I); sheath cells infrequently present. Solitary rhomboidal crystals present, scarce to abundant, in chambered axial parenchyma cells, infrequently in non-chambered ray cells. Silica bodies not observed. All elements non-storied.

Growth and development Under natural conditions, it takes approximately 150 years for a petaling tree to grow to a diameter of 50 cm, and 200 years to reach a diameter of 60 cm, but a mean annual diameter increment of about 1.0 cm has been reported for an individual 44-year-old tree in the arboretum of the Forest Research Institute of Malaysia. In a sample plot with 308 petaling trees an annual diameter increment of 0.5 cm has been measured. Early growth is about 2.4 m in height in 5 years. In a plantation trial in Malaysia, trees with an age of 33 years attained a mean height of 21 m.

Petaling trees flower almost throughout the year, except for December and January; fruits may be found throughout the year, but mast fruiting years have been observed. Animals like monkeys and birds most probably disperse the seeds, by eating the fruits.

Other botanical information Petaling is easily recognized by its typical flower arrangement. The mottled bark is also characteristic. The wood is similar to kulim (*Scorodocarpus borneensis* (Baillon) Becc.), but does not smell of garlic.

Ecology Petaling is a fairly common but scattered understorey or rarely canopy tree of primary or sometimes secondary lowland rain forest. It often thrives in mixed dipterocarp forest on undulating country or hillsides and ridges, up to 950 m altitude. It is found on clay-rich, loamy or sandy, usually well-drained soils, apparently growing well on laterite, and is only rarely found in periodically inundated locations.

Propagation and planting Petaling can be propagated by seed. However, during a test seed germinated very slowly; the first seedling was observed 2.5 months after sowing and the last one more than 2 years after sowing. The germination percentage is about 20%. Petaling can be planted on a variety of soils.

Silviculture and management Natural regeneration of petaling is sparse and scattered, but may be fairly plentiful under favourable conditions. It is very tolerant of shade and only rarely reaches the canopy top. Natural vegetative reproduction takes place by means of coppice shoots and root suckers. In natural forest in Peninsular Malaysia, the average number is 1 tree of commercial size to 1.6 ha, but locally it may be as much as 2.5 trees/ha. Petaling is useful for underplanting in forest plantations to reduce weed growth and hence the costs of weed control. In this way it has been successfully planted with meranti (*Shorea* spp.) in Peninsular Malaysia. It is not resistant to fire, as about 90% mortality was observed after fire in East Kalimantan.

Harvesting Logs are generally without defects.

Yield The estimated timber volume of petaling is 1 m^3/ha in forest near Samarinda, East Kalimantan, and 10.3 m^3/ha in the Krueng Pirak forest, Aceh.

Handling after harvest The logs sink in water and cannot be transported by river unless when fastened to the floating logs of other timbers.

Genetic resources Petaling is not in great demand or sought for locally and the conservation of its genetic resources is directly linked to the conservation of its habitats.

Prospects Petaling is probably most frequently traded together with other medium-weight and heavy woods as mixed hardwood. When, however, directly recognized at the saw mill or during logging, petaling timber may be traded separately to be used for specific purposes such as gymnasium equipment, and may command a better price. Due to its slow growth, it does not have potential as a timber plantation species. Petaling is well suited for underplanting and deserves more attention.

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Other selected sources 24, 47, 69, 78, 99, 175, 234, 365, 387, 435, 465, 472, 526, 570, 584, 721.

E. Boer (general part),
M.S.M. Sosef (general part),
W.C. Wong (properties)
L. van den Oever (wood anatomy)

Octomeles Miq.

Fl. Ind. Bat., Suppl. 1 (Prodr. Fl. Sum.): 336 (1861).

DATISCACEAE

x = unknown; $2n$ = unknown

Trade groups Binuang: lightweight hardwood, a single species, *Octomeles sumatrana* Miq., Fl. Ind. Bat., Suppl. 1 (Prodr. Fl. Sum.): 336 (1861), synonym: *Octomeles moluccana* Teijsm. & Binnend. ex Hassk. (1866).

Vernacular names Binuang. Indonesia: benuang, winuang, binuang bini (general). Papua New Guinea: erima, irima, ilimo (general). Philippines: bilus (Tagalog), barong (northern Luzon), barousan (southern Luzon).

Origin and geographic distribution This monotypic genus occurs in Sumatra, Borneo, Sulawesi, the Moluccas, the Philippines, New Guinea and the Solomon Islands.

Uses The wood is used for several purposes, especially where strength is not important. The wood can only be used under cover for light furniture and joinery, interior finish, mouldings, wide shelves, louvred doors, coffin boards, large dugout canoes, rafts, sledges, jungle drums, concrete shuttering, packing, low-quality crates and boxes, buoys and fish-net floats, matchboxes, back and core veneer, firewood, chipboard and fibreboard, and for pulp and paper manufacture.

In Kalimantan the bark used to be combined with roots of mengkudu (*Morinda citrifolia* L.) and leaves of jirak (*Symplocos* spp.), to dye split rattan red. The inner bark contains a bitter purgative and a yellow dye. Young leaves are eaten as vegetable and the juice is used in local medicine to treat stomach-ache. Binuang trees are valued by local people as wild bees often nest in them.

Production and international trade The export of binuang timber from Sabah in 1987 was 201 000 m^3 of logs with a value of US$ 12.7 million, and in 1992 it was 95 000 m^3 (21% as sawn timber, 79% as logs) with a total value of US$ 8.3 million (US$ 141/m^3 for sawn timber, US$ 73/m^3 for logs). In Papua New Guinea, binuang ('erima') is a fairly important export timber and ranked in MEP (Minimum Export Price) group 3; saw logs fetched a minimum price of US$ 50/m^3 in 1992. The import in Japan is about 1.5% of the total timber import from Papua New Guinea.

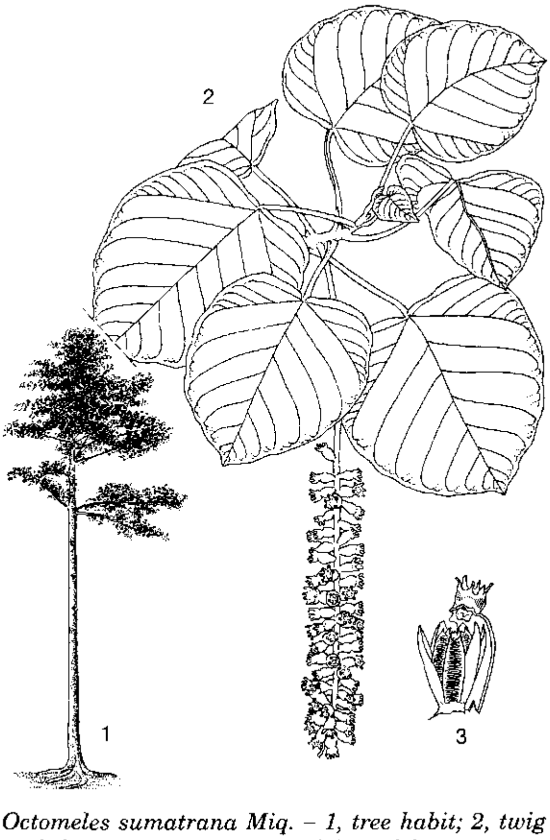
Properties Binuang is a lightweight and comparatively soft hardwood. The heartwood is buff-coloured to pale brown, sometimes reddish-grey to brownish-grey or pinkish-brown, and moderately sharply defined from the 7.5–15 cm wide, almost white sapwood that has a faint greyish-yellow tinge. The density is (160–)270–400(–480) kg/m^3 at 15% moisture content. The grain is usually interlocked, texture moderately coarse to coarse; quarter-sawn surfaces may show a broad-stripe figure.

At 12% moisture content, the modulus of rupture is (33.5–)41.5–55 N/mm^2, modulus of elasticity (4700–)6200–8500 N/mm^2, compression parallel to grain (22–)24–37.5 N/mm^2, compression perpendicular to grain 2–4 N/mm^2, shear 4–6 N/mm^2, cleavage 29–64 N/mm radial and 39–57 N/mm tangential, Janka side hardness (990–)1490–1960 N and Janka end hardness (1340–)1960–2240 N. See also the table on wood properties.

The rates of shrinkage are moderate: from green

to 12% moisture content 1.9% radial and 4.3% tangential, from green to oven dry 3.0% radial and 6.9% tangential. Considering its low density, binuang seasons slowly with rather severe degrade, especially in the zone between the heartwood and sapwood; degrade is caused by checking, splitting and distortion. Knots split moderately badly and staining is liable to occur. Boards 20 mm thick can be air dried in about 35 days to 18% moisture content, and boards 40 mm thick in about 90 days to 20% moisture content. Malaysian kiln schedule C is recommended for kiln drying, but even with this very mild schedule drying may be unsatisfactory. Once dry, binuang has good dimensional stability.
Binuang is easy to work with hand or machine tools. Because silica is absent or scarce, the wood has little dulling effect on cutting edges, but occasionally white deposits in the wood may chip planer knives. Sometimes severe woolly or fuzzy grain may be present on sawn surfaces. Ripsaws with 54 spring-set teeth and 25° hook cut the timber satisfactorily. Arrises tend to chip and the cutting angle has to be reduced to 20° to minimize picking-up in planing; sharp knives are particularly necessary with a reduced cutting angle to avoid a woolly finish. End-grain tends to crumble in mortising and paring, and a poor finish is usually obtained in drilling and cross-cutting; adequate support is needed to prevent breaking away at the exit of tools used across the grain. Binuang stains and polishes satisfactorily and nails moderately well, but screw and nailholding characteristics are sometimes poor. Steam-bending properties are very poor. Gluing properties are good. The timber is easy to cut and peels readily to smooth, tight veneer of uniform thickness without any bolt conditioning. The veneer dries flat and split-free, but it is liable to stain. Presence of brittle heart may cause problems in chucking. Because of its drab appearance, the wood is considered to be more suitable as core veneer. The pulp is rated as excellent for paper making.
Binuang heartwood is rated as non-durable in contact with the ground or exposed to the weather under tropical conditions, and as very perishable. In temperate regions the heartwood is also rated as perishable; samples were all destroyed in about 4 years in graveyard tests. The wood is very susceptible to termite attack. Sapwood is susceptible to *Lyctus* attack and frequently attacked by ambrosia beetles. The heartwood is moderately resistant to preservative treatment and requires pressure treatment to obtain fair results. The sapwood is reported as permeable, i.e. it can be penetrated completely under pressure without difficulty, and can be impregnated with satisfactory results by the open-tank process.
The wood contains c. 61% holocellulose, 23–32% lignin, 14–24% pentosan, 1.1–1.5% ash and up to 0.2% silica. The solubility is 1.7–2.9% in alcohol-benzene, 0.2% in cold water, 2.6–3.6% in hot water and 15.1–16.1% in a 1% NaOH solution. The energy value is about 19 750 kJ/kg.

Description Large to very large dioecious evergreen trees up to 60(–75) m tall; bole cylindrical, straight, branchless for up to 30(–40) m, up to 250(–400) cm in diameter, with prominent buttresses up to 6 m high; bark surface fissured or irregularly cracked, often pustular, grey to grey-brown, inner bark fibrous, yellowish but rapidly turning brown on exposure, without exudate; crown open, pagoda-like with whorled branches when young, semi-globular when mature; twigs sharply 3-angled. Leaves arranged spirally, simple and entire, thin, roundish cordate, 12–30 cm × 6–23 cm, acuminate, with 5–7(–9) palmate veins, minutely scaly and below with large domatial



Octomeles sumatrana Miq. – 1, tree habit; 2, twig with female inflorescence; 3, dehisced fruit.

glands in the axils of the main veins; petiole 6–30 cm long; stipules absent. Flowers unisexual, actinomorphic, sessile, 5–8-merous, green, in solitary axillary spikes. Male inflorescence 20–60 cm long; flowers campanulate, 4–5 mm × 5 mm, petals with an incurved appendage, anthers kidney-shaped. Female inflorescence 8–12 cm long; flowers c. 5 mm long, calyx campanulate, petals absent, ovary inferior, 1-celled, with 3–8 parietal placentae and many ovules, styles 5–8, inserted on the throat of the calyx tube, stigma capitate. Infructescence 15–40 cm long, on a 10–20 cm long peduncle. Fruit a barrel-shaped capsule, splitting from the top downwards, 12 mm long. Seeds many, spindle-shaped, c. 1 mm × 0.2 mm.

Wood anatomy

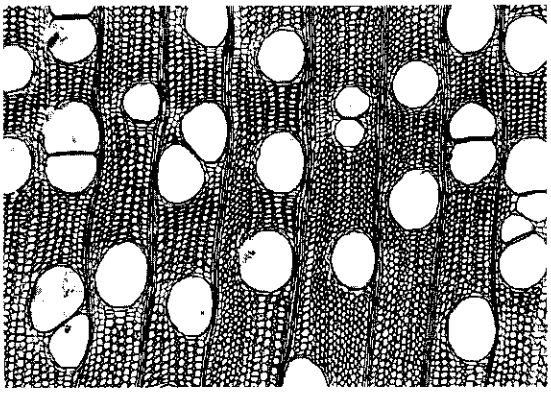
– Macroscopic characters:

Heartwood pale brown, yellowish-brown to reddish-grey or brownish-grey, sometimes with pink tinge, moderately distinctly demarcated from the almost white to yellowish-white sapwood. Grain usually interlocked, sometimes straight. Texture moderately coarse to coarse; quarter-sawn surfaces lustrous and with broad stripes; wood without taste and odour, but green or wetted wood sometimes with foetid odour. Growth rings indistinct or absent; vessels visible to the naked eye, tyloses occasionally present; parenchyma indistinct; rays distinct to the naked eye; ripple marks absent.

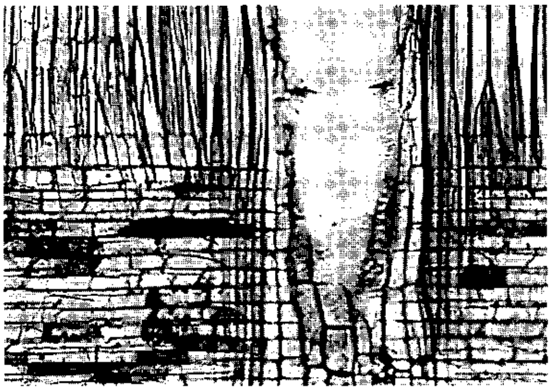
– Microscopic characters:

Growth rings, if present, marked by narrow marginal parenchyma bands. Vessels diffuse, (1–)2–4 (–7)/mm^2, solitary and in radial multiples of 2–3, round to oval, average tangential diameter 140–230 μm; perforation plates simple; intervessel pits alternate, polygonal, 6–9 μm; vessel-ray pits with strongly reduced borders, large and gash-like to oval; tyloses occasionally present. Fibres 900–1600(–2000) μm long, non-septate, thin-walled (walls 3–5 μm thick), with minutely bordered to simple pits confined to the radial walls. Paratracheal parenchyma vasicentric or unilateral, in narrow (1–2 cells wide) sheaths or caps; apotracheal parenchyma usually absent, but occasionally marginal parenchyma bands present, in 2–4(–8)-celled strands. Rays 3–5/mm, (1–)2–5-seriate, 7–50 cells and up to 1800 μm high, heterocellular with 1–2 rows of upright or square marginal cells (Kribs type heterogeneous II and III). Crystals absent; reddish gummy substance and/or granular contents sometimes present in ray cells. Silica absent. Intercellular canals absent.

Growth and development Binuang is very



transverse section (×25)



radial section (×75)

tangential section (×75)

Octomeles sumatrana

fast growing. In trial plantations in the Solomon Islands, 4.5-year-old trees had an average height of 16 m and an average diameter of 21 cm. In Sabah, trees reached a height of 10 m 2.5 years after planting. For a 4-year-old binuang tree planted on volcanic soils in Bogor (West Java) a height of 25 m and a diameter of 47 cm have even been reported. Trees can attain 48 m height and 105 cm in diameter in 60 years.

The tree architecture is according to Massart's model, with an orthotropic, monopodial trunk having rhythmic growth and consequently producing regular tiers of plagiotropic branches.

Other botanical information The *Datiscaceae* form a small family of only 4 species. The only other South-East Asian representative is *Tetrameles nudiflora* R.Br., a deciduous tree with hairy leaves and 4–5-merous flowers and by contrast it occurs only in slightly seasonal climates. The best field characteristics to identify binuang are the light-coloured bole, the nearly horizontal branches in young trees, and the form, texture and venation of the leaves.

Binuang trees often have bee nests attached to the branches.

Ecology Binuang grows in lowland evergreen rain forest, up to 1000 m altitude. It is especially common in natural secondary and seral riverine alluvial forest where it is sometimes found in even-aged pure stands. Binuang is a pioneer of bare alluvial soil, binding the soil with a network of roots and thus improving the site. As such it precedes the successional stage of mixed lowland rain forest in which it may occur scattered. Binuang grows naturally in various other open locations such as on volcanic deposits and abandoned logging roads. In Sabah, binuang is frequently associated with kadam (*Anthocephalus chinensis* (Lamk) A. Rich. ex Walp.). In Papua New Guinea and New Britain, binuang occurs in habitats similar to those of kamarere (*Eucalyptus deglupta* Blume) with which it is sometimes associated. The riverine binuang forest is usually characterized by good drainage and only temporary flooding. The most important condition for growth of binuang appears to be an evenly distributed annual rainfall of at least 1500 mm.

Propagation and planting Binuang can be propagated by seed. Once every 3–4 years fruit production is very abundant. The capsules can be collected when they begin to turn brown. They split upon drying and vigorous shaking is necessary to release the seeds. There are 11 500–20 000 dry seeds in one kg. Seed is susceptible to damage by fungi during transportation. The germination rate is variable but generally quite low, about 40%, and decreases rapidly with time, to 25% after 2 months and there is no germination at all after 3 months.

For sowing, seeds are mixed with fine river sand and sown in special trays which are kept moist under full shade. The seed must be sown thinly, to prevent dense clumps of seedlings. Damping-off can be prevented by good ventilation. Seedlings can be pricked out 5–6 weeks after sowing and are ready for planting after about 4 months when they are 15–20 cm tall. Different spacings have been tested, ranging from 2.4 m × 2.4 m to 4.8 m × 4.8 m. A spacing of 2.4 m × 4.8 m seems most appropriate for plantation establishment. Binuang needs a fertile, deep soil for proper development.

Silviculture and management Binuang is considered a true pioneer and establishes itself readily in open areas such as dry river beds, on volcanic deposits and abandoned logging roads, where light and freshly exposed soil can be found. It does not tolerate any shade. Rapid early growth and crown closure (1–1.5 years after planting) are advantageous characteristics in plantations as well as its good self-pruning capacity and freedom from serious pests. Survival after planting is generally high. In open stands herbaceous and woody climbers may cause considerable damage to binuang as they hang down in large masses from the horizontal branches and often completely smother the trees. These climbers must be weeded out or cut out. Apparently, binuang does not thrive in closed plantations and the spreading crown seems to suffer from branch contact with neighbouring trees. It is fairly resistant to fire. Trials with binuang have also been established outside the South-East Asian region, e.g. in Brazil.

Diseases and pests Brittle heart is a defect found in binuang logs. *Characoma* moths cause partial or complete defoliation and dieback. Unidentified shoot borers have also been observed, but did not cause serious damage. Trees with severely perforated leaves are very common, but usually recover well.

Harvesting For the production of pulpwood, harvesting can start 4–5 years after planting, depending on the site conditions. No data are available on the rotation cycle of binuang harvested for timber, but a cycle of 30–40 years like that used for *Anthocephalus chinensis*, seems to be applicable for binuang as well. Boles from natural forest are usually obtainable in lengths of 21 m or more.

Yield Thinned and unthinned plots in a natural regenerated stand in the Philippines displayed a mean annual increment of 46 and 36 m^3/ha, respectively, over the period of 4–6 years after logging. For large-scale plantations in Indonesia the expected annual increment during a rotation of 30 years is 25–40 m^3/ha.

Handling after harvest The wood deteriorates very rapidly and must be extracted from the forest is immediately. The timber has to be worked up soon after cutting and it should be treated within 2 days or be submerged in water. Immediately after sawing binuang has to be treated to prevent stain. The logs float in water and can be transported by river.

Genetic resources At present, a fair supply of *O. sumatrana* is still available in the South-East Asian region, particularly in Irian Jaya and Papua New Guinea. There seems to be no immediate risk of genetic erosion as it occurs frequently and regenerates abundantly along rivers and in open low-lying locations in secondary forest. Plantations have been established to some extent in the Philippines and Papua New Guinea.

Prospects Binuang merits attention as a plantation species, especially for the production of raw material for the manufacture of plywood and of pulp for paper making. It develops well in open areas and can be used for enrichment planting in logged-over forest and as a fast-growing species on low-lying alang-alang (*Imperata cylindrica* (L.) Raeuschel) grasslands. The development of silvicultural management techniques is a research priority.

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Other selected sources 12, 60, 69, 77, 96, 114, 115, 158, 164, 216, 218, 255, 289, 297, 330, 352, 356, 393, 414, 478, 489, 527, 592, 644, 695, 703, 719, 729, 730.

J.W. Hildebrand (general part),
E. Boer (general part),
P.B. Laming (properties),
J.M. Fundter (wood anatomy)

Parishia Hook.f.

Trans. Linn. Soc. Lond. 23: 169 (1860).
ANACARDIACEAE
x = unknown

Trade groups Lelayang: lightweight to medium-weight hardwood, e.g. *Parishia insignis* Hook.f., *P. maingayi* Hook.f.

Vernacular names Lelayang. Indonesia: kayu sepa, kayu bengkarung, balom tembaga (Sumatra). Malaysia: sepul, kayu pontianak (Peninsular), rengas susu, upi (Sarawak), layang-layang (Sabah). Philippines: bulabog, malabog. Burma (Myanmar): pwe-baung. Thailand: ngokkhang, chan-ruchi (peninsular).

Origin and geographic distribution *Parishia* consists of 5 species and is distributed in Burma (Myanmar), the Andaman Islands, Thailand and western Malesia (Peninsular Malaysia, Sumatra, Borneo and the Philippines). Borneo is richest with 4 species, whereas 3 species occur in Peninsular Malaysia and Sumatra and 2 species in the Philippines. *P. insignis* has the largest area of distribution, covering the entire range of the genus.

Uses The light and comparatively soft wood is used for temporary constructions, veneer (especially for core layers of plywood), boxes and crates, and as firewood. The logs are also used to raft heavy timbers.

Production and international trade Lelayang timber has little importance in the trade and export, and probably only small amounts are traded as 'mixed light hardwood'.

Properties Lelayang wood is lightweight to medium-weight. The heartwood is greyish to pale brown or reddish-brown and not clearly distinct from the paler sapwood. The density is (415–)495–770 kg/m^3 at 15% moisture content. The grain is interlocked, texture fine to moderately fine and even.

A test on *P. insignis* wood in Malaysia showed the following mechanical properties at 15% moisture content: the modulus of rupture 94 N/mm^2, modulus of elasticity 12 515 N/mm^2, compression parallel to grain 49 N/mm^2 and shear 13 N/mm^2.

The rates of shrinkage are high: from green to 15% moisture content 2.0–2.2% radial and 5.3–5.5% tangential; however, from green to oven dry a shrinkage of 2.2% radial and 6.3% tangential has been reported which is fairly low. The timber air dries fairly rapidly with slight degrade in the form of cupping, bowing and twisting. Boards 15 mm thick take about 2 months to air dry to 15% moisture content and boards 40 mm thick take 3–4 months. In Malaysia, kiln-drying schedule H is recommended.

Lelayang wood is generally not easy to work: it is very difficult to saw because of the presence of silica and tension wood, and difficult to plane producing rough surfaces because of the interlocked grain.

The wood is generally non-durable; it is susceptible to attack by sap-staining fungi and powder-post beetles. The sapwood is moderately easy to treat with preservatives, but the heartwood difficult. Tests on treatability in Malaysia showed diverging results, probably because of the variable amounts of sapwood which is difficult to distinguish from the heartwood.

Lelayang wood contains about 76% holocellulose, 45% α-cellulose, 19% lignin, 21% pentosan and 0.7% ash. The solubility is 2.5% in alcohol-benzene, 8.5% in hot water and 23.7% in a 1% NaOH solution.

The sap of *Parishia* is possibly non-poisonous, unlike that in several other *Anacardiaceae* genera such as *Gluta*. The allergenic properties of *Parishia* have not yet been demonstrated.

Description Medium-sized to very large, deciduous, dioecious trees up to 60 m tall with bole up to 110–(120) cm in diameter; buttresses usually present, often tall and spreading, up to 5 m high and extending outward up to 2 m from the trunk; bark surface smooth to shallowly fissured, scaly or flaky, inner bark laminated or soft, pink or reddish and often with white wedges, with abundant white latex, darkening on drying. Leaves arranged spirally, imparipinnate, petioled, without stipules; leaflets subopposite or opposite, entire. Inflorescence axillary and/or terminal, paniculate. Flowers unisexual, 4-merous; calyx lobes usually hairy on both surfaces, greatly enlarged, often wing-like, in fruit; petals imbricate in bud, glabrous or sparsely hairy on the outer surface; disk present, intrastaminal, round or slightly 4-angular, flat or discoid, 4-notched or -lobed, or pulvinate and 4-grooved, hairy; stamens 4, with long, thin, glabrous filaments and usually ovoid, dorsifixed or dorso-basifixed anthers abortive in female flowers; ovary superior, 1-celled, densely hairy, style 3(–4)-lobed with 3(–4) stigmas, pistil in male flowers strongly reduced. Fruit a 1-celled and 1-seeded, densely brown hairy drupe, seated in an enlarged calyx with wing-like lobes; endocarp hard and tough. Seed with testa adhering to the endocarp; embryo straight, cotyledons planoconvex and free. Seedling with epigeal germination; cotyledons sessile, entire, glabrous and green; hypocotyl strongly enlarging; first 2 leaves opposite, (1–)2(–3)-foliolate, subsequent leaves arranged spirally and imparipinnate.

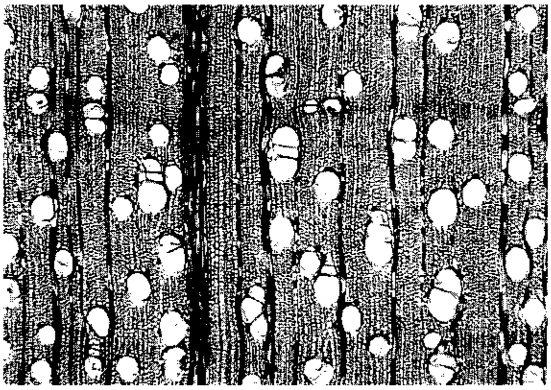
Wood anatomy

– Macroscopic characters:

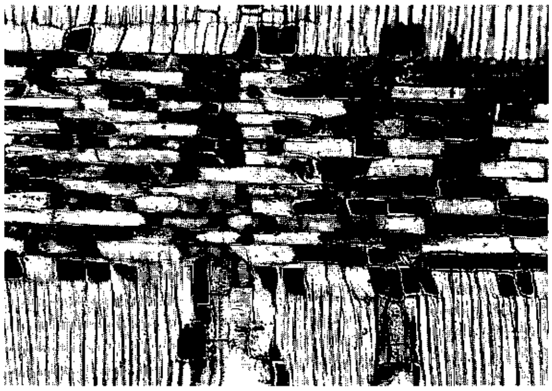
Heartwood pale brown, greyish-brown to reddish-brown, indistinctly demarcated from the greyish-brown sapwood. Grain finely interlocked. Texture moderately coarse; wood weakly lustrous. Growth rings indistinct; vessels small, barely visible to the naked eye, tyloses sparse; parenchyma indistinct; rays almost invisible to the naked eye; ripple marks absent.

– Microscopic characters:

Growth rings absent, or weakly present and defined by thick-walled fibres (*P. insignis*). Vessels diffuse, 10–14/mm^2, solitary (45–80%) or in multiples of 2–5, generally oval, average tangential diameter 55–95 μm, maximum tangential diameter 105–170 μm; perforation plates simple; intervessel pits dense and alternate, 6–8 μm; vessel-ray pits with much reduced borders to almost simple, horizontal to vertical, large, 7–25 μm; tyloses sparse or absent. Fibres 0.5–1.5 mm long, non-septate, thin-



transverse section (×25)



radial section (×75)

tangential section (×75)

Parishia insignis

walled, with very sparse minutely bordered pits mainly confined to the radial walls. Axial parenchyma paratracheal, vasicentric, occasionally aliform, in 3–6-celled strands. Rays 1–3(–8) cells wide, up to 750 μm high, heterocellular with 1–3 rows of square to upright marginal cells, uniseriate rays mostly less than 0.5 mm high. Wide fusiform rays with intercellular canals (ducts) present. Silica bodies sparse in ray cells. Horizontal intercellular canals present, 1–2 in each fusiform ray, 20–120 μm in diameter; axial canals absent. Species studied: *P. insignis*, *P. malabog*.

Growth and development In *P. insignis*, the taproot and hypocotyl emerge from the top of the fruit between the wing-like calyx lobes. After establishment of the root the hypocotyl elongates and the cotyledons are withdrawn from the fruit. When two leaves have developed, a short resting stage occurs.

Lelayang trees are deciduous and flowering occurs either before the new leaves develop or simultaneously. The winged fruits turn upside-down when falling from the tree and rotate; usually they are dispersed over small distances only.

Other botanical information *Parishia* is unique among Malesian *Anacardiaceae* in the enlarged wing-like calyx of its fruit. In *Gluta* and *Swintonia* the petals are often enlarged and wing-like in fruit. *Parishia* is classified in the tribe *Rhoeae*, together with, for example *Campnosperma* and *Pentaspadon*.

Parishia trees can be confused with *Sapotaceae* trees (nyatoh) which also have a pinkish or reddish inner bark and latex, but these differ by having simple leaves. Kedondong (*Burseraceae*) trees which have compound leaves and scaly bark in common with lelayang, differ in the absence of latex when the bark is cut (or sometimes little latex present), and the swollen leaflet stalks. Sterile *Parishia* specimens and specimens with immature inflorescences or young fruits are often difficult to identify.

Ecology Lelayang trees occur in lowland forest, rarely above 600 m altitude, in dryland mixed dipterocarp forest in hilly country as well as in freshwater swamp forest and on temporarily inundated river banks. Lelayang is also found on limestone and ultrabasic soils.

Propagation and planting Germination of *P. insignis* is poor. Seedlings are liable to be affected by adverse conditions during the period between germination and root penetration that cause the roots to dry out.

Silviculture and management *Parishia* species often occur scattered in natural forest and are not sufficiently abundant to be of importance.

Yield In the Semangus forest complex, Palembang (Sumatra), the timber volume of *P. maingayi* of commercial size was estimated to be 0.23 m^3/ha, whereas in Aceh it averaged 1.3 m^3/ha.

Handling after harvest The lightweight logs of lelayang float in water and are used to raft heavy timbers.

Genetic resources *Parishia* trees are common in many areas, although they occur scattered. They are rarely selectively logged for timber, and thus not endangered as long as adequate areas of lowland forest exist.

Prospects The timber of lelayang is not of good quality and, together with its scattered occurrence in natural forests, there is no reason to expect an increased utilization in the near future. There is no need to start research in the establishment of *Parishia* plantations. In some areas, lelayang trees are even regarded as weeds and as being undesirable.

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Selection of species

Parishia insignis Hook.f.

Trans. Linn. Soc. Lond. 23: 170, t. 26 (1860).

Synonyms *Parishia pubescens* Hook.f. (1876), *Parishia rosea* Ridley (1911), *Parishia borneensis* Ridley (1933), *Parishia lowei* Ridley (1933).

Vernacular names Indonesia: balam tembaga, surian rimbo (Sumatra), lomu kujang (South Kalimantan), medang somkon, keramu (Kalimantan). Malaysia: sepul, kayu pontianak (Peninsular), upi paya (Sarawak). Thailand: thongchon (Satun), ngokkhang (Pattani), tina (Ranong).

Distribution Southern Burma (Myanmar), the Andaman Islands, Thailand, Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses The wood is used as lelayang, as a general utility wood and for core veneer.

Observations A large, sometimes very large tree up to 50(–60) m tall, bole up to 110 cm in diameter, with tall buttresses up to 5 m high, bark surface smooth to shallowly fissured; leaves with 4–6(–7) pairs of leaflets, leaflets asymmetrical or oblique at base, petiolules (if present) flat or convex above; flowers pedicelled, petals broadly ovate to ovate-oblong or elliptical, up to 5 mm long, white or pinkish; fruit subglobose, 1–1.5 cm in diameter, pointed, fruit calyx with c. 0.5 cm long tube and 7–8.5(–12) cm long red wing-like lobes. *P. insignis* is variable, especially in the shape and hairiness of the leaflets. It is widely distributed in lowland dryland forest and swamp forest, and is also common locally on limestone hills, up to 300 m altitude. The density of the wood is 415–755 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 69, 77, 78, 104, 136, 140, 162, 470, 546, 549, 705.

Parishia maingayi Hook.f.

Fl. Brit. India 2: 30 (1876).

Synonyms *Parishia oblongifolia* Merr. (1919), *Parishia minor* Ridley (1933), *Parishia polycarpa* Ridley (1933).

Vernacular names Brunei: lampong. Indonesia: bulu, parak, suren (Sumatra), rengas susu (Kalimantan). Malaysia: sepul (Peninsular), layang-layang (Sabah), rengas susu, upi keranges (Sarawak). Philippines: bulabog (Panay Bisaya).

Distribution Peninsular Malaysia, Singapore, Sumatra, Borneo and the Philippines (Panay, Sibuyan).

Uses The wood is used as lelayang.

Observations A medium-sized to fairly large, sometimes large tree up to 40(–55) m tall, bole up to 85(–95) cm in diameter, with short buttresses up to 1.5 m high, bark surface scaly, flaky or fissured, brownish; leaves with (4–)7–12 pairs of leaflets, leaflets symmetrical at base, petiolules grooved above; flowers pedicelled, petals oblanceolate or narrowly oblong, up to 8 mm long, white; fruit ovoid or broadly ellipsoid, 1–2.5 cm long, pointed, fruit calyx with 1.5–3 cm long tube and 6–10.5(–16) cm long red wing-like lobes. *P. maingayi* occurs scattered, but locally abundant, in mixed dipterocarp forest, freshwater swamp forest and on inundated river banks, sometimes on limestone ridges and ultrabasic soils, up to 600 m altitude, rarely higher. The density of the wood is 545–770 kg/m^3 at 15% moisture content.

Selected sources 77, 104, 140, 162, 414, 474, 595, 705.

Parishia malabog Merr.

Philipp. Journ. Sc., Bot. 7: 281 (1912).

Vernacular names Philippines: malabog (general), buikan (Tagalog), mulabu (Masbate).

Distribution The Philippines.

Uses The wood is used for temporary construction and cheap grades of veneer and plywood; it is also used for making canoes.

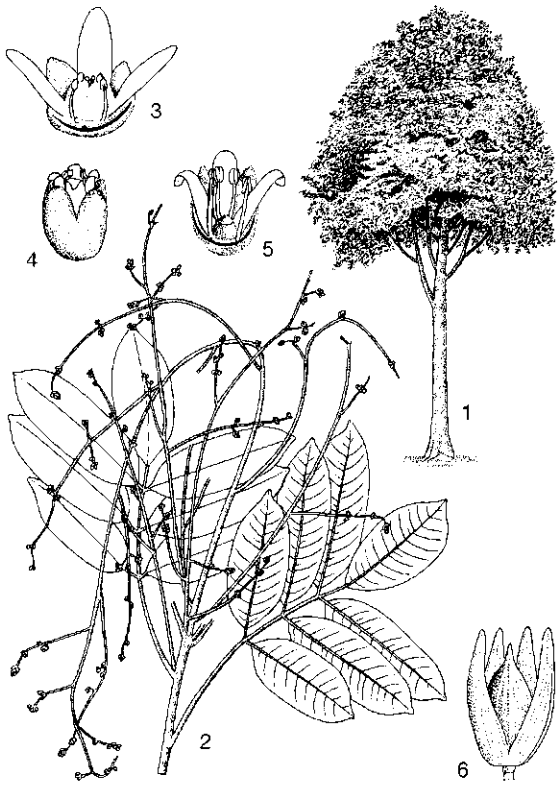
Observations A medium-sized tree up to 25 m tall, bole generally straight and regular, up to 60(–120) cm in diameter; leaves with 4–7 pairs of leaflets, leaflets asymmetrical or oblique at base, petiolules flat or convex above; flowers subsessile, petals elliptical to elliptical-oblong, up to 4 mm long, pinkish; fruit ovoid, c. 2 cm long, fruit calyx with c. 1.5 cm long tube and 5.5–10 cm long wing-like lobes, red when young and becoming brownish in ripe fruit. *P. malabog* occurs on forested slopes and rocky hills at low altitudes, also on rocky cliffs near the seashore, and is locally common. The density of the wood is 610–755 kg/m^3 at 15% moisture content.

Selected sources 125, 162, 414, 527.

Parishia paucijuga Engl.

A.DC., Monogr. phan. 4: 309, t. 10, fig. 25–27 (1883).

Vernacular names Brunei: sememdoh. Indonesia: barat daja (Batak, Sumatra). Malaysia: sepul (Peninsular).



Parishia paucijuga Engl. – 1, tree habit; 2, flowering twig; 3, opened female flower; 4, male flower; 5, opened male flower; 6, fruit.

Distribution Peninsular Malaysia, Singapore, Sumatra (Tapanuli) and Borneo (Sarawak, Brunei).

Uses The wood is used for construction, but is not very durable.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 15 m, up to 60 cm in diameter, with buttresses up to 3 m high, bark surface fissured, scaly or flaky, greyish-brown or reddish-brown; leaves with 2–3(–4) pairs of leaflets, leaflets symmetrical at base, petiolules grooved above; flowers subsessile or shortly pedicelled, petals obovate-oblong or oblong, up to 6 mm long, white; fruit ellipsoid, 4–6 cm long, pointed, fruit calyx with c. 0.5 cm long tube and 3.5–5 cm long wing-like lobes. *P. paucijuga* occurs in lowland forest up to 200(–400) m altitude, sometimes also in swamp forest. The density of the wood is 570–680 kg/m^3 at 15% moisture content.

Selected sources 104, 162, 276, 474, 705.

Parishia sericea Ridley

Kew Bull.: 201 (1933).

Vernacular names Malaysia: rengas susu, serian, upi paya (Sarawak), layang-layang (Sabah).

Distribution Borneo (Sarawak, Sabah).

Uses The wood is sometimes used but has no commercial importance.

Observations A medium-sized tree up to 25 m tall, bole up to 50 cm in diameter, with small buttresses up to 1.5 m high, bark surface scaly; leaves with 4–5(–7) pairs of leaflets, leaflets symmetrical at base, petiolules grooved above; flowers subsessile or shortly pedicelled, petals oblanceolate, c. 5 mm long; fruit ellipsoid, 5–6 cm long, pointed, fruit calyx with c. 0.8 cm long tube and short, 2–3 cm long lobes. *P. paucijuga* occurs in lowland forest, rarely up to 750 m altitude, often in mixed peat-swamp forest near the coast, but sometimes also on ultrabasic soils. The density of the wood is 620–745 kg/m^3 at 15% moisture content.

Selected sources 77, 162, 576.

E. Boer (general part),
R.H.M.J. Lemmens (general part, selection of species),
H.C. Sim (properties),
S. Noshiro (wood anatomy)

Pentace Hassk.

Hort. bogor. descr.: 110 (1858).

TILIACEAE

x = unknown

Trade groups Melunak: lightweight to medium-weight hardwood, e.g. *Pentace burmanica* Kurz, *P. laxiflora* Merr., *P. polyantha* Hassk., *P. triptera* Masters.

Melunak is sometimes traded in mixed consignments with surian batu (*Chukrasia tabularis* A.H.L. Juss.), red meranti (*Shorea* spp.) or other reddish woods.

Vernacular names Melunak: Burma mahogany (En). Brunei: kedang pinit. Indonesia: kayu pinang. Malaysia: takalis (Sabah), bary baran (Sarawak). Burma (Myanmar): thitka, thit-kashit, thit-sho. Cambodia: tassiet. Laos: sisièt. Thailand: sisiat, sisiat-pluak (central, peninsular), thongsuk (Nakhon Si Thammarat).

Origin and geographic distribution *Pentace* consists of 27 species. They are distributed in Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, western Java, Borneo, Sulawesi and the southern Philippines. The main centres of diversity are found in Peninsular Malaysia (16 species) and Borneo (12 species).

Uses The wood is used extensively for light construction such as weatherboards, decorative panelling, ceilings, beams, scantlings, furniture of good quality, and it is also highly valued for cabinet work. Other applications are for musical instruments, mathematical instruments, boat building, mouldings, flooring, handicraft, paddles and gunstocks.

The bark is used locally for house walls, or chewed together with betel nut (*Areca catechu* L.).

Production and international trade Melunak is traded in fairly large amounts from Borneo. In 1987, the export of melunak round logs from Sabah was 61 000 m^3 with a value of US$ 3.8 million, and in 1992 it was 38 000 m^3 (26% as sawn timber, 74% as logs) with a total value of US$ 3.7 million. Elsewhere, the amounts traded are only small and no trade figures are available; the wood is mainly used domestically, e.g. in Thailand. Small amounts are imported into Japan, mainly from Sabah and Sarawak, often in mixed consignments with red meranti.

Properties Melunak is a lightweight to medium-weight, sometimes heavy hardwood. The heartwood is golden brown, reddish-brown or deep red-brown, generally darkening on exposure. The sapwood is paler and more yellowish, but often not clearly demarcated from the heartwood. The density varies greatly among species, (320–)500–750(–960) kg/m^3 at 15% moisture content. The grain is usually shallowly to deeply interlocked, texture moderately fine and even; planed surfaces are lustrous and the wood has no distinctive odour or taste, radial surfaces show narrow, regular stripes.

At 16% moisture content, wood of *P. triptera* has the following mechanical properties (based on a test in Peninsular Malaysia): the modulus of rupture 85 N/mm^2, modulus of elasticity 12 000 N/mm^2, compression parallel to grain 44 N/mm^2, compression perpendicular to grain 4.5 N/mm^2, shear 11 N/mm^2, Janka side hardness 4100 N and Janka end hardness 5220 N.

The rates of shrinkage are fairly low to moderate: from green to 15% moisture content 1.4% radial and 2.5% tangential and from green to oven dry 3.5–4.2% radial and 6.5–7.6% tangential. The timber air dries rather slowly and with slight defects such as bowing, twisting and checking (slightly more degrade than in red meranti). Boards 15 mm thick take about 3.5 months to air dry, and boards

40 mm thick take about 5 months. Kiln drying is satisfactory.
The working properties vary from easy to moderately difficult, generally because of differences in density of the wood among species; the lighter wood is easier to work than the heavier wood. Generally the wood is satisfactory to work with hand and machine tools, although the interlocked grain can cause problems with tearing when radial surfaces are planed. Melunak bores, turns, nails, glues and finishes well, but tends to splinter rather easily. There is little information on slicing or rotary peeling, but a test on one billet of *P. triptera* in Peninsular Malaysia showed that 1.6 mm thick veneer can easily be obtained in continuous length without any heat treatment; the veneer was attractive and dried well without much degrade. Melunak may be suitable for decorative plywood used for high-class furniture and cabinet work, but it has also been reported that melunak is mainly used as core material for plywood. Quartered sliced veneer can be particularly decorative.
Reports on heartwood durability are variable; the wood of some species is rated as non-durable and that of others as durable, but most wood is moderately durable. In graveyard tests in Malaysia, the average service life of test stakes in contact with the ground was 2.1 years. The heartwood is difficult to treat with preservatives; in a test in Malaysia using the open tank process and an equal mixture of creosote and diesel fuel, an absorption of only 17 kg/m^3 was achieved. The sapwood is more permeable.
The chemical contents of wood of *P. floribunda* and *P. triptera* were tested in Malaysia. The wood contains 70–73% holocellulose, 46–47% α-cellulose, 28% lignin, 11–12% pentosan and 0.4–0.8% ash. The solubility of *P. floribunda* wood is 3.0% in alcohol-benzene, 5.4% in hot water and 11.5% in a 1% NaOH solution. The solubility of *P. triptera* wood is 0.6% in alcohol-benzene, 1.8% in hot water and 8.7% in a 1% NaOH solution.

Description Small to large trees up to 60 m tall; bole straight, up to 125 cm in diameter, with short to tall buttresses; bark surface shallowly fissured to scaly and flaky, grey-brown to dark brown, inner bark laminated, pink to red. Newly formed shoots, inflorescences and lower leaf surfaces covered with stellate hairs or scales. Leaves arranged spirally, simple, elliptical to ovate or slightly obovate, sometimes slightly 3-lobed, margin entire or dentate, base obtuse to cordate, palmately veined with 3(–7) main veins which are depressed above, tertiary venation usually scalariform; petiole slender, swollen at both ends; stipules early caducous. Inflorescence terminal or axillary, lax. Flowers bisexual, regular, 5-merous; sepals united in a shallow tube, densely scaly outside, with triangular lobes; petals free, spatulate, white, glabrous; stamens many, free or in 5 indistinct bundles with the filaments united at base, inner row staminodial; ovary superior, 3–10-ribbed, densely stellate-scaly, 3–10-celled, with 2 ovules in each cell, style 1, apically sometimes divided into 3–5 arms, stigma truncate. Fruit a non-dehiscent samara with 3–10 wings, 1-seeded, covered with stellate hairs, scales and/or bristles. Seed albuminous; cotyledons thick, oblong.

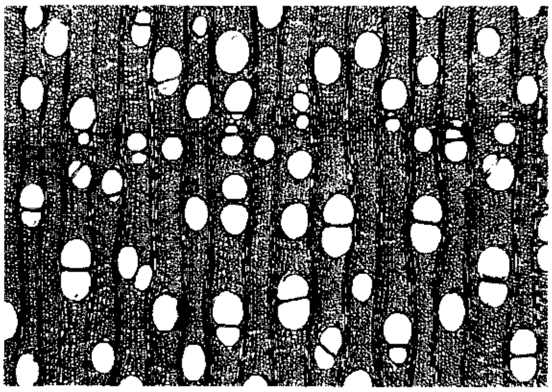
Wood anatomy

– Macroscopic characters:

Heartwood golden brown, reddish-brown or deep red-brown, darkening on exposure, not clearly distinct from the yellowish sapwood. Grain usually shallowly interlocked. Texture moderately fine and even; quartered surfaces with narrow and regular stripe figure. Growth rings distinct or indistinct, delimited by darker bands of fibres or marginal bands of parenchyma; vessels barely visible to the naked eye, tyloses occasional to infrequent but mostly absent; parenchyma difficult to see with hand lens, in fine narrow marginal bands or finely diffuse or diffuse-in-aggregates; rays not visible with the naked eye; ripple marks distinct on all surfaces.

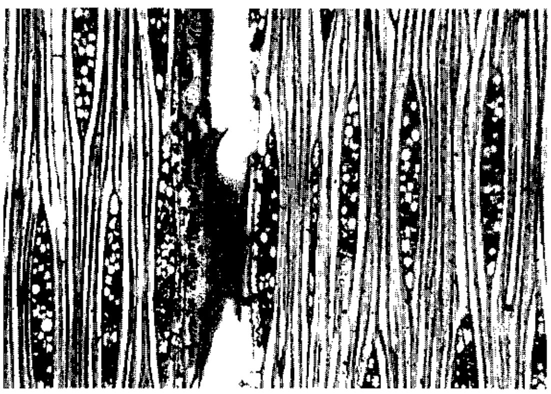
– Microscopic characters:

Growth rings distinct or indistinct, sometimes demarcated by uniseriate to biseriate bands of axial parenchyma. Vessels diffuse, mostly 9–20/mm^2, solitary and in short radial multiples (sometimes in radial multiples of 5–8 and in tangential pairs or clusters of 3–7), (100–)120–200(–250) μm in tangential diameter; perforation plates simple; intervessel pits alternate, non-vestured, circular or oval, 2–4 μm; vessel-ray pits simple or with much reduced borders, enlarged, horizontally to vertically elongated or round; thin-walled tyloses occasional to infrequent but mostly absent. Fibres 1.4–1.8 mm long, non-septate, thin-walled to thick-walled, with simple to minutely bordered pits. Axial parenchyma abundant, predominantly diffuse or diffuse-in-aggregates, paratracheal parenchyma generally narrowly vasicentric, banded parenchyma infrequent and faint but occasionally in marginal bands (irregularly zonate), in 8-celled strands. Rays 6–9/mm, 200–500 μm high (storied, sometimes rays span two tiers doubling the ray height), homocellular to heterocellular with one row of upright and/or square marginal cells,



transverse section (×25)

radial section (×75)



tangential section (×75)

Pentace burmanica

2–4(–5) cells wide. Crystals and silica bodies absent. Generally all elements storied, rays in 2–3 tiers/mm.

Species studied: *P. burmanica*, *P. curtisii*, *P. laxiflora*, *P. triptera*.

Growth and development A 33-year-old *P. triptera* tree in the arboretum of the Forest Research Institute Malaysia was 24 m tall with a clear bole of 7 m and a diameter of 36 cm, i.e. a mean annual diameter increment of 1.1 cm. The mean annual diameter increment of *P. burmanica* is reported as 1.3–1.7 cm and that of *Pentace* sp. from Sabah 0.5–1.0 cm.

The flowering to fruiting period for a single *P. strychnoidea* tree under partial shade was observed as 3–5 months; the tree flowered only once in 6 years of observation. Fruiting of *P. triptera* in Peninsular Malaysia is more frequent than that of dipterocarps (once in 2–5 years). The fruits are dispersed by wind.

Other botanical information *Pentace* is closely related to *Brownlowia*. Sterile material is difficult to ascribe to either of the genera. The two genera differ in fruit characters, *Pentace* having winged, wind-dispersed fruits and *Brownlowia* having wingless water-dispersed fruits.

Pentace and *Pentacme* (a synonym of *Shorea*) are sometimes confused with each other.

Ecology Melunak is usually fairly common but scattered in primary evergreen lowland or hill rain forest in well-drained locations such as hill slopes, ridges, or near small streams, up to 1000 m altitude. Melunak trees are generally shade-loving trees persisting under heavy shade for years. *P. rigida*, found in Sarawak, is probably a light-demanding species, however. Occasionally, menulak is found as a pioneer in fire breaks. Some species prefer limestone, sandstone or podzolic soils, whereas others are also found in seasonal swamps.

Propagation and planting For Peninsular Malaysia the following data are available on the propagation of melunak (mainly *P. triptera*). Seeds lose their viability in less than one week and germination starts in a few days. Fresh, ripe fruits have red to reddish-brown wings; pale-coloured wings indicate immaturity. Fruits should be sown with one wing vertical, the seed just in the soil and the other two wings buried.

Seedlings a few months old have been planted very successfully. Small trials where wildlings were planted under the shade of secondary vegetation showed 68% and 54% success, respectively, in two different blocks. Natural regeneration is generally good, and dense carpets of seedlings can be found under mother trees, presumably because of inefficient seed dispersal. Wildlings can easily be collected from these spots. No plantations of *Pentace* spp. have been established.

Silviculture and management Sudden exposure to more light, as in large openings, does not harm established seedlings. Fairly large stumps of *P. rigida* coppice freely. In Peninsular Malaysia, *P. triptera* is among the specially desired species in regenerating forest, and 5–15 years after logging it should be freed from competition if it has leaders in the canopy.

Harvesting Logs are generally free from defects. The amount of bark peeled from living trees for chewing should not exceed two stripes of 10 cm wide for a tree of about 50 cm diameter.

Yield The standing stock of melunak in forests in Burma (Myanmar) is estimated as about 25 m^3 of wood per ha. The standing stock of melunak in various forests in East Kalimantan varies between 8.6 and 53.3 m^3/ha.

Handling after harvest The ends of logs should be treated with tar. Bark should be kept dry. It is often traded on markets together with the bark of *Lithocarpus*, *Quercus* and *Shorea* spp.

Genetic resources Melunak trees do not seem to be at immediate risk of genetic erosion, except perhaps for some rare species. Logging of melunak trees on a larger scale is only practised locally in Borneo.

Prospects Melunak may be promising for enrichment planting in selectively logged forest. The wood can be used for various purposes and the trees are often fairly rapid growers. However, more research is needed on propagation and silviculture.

Literature |**1**| All Nippon Checkers Corporation, 1989. Illustrated commercial foreign woods in Japan. Tokyo. p. 139. |**2**| Barnard, R.C., 1956. A manual of Malayan silviculture for inland lowland forests. Research Pamphlet No 14. Forest Research Institute, Kepong, Selangor. 199 pp. |**3**| Browne, F.G., 1955. Forest trees of Sarawak and Brunei and their products. Government Printing Office, Kuching. pp. 345–346. |**4**| Ho, K.S., 1983. Malaysian timbers – melunak. Malaysian Forest Service Trade Leaflet No 80. Malaysian Timber Industry Board, Kuala Lumpur. 6 pp. |**5**| Kochummen, K.M., 1983. Tiliaceae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. A manual for foresters. 2nd edition. Forest Research Institute Malaysia. Vol. 2. Longman Malaysia SDN. Berhad, Kuala Lumpur. pp. 392–412. |**6**| Kostermans, A.J.G.H., 1964. A monograph on the genus Pentace Hassk. (Tiliaceae). Pengumuman Lembaga Penelitian Hutan No 87. 78 pp. |**7**| Lee, Y.H. & Chu, Y.P., 1965. The strength properties of Malayan timbers. Malayan Forester 28(4): 307–319. |**8**| Malaysian Timber Industry Board, 1986. 100 Malaysian timbers. Kuala Lumpur. pp. 158–159. |**9**| Phengklai, C., 1986. Study in Thai flora, Tiliaceae. Thai Forest Bulletin, Botany 16: 71–75. |**10**| Research Institute of Wood Industry, 1988. Identification, properties and uses of some Southeast Asian woods. Chinese Academy of Forestry, Wan Shou Shan, Beijing & International Tropical Timber Organization, Yokohama. p. 192.

Selection of species

Pentace adenophora Kosterm.

Reinwardtia 5: 238 (1960).

Vernacular names Malaysia: melunak (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as melunak.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 70 cm in diameter, with buttresses up to 2 m high, bark surface fissured and scaly, dark brown, inner bark fibrous to slightly laminated, pink to red-brown; leaves suborbicular to broadly ovate, 9–20 cm × 7.5–17 cm, margin toothed to crenulate, glandular, apex rounded to emarginate, lower surface densely stellate-scaly or hairy, with 6–8 basal veins and 3–4 pairs of lateral veins, petiole 4–9 cm long; flowers densely stellate-pilose, petals 6–10 mm long; fruit 5-winged, wings 3.5–6 cm × 2–3 cm. *P. adenophora* is found in lowland forest in swampy or undulating country.

Selected sources 77, 313, 315, 705.

Pentace burmanica Kurz

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 40(2): 47 (1871).

Vernacular names Burma mahogany (En). Burma (Myanmar): thitka, thit-kashit, thit-so. Cambodia: sisiět. Thailand: sisiat, sisiat-pluak (central, peninsular), sisiat-om (north-eastern).

Distribution Burma (Myanmar), Indo-China (Cambodia) and Thailand.

Uses The wood is used for furniture and cabinet work, boat building and other decorative purposes. The bark is chewed with betel nut.

Observations A medium-sized to fairly large tree up to 40 m tall, bole straight, up to 100 cm in diameter, bark surface shallowly fissured to scaly and flaky, dark greyish-brown; leaves elliptical to ovate or subobovate, 10–15 cm × 5–7 cm, margin entire or sinuate near apex, apex acute to acuminate, lower surface densely stellate-hairy, with c. 5 pairs of secondary veins, lower pair basal, petiole 1.5–2 cm long; flowers densely stellate-pilose, petals c. 6 mm long; fruit 5-winged, wings 4 cm × 2 cm. *P. burmanica* is found in lowland evergreen forest up to 300 m altitude. The density of the wood is 640–705 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 171, 315, 336, 380, 496, 526, 595.

Pentace corneri Kosterm.

Pengum. Lemb. Penel. Hutan 87: 25 (1964).

Distribution Peninsular Malaysia (rare) and Borneo (Sarawak, Brunei, Kalimantan).

Uses The wood is reputed to be used as melunak. The fibrous bark is used for house walls.

Observations A large tree up to 50 m tall, bole up to 95 cm in diameter, with buttresses up to 2 m high, bark surface flaky or papery scaly, brown, inner bark laminated, pink; leaves suborbicular to broadly ovate, 4.5–11 cm × 4.5–9 cm, margin entire, apex shortly acuminate to rounded, lower surface densely scaly and hairy on the main veins, with c. 7 basal veins and 2 pairs of lateral veins, petiole 2–4 cm long; flowers densely stellate-pilose, petals 5 mm long; fruit 5-winged, wings c. 2 cm × 1 cm. *P. corneri* has been found in hill forest and near small streams, at low altitude.

Selected sources 315, 705.

Pentace curtisii King

Journ. As. Soc. Beng. 60: 103 (1891).

Vernacular names Malaysia: melunak bukit, seraya pulau (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as melunak.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 95 cm in diameter, with buttresses up to 2 m high, bark surface shallowly fissured becoming flaky, yellow to grey-brown, inner bark orange-brown to red-brown; leaves ovate to elliptical, 8–15 cm × 4.8–5.5 cm, margin entire, apex acute to broadly acuminate, lower surface densely fimbriate-scaly, with 3 basal veins and 1–2 pairs of lateral veins, petiole 2–4 cm long; flowers stellate-pilose, petals 4 mm long, styles coherent; fruit 10-winged, c. 1.2 cm × 1.2 cm. *P. curtisii* is a fairly common tree of dipterocarp hill forest, and in Peninsular Malaysia it has been found in association with *Shorea platyclados* v. Slooten ex Foxw.

Selected sources 78, 315, 705, 734.

Pentace discolor Merr.

Univ. Calif. Publ. Bot. 15: 187 (1929).

Vernacular names Malaysia: takalis (Malay, Sabah)

Distribution Borneo (Sabah).

Uses The wood is reputed to be used as melunak.

Observations A medium-sized tree with bole up to 60 cm in diameter, with fluted buttresses up to 2 m high, bark surface scaly; leaves obovate-elliptical, 8–13(–32) cm × 5–8(–17) cm, margin glandular, apex truncate with a short mucro, lower surface densely stellate-scaly, with 5 basal veins and 3 pairs of lateral veins, petiole 2–4(–6) cm long; flowers densely stellate-hairy, petals 4 mm long, styles coherent; fruit 5-winged, 12 mm long and up to 18 mm in diameter. *P. discolor* is locally common at low altitude.

Selected sources 77, 315.

Pentace erectinervia Kosterm.

Pengum. Lemb. Penel. Hutan 87: 24 (1964).

Vernacular names Malaysia: takalis (Sabah).

Distribution Borneo (Sabah, Kalimantan).

Uses The wood is used as melunak, and is especially valued for construction purposes.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 100 cm in diameter, with buttresses up to 1.6 m high, bark surface obscurely fissured, peeling off, brown, inner bark laminated, fleshy red; leaves obovate-elliptical to elliptical, 6–11 cm × 3–6 cm, margin vaguely serrate towards the apex, apex acuminate, lower surface densely fimbriate-scaly, with 3–5 basal veins and 5 pairs of lateral veins, petiole 1–2 cm long; flowers densely stellate-pilose and scaly, style 1; fruit unknown. *P. erectinervia* is a still imperfectly known species, probably providing most of the melunak timber in Sabah. The density of the wood is 655–800 kg/m^3 at 15% moisture content.

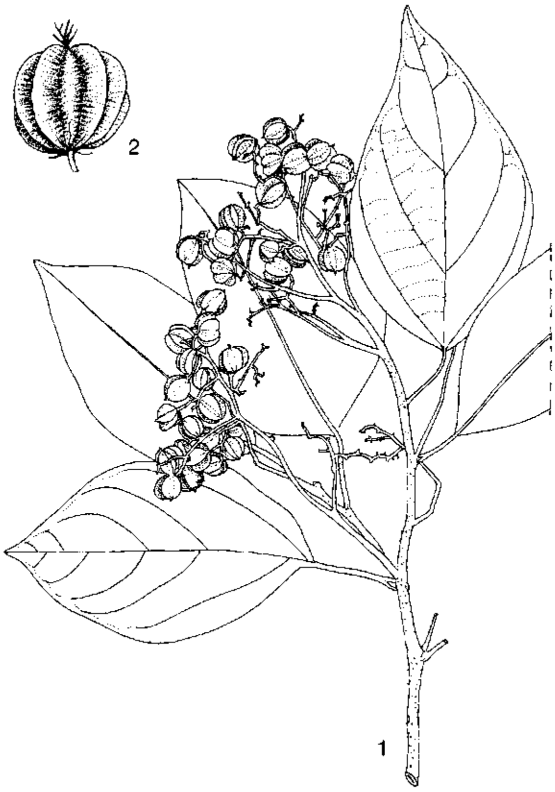
Selected sources 77, 315.

Pentace excelsa Kochummen

Gard. Bull. Sing. 26: 59 (1972).

Vernacular names Malaysia: melunak (Peninsular).

Distribution Peninsular Malaysia.



Pentace excelsa Kochummen – 1, fruiting twig; 2, fruit.

Uses The wood is reputed to be used as melunak.

Observations A large to very large tree up to 60 m tall, bole up to 125 cm in diameter, bark surface with distant loose scales, pale brown, inner bark deep brown; leaves elliptical to elliptical-ovate, (5–)8.5–15 cm × (2.5–)6–11.5 cm, margin entire, apex acuminate, lower surface densely grey-scaly, with 3 basal veins and 3 pairs of lateral veins, petiole 2.7–4.5 cm long; flowers densely scaly, petals 4 mm long, styles 7, free; fruit 7-winged, 1.2 cm × 1.2 cm. *P. excelsa* is uncommon but occurs locally frequently.

Selected sources 301, 705.

Pentace eximia King

Journ. As. Soc. Beng. 60: 103 (1891).

Vernacular names Malaysia: medang lusa (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as melunak, e.g. formerly for house building.

Observations A small to medium-sized tree up to 20(–30) m tall, bole up to 50 cm in diameter, bark surface smooth to shallowly fissured and scaly, dark grey; leaves ovate to elliptical, 5.5–14 cm × 3.5–10 cm, margin entire, apex acuminate, lower surface densely fimbriate-scaly, with 3 basal veins and c. 2 pairs of lateral veins, petiole 2–4 cm long; flowers scaly and stellate-pilose, small, styles 10, free; fruit 8–10-winged, c. 1 cm in diameter. *P. eximia* is rare and usually occurs on coastal hills.

Selected sources 78, 315, 705.

Pentace floribunda King

Journ. As. Soc. Beng. 60: 102 (1891).

Vernacular names Thailand: thongsuk (Nakhon Si Thammarat), thongsuk-dam, simon, ngonkai (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo (eastern Kalimantan).

Uses The wood is reputed to be used as melunak.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, with steep buttresses up to 5 m high, bark surface fissured, dark red-brown, inner bark mottled and laminated, red-brown with orange streaks; leaves elliptical to ovate-elliptical, 6–23 cm × 3–12 cm, margin toothed in the apical part, apex acuminate, lower surface densely fimbriate-scaly, drying dark brown, with 3 basal veins and 2(–3) pairs of lateral veins, petiole 1.2–3.5 cm long; flowers densely scaly, petals 2.5 mm long, styles coherent; fruit 10-winged, 1.5–2 cm across. *P. floribunda* is uncommon in evergreen forest, up to 600 m altitude.

Selected sources 294, 315, 496, 705.

Pentace hirtula Ridley

Fl. Mal. Pen. 1: 295 (1922).

Distribution Peninsular Malaysia, Sumatra (Siberut Island and Bengkulu) and Borneo (Sarawak).

Uses The wood is reputed to be used as melunak.

Observations A medium-sized to fairly large tree up to 37 m tall, bole up to 75 cm in diameter, with buttresses up to 2 m high, bark surface smooth, mottled pink-brown and grey, inner bark red; leaves elliptical to broadly elliptical, 4–15 (–18) cm × 2.5–7 cm, margin shallowly sinuate in the apical part, apex distinctly acuminate, lower surface densely long-fimbriate scaly and besides stellate-hairy on the main veins, with 3 basal veins and 2–5 pairs of lateral veins, petiole 1–3 cm long; flowers densely stellate-scaly, petals 2.5–3 mm long, styles coherent; fruit 8–10-winged, 8–12 mm in diameter. *P. hirtula* is an uncommon species, found up to 900 m altitude.

Selected sources 315, 705.

Pentace laxiflora Merr.

Philipp. Journ. Sci., Bot. 30: 82 (1926).

Vernacular names Indonesia: kelembing (Punan Dayak, Kalimantan), mooi (Kenyah Dayak, Kalimantan), pose (Malay Dayak, Kalimantan). Malaysia: takalis (Sabah).

Distribution Borneo.

Uses *P. laxiflora* is an important source of melunak wood; the wood is valued for construction purposes, and sometimes used as a substitute for red meranti.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 17 m, up to 70 cm in diameter, with buttresses up to 3 m high, bark surface narrowly fissured, rusty or dark brown, inner bark fibrous, rusty to orange-brown; leaves lanceolate to lanceolate-ovate, (4–)6–8(–10) cm × (1–)1.5–2.5 cm, margin entire, apex long-acuminate, lower surface densely fimbriate-scaly, with 3 basal veins and 3(–4) pairs of lateral veins, petiole up to 0.5 cm long; flowers densely stellate-tomentulose, styles coherent; fruit 5-winged, 1–1.5 cm × 0.5–0.8 cm. *P. laxiflora* is common in lowland and hill forest, also in seasonal swamps. The shape of the bole is described as poor but also as regular.

Selected sources 77, 315.

Pentace macrophylla King

Journ. As. Soc. Beng. 60: 102 (1891).

Vernacular names Malaysia: melunak, kempayang hantu (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is used as melunak.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 55 cm in diameter, with buttresses up to 1 m high, bark surface shallowly fissured and scaly, brown to greyish, inner bark yellow and pink; leaves broadly elliptical to orbicular, 19–32 cm × 12–21 cm, margin entire, apex rounded to shortly abruptly acuminate, lower surface densely fimbriate-scaly, with 3 basal veins and 3–4 pairs of lateral veins, petiole 5–8 cm long; flowers densely stellate-scaly, styles coherent; fruit 10-winged, globose, c. 2 cm in diameter. *P. macrophylla* is rare but occurs locally abundantly in lowland and hill forest.

Selected sources 315, 705, 734.

Pentace microlepidota Kosterm.

Reinwardtia 5: 236 (1960).

Vernacular names Malaysia: melunak (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as melunak.

Observations A large to very large tree up to 60 m tall, bole up to 80 cm in diameter, with buttresses up to 5 m high, bark surface smooth to scaly and with lenticels in vertical rows, ochre, inner bark pink; leaves orbicular to broadly ovate, 15–20 cm × 10–22 cm, margin toothed, apex truncate to shortly pointed, lower surface laxly silvery scaly, with 5(–7) basal veins and 3 pairs of lateral veins, petiole 8–14 cm long; infructescence stellate-scaly; fruit 5-winged, c. 3 cm × 4 cm. *P. microlepidota* is rare and occurs in lowland and hill forest.

Selected sources 313, 315, 705.

Pentace polyantha Hassk.

Hort. bogor. descr.: 110 (1858).

Vernacular names Indonesia: ki segeung, ki sinduk (Sundanese, Java), malam salar (Bassap-Dayak, Kalimantan).

Distribution Sumatra, western Java and Borneo; possibly also in Sulawesi.

Uses *P. polyantha* is an important source of melunak wood; the wood is used for house and bridge building.

Observations A medium-sized to fairly large tree up to 40 m tall, bole long, cylindrical, up to 150 cm in diameter, bark surface fissured, greyish-brown to dark red, inner bark reddish; leaves ovate to elliptical, (8–)10–18 cm × (4–)5–8 cm, margin entire, apex shortly bluntly acuminate, lower surface densely silvery stellate-scaly, with 5 basal veins and 4–5 pairs of lateral veins, petiole 2–4 cm long; flowers stellate-pilose and stellate-scaly, petals up to 4 mm long, styles coherent; fruit 5-winged, with wings up to 20 mm × 12 mm. *P. polyantha* is fairly common in evergreen rain forest, up to 1000 m altitude. The density of the wood is 590–870 kg/m^3 at 15% moisture content.

Selected sources 78, 234, 303, 315, 474.

Pentace rigida Kosterm.

Pengum. Lemb. Penel. Hutan 87: 22 (1964).

Vernacular names Malaysia: baruh baran, baran bukit (Sarawak).

Distribution Borneo (Brunei, Sarawak and western Kalimantan).

Uses The wood is used as melunak, e.g. for boat building.

Observations A medium-sized tree up to 33 m tall, bole up to 45 cm in diameter, with steep buttresses up to 1 m high, bark surface cracking longitudinally and flaking, brown, inner bark reddish-brown; leaves broadly elliptical to suborbicular or ovate-orbicular, 5–12 cm × 5–9 cm, margin shallowly toothed in the apical part, apex abruptly acuminate, lower surface densely stellate-scaly, with 5(–7) basal veins and 1–3 pairs of lateral veins, petiole 1.5–6 cm long; flowers densely scaly, petals 5–6 mm long, styles coherent; fruit 5-winged, wings up to 5 cm × 2.5 cm. *P. rigida* occurs in well-drained lowland forest, mainly on podzolic soils, up to 200 m altitude.

Selected sources 69, 315.

Pentace strychnoidea King

Journ. As. Soc. Beng. 60: 105 (1891).

Vernacular names Malaysia: melunak (Peninsular).

Distribution Peninsular Malaysia.

Uses The wood is reputed to be used as melunak.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, with buttresses up to 2 m high, bark surface smooth to cracking or fissured, grey-brown to dark brown, inner bark orange-brown to red-brown; leaves broadly ovate to broadly elliptical, rarely obovate or elliptical, 5.5–14 cm × 2.5–9 cm, margin entire, apex conspicuously acuminate, lower surface glabrous except for a few small scales, with 3 basal veins and without lateral veins (sometimes with 1 pair), petiole 1–2.5 cm long; flowers fimbriate-scaly, petals 4 mm long, styles coherent; fruit 10-winged, 1.8 cm long and broad. *P. strychnoidea* occurs in lowland and hill forest, up to at least 500 m altitude.

Selected sources 315, 410, 705.

Pentace subintegra (Merr.) Burret

Notizbl. Bot. Gart. Berlin 9: 620, 814 (1926).

Synonyms *Columbia subintegra* Merr. (1915).

Distribution The Philippines (Mindanao).

Uses The wood is reputed to be used as melunak.

Observations A medium-sized to fairly large tree up to 35 m tall; leaves ovate to ovate-oblong, 14–17 cm × 7–10 cm, margin entire, apex acuminate, lower surface glabrous, with 3 basal veins and 5–7 pairs of lateral veins, petiole 2–2.5 cm long; inflorescence stellate-hairy; fruit 5-winged, 2–2.5 cm in diameter. *P. subintegra* is rather uncommon.

Selected sources 315.

Pentace sumatrana Kosterm.

Pengum. Lemb. Penel. Hutan 87: 44 (1964).

Distribution Western Sumatra.

Uses The wood is used as melunak.

Observations A medium-sized to fairly large tree up to 38 m tall, bole up to 70 cm in diameter, with buttresses up to 1 m high, bark surface dark brown, inner bark red; leaves lanceolate, 5–9 cm × 2–3 cm, margin entire, apex gradually acuminate, lower surface densely set with entire scales, with 3 basal veins and 2(–3) pairs of lateral veins, petiole up to 1.5 cm long; flowers and fruits unknown. *P. sumatrana* is still imperfectly known. The wood is highly esteemed because of its strength.

Selected sources 315.

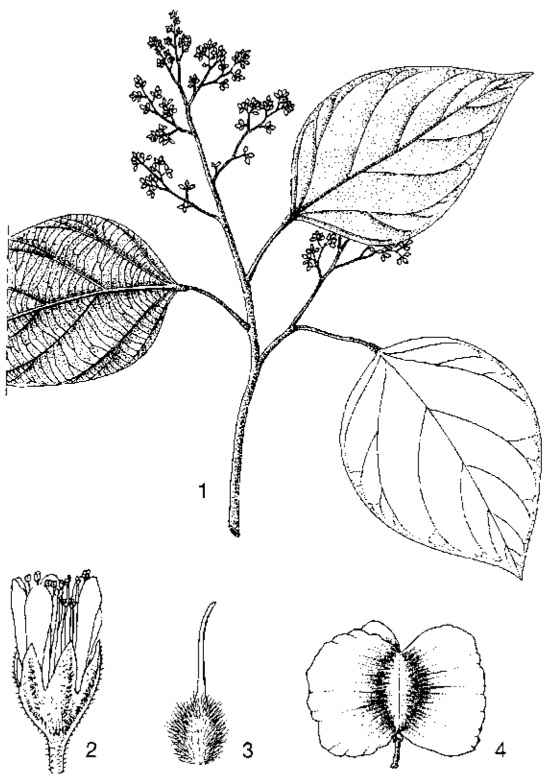
Pentace triptera Masters

Hook.f., Fl. Brit. India 1: 382 (1874).

Vernacular names Malaysia: melunak pusat beludu, janda baik, balong ayam (Peninsular). Thailand: luatnok (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses *P. triptera* is an important source of melu-



Pentace triptera Masters – 1, flowering twig; 2, flower; 3, pistil; 4, fruit.

nak wood. The bark has been used for walls of houses.

Observations A medium-sized to large tree up to 45 m tall, bole up to 110 cm in diameter, with buttresses up to 2.5 m high, bark surface flaky, grey-brown to reddish-brown, inner bark pinkish to red; leaves elliptical to ovate-elliptical, 6–16 cm × 3–9 cm, margin entire or coarsely serrate towards the apex, lower surface densely silvery fimbriate-scaly with additional fringed scales, with 3(–5) basal veins and 4–6 pairs of lateral veins, petiole 1–3.5 cm long; flowers stellate-pilose and stellate-scaly, petals c. 2.5 mm long, styles coherent; fruit 3-winged, up to 2 cm × 3.5 cm. *P. triptera* occurs in evergreen forest, also in seasonal swamp areas, up to 400 m altitude. The timber is highly valued. See also the table on wood properties.

Selected sources 47, 77, 78, 237, 294, 315, 363, 466, 496, 595, 705, 734.

C. Phengklai (general part),
R.B. Miller (properties, wood anatomy),
M.S.M. Sosef (selection of species)

Pentaspadon Hook.f.

Trans. Linn. Soc. Lond. 23: 168 (1860).
ANACARDIACEAE
x = unknown; $2n$ = unknown

Trade groups Pelajau: lightweight to medium-weight hardwood, *Pentaspadon motleyi* Hook.f. and *P. velutinus* Hook.f.

Vernacular names Pelajau. Indonesia: pelaju. Malaysia: pelong (Peninsular), plajau (Sarawak), empelanjau (Dayak, Sabah). Thailand: toei-na (Satun), oei-nam (Ranong). Vietnam: vi h[uf]ng trung.

Origin and geographic distribution *Pentaspadon* consists of 6 species, and is found in Vietnam, Thailand, Peninsular Malaysia, Sumatra, Borneo, the Moluccas, New Guinea and the Solomon Islands. Within the Malesian area 3 species occur; 2 species (*P. motleyi* and *P. velutinus*) are large timber trees, the third one (*P. curtisii* (King) Corner) is a small tree with a small area of distribution (peninsular Thailand and Langkawi).

Uses The timber is used for flooring, interior construction, house posts, panelling, partitioning, mouldings, skirtings, planking, fence posts, plywood, boxes and crates, and artifacts. Because of its poor durability, all applications should be under cover. The timber is regarded as suitable for picture frames and veneer.

An oil can be obtained from the trunk. It is called 'minyak plang' in Peninsular Malaysia and 'minyak pelanjau' in Borneo. This black resin and its sediment are used against skin eruptions. The fruits of *P. motleyi* are edible after boiling, and the seeds can be eaten raw or boiled and are regarded as a delicacy in Borneo. An oil can be extracted from the seeds and sprinkled over food. The seed are also used as marbles for children's games.

Production and international trade Pelajau has no real commercial importance and no statistics are available on production and trade. The timber is usually traded in mixed consignments of light hardwood.

Properties Pelajau is a lightweight to medium-weight and moderately hard wood. The heartwood is whitish-yellow or yellow-green to pale grey-pink and often indistinctly demarcated from the sapwood (greenish-white to pale yellow with a pink tinge). The density is 485–825 kg/m^3 at 15% moisture content. The grain is straight to shallowly interlocked, texture moderately fine and even.

At 12% moisture content, wood of *P. velutinus* from Thailand has the following mechanical properties: the modulus of rupture c. 81.5 N/mm^2, modulus of elasticity 8250 N/mm^2, compression parallel to grain 38 N/mm^2, compression perpendicular to grain 8 N/mm^2, shear 17 N/mm^2, and Janka side hardness 4115 N.

The rates of shrinkage are fairly low to moderately high: from green to 15% moisture content 1.0–2.0% radial and 1.9–4.3% tangential and from green to oven dry c. 4.0% radial and 6.7% tangential. The timber air dries rather slowly, usually without serious defects, although slight checking and end splitting may occur. The sapwood is susceptible to staining during drying. Boards 12.5 mm thick take about 3 months to air dry, boards 25 mm thick 3.5–5 months.

Pelajau is easy to work. It saws comparatively easily, although some gumming up of saw teeth may occur. The wood is easy to plane, bore and turn, giving a smooth finish, except for some picking up of grain on radial surfaces. The nailing properties are rated as poor.

The wood is rated as only moderately durable. Graveyard tests in Malaysia showed an average service life in contact with the ground of 2.5 years. Pelajau should not be used in contact with the ground or in exposed conditions in the tropics. It is susceptible to attack by termites and powder-post beetles. The heartwood is very difficult to treat with preservatives, even when using a pressure treatment. It absorbs up to 7 kg/m^3 using the open tank method and an equal mixture of creosote and diesel fuel. However, sapwood absorbs preservatives very well.

The wood has allergenic properties. Medicinal application of the black resin should be done with caution as it may cause severe irritation of the skin, which may be worse than the actual disease.

Description Usually large, deciduous trees up to 50(–60) m tall; bole straight, cylindrical, branchless for up to 20(–25) m, up to 85 cm in diameter, distinctly buttressed with narrow buttresses up to 5 m high; bark surface smooth to rough or scaly and lenticellate, brown to grey or grey-green, inner bark pink or reddish, with little white latex; crown feathery, completely covered by flowers when flowering. Leaves arranged spirally, crowded towards the end of twigs, imparipinnate, about 10–30 cm long; leaflets opposite to subopposite, entire, often with hairy domatia below. Inflorescence axillary, paniculate; bracts and bracteoles caducous. Flowers actinomorphic, bisexual, 5-merous, fragrant, white or pink or red; calyx lobed; petals imbricate, papillose on both surfaces; stamens 5, opposite the calyx lobes and alternating with 5 staminodes, filaments papillose, anthers basi- or dorsifixed; disk intrastaminal, short-cupular, 10-grooved or wavy outside; pistil consisting of only a single carpel, ovary superior, 1-celled, with a single ovule attached to the side of the cell, hairy, style short, stigma subglobose or slightly 2-lobed. Fruit a drupe, 1-celled, green to purplish, later black, endocarp thin. Seed with testa free from endocarp. Seedling with epigeal germination; cotyledons free, fleshy; first 2 leaves opposite, trifoliolate, subsequent leaves arranged spirally.

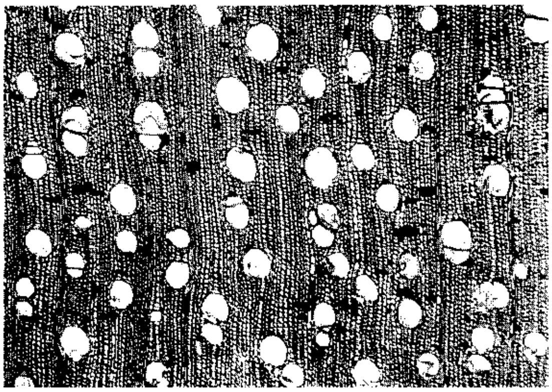
Wood anatomy

– Macroscopic characters:

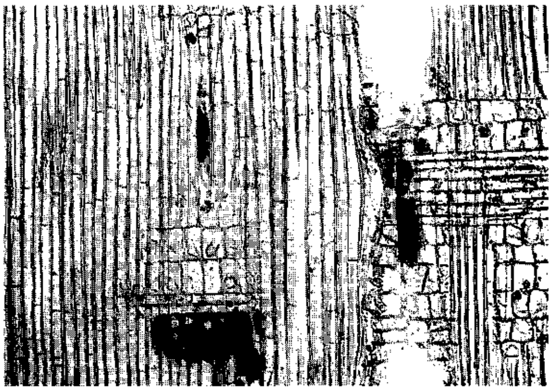
Heartwood pale pinkish-brown to creamy grey, sometimes greenish-grey, not always clearly demarcated from the pale yellow sapwood, sometimes with a pinkish tinge. Grain straight to shallowly interlocked. Texture moderately fine and even; wood somewhat lustrous, without appreciable figure. Growth rings not evident; vessels small and indistinct to the naked eye, evenly distributed; parenchyma sparse, paratracheal, widely spaced irregular bands of parenchyma rare; rays fine, barely discernible to the naked eye as individual rays; ripple marks absent, although rays may show a wavy tendency horizontally.

– Microscopic characters:

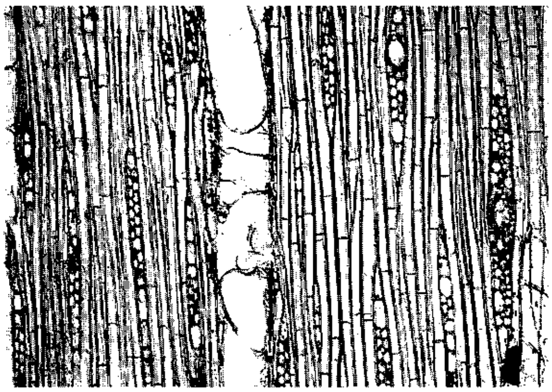
Growth rings inconspicuous or absent. Vessels dif-



transverse section (×25)



radial section (×75)



tangential section (×75)

Pentaspadon motleyi

fuse, 7–10/mm², solitary (c. 80%) and in radial multiples of 2–3, mostly circular to oval, average tangential diameter 140–160 μm; perforations simple; intervessel pits alternate, rounded to polygonal, 8–9 μm in diameter; vessel-ray pits with much reduced borders, rounded to elongated; helical thickenings absent; tyloses present but not abundant. Fibres c. 1.4 mm long, septate, moderately thin-walled, with inconspicuous simple to minutely bordered pits, mainly confined to the radial walls. Parenchyma scanty paratracheal, in 2–4-celled strands. Rays 4–7/mm, 2–3(–4)-seriate, 400–600 μm high, heterocellular with 1–4 rows of square and upright cells (Kribs type heterogeneous II). Large prismatic crystals present, mainly in marginal ray cells. Silica absent. Horizontal intercellular canals present, sometimes 2 in a single ray.

Species studied: *P. motleyi*, *P. velutinus*.

Although the wood of *Canarium* spp. is generally distinctly pink with extraneous material in the rays, it may show considerable similarity to the wood of *Pentaspadon*.

Growth and development Two 24-year-old *P. motleyi* trees in the arboretum of the Forest Research Institute Malaysia were 24 m tall and had a bole branchless for 5.5 m with a diameter at breast height of 43 cm, indicating a mean annual diameter increment of almost 2 cm.

Leaflets of seedlings are coarsely toothed, later ones entire. Leaves fall after spells of dry weather and flowering occurs together with the development of new leaves and can be once or twice in a year. The crown of the tree may be covered with inflorescences. Growth is in flushes. The architectural model of the tree is that of Fagerlind: it is determined by a monopodial, orthotropic and episodically growing trunk with indefinite growth of the trunk meristem and producing tiers of sympodial and plagiotropic branches.

Other botanical information The genus *Pentaspadon* belongs to the tribe *Rhoeae*, together with e.g. the genera *Campnosperma*, *Parishia*, *Pistacia* and *Rhus*. Within the family, *Pentaspadon* is characterized by the combination of compound leaves with hairy domatia, 5 fertile and 5 sterile stamens, and a 1-celled ovary.

Ecology Species of *Pentaspadon* usually occur scattered but sometimes co-dominant in primary, or sometimes secondary lowland rain forest, on flat to undulating land, up to 350 m altitude. Although the trees are deciduous, they are found in the humid zone, preferring riparian habitats or seasonally inundated places and swamp forest. They avoid peat soils. In Jambi, Sumatra, pelajau occurs in dipterocarp forest on red-yellow podzolic and lithosol soil types and receiving an average annual rainfall of 2400–2900 mm.

Propagation and planting The germination of fresh fruits of *P. motleyi* was 85% in 12–25 days. No commercial planting has been attempted.

Silviculture and management Natural forest management systems, such as selective felling systems, are also applicable to forests from which pelajau timber is harvested.

Harvesting Logs often show a central zone of spongy heart or heart-rot. The black oily resin is tapped in the same way as dammar is collected from *Dipterocarpaceae* species, i.e. by making a deep cavity in the trunk sloping downwards to the centre of the tree. The cavity is burned to promote the flow of the resin.

Yield The standing stock of pelajau is generally small. In a dipterocarp forest in Sumatra it amounts to 1.5 m^3, 2.0 m^3 and 3.3 m^3 per ha for trees with a diameter of over 60 cm, 50 cm and 35 cm, respectively.

Handling after harvest Logs usually float in water and can thus be transported by river.

Genetic resources Pelajau trees are usually found scattered in lowland forest. There is no indication that they are overexploited and becoming rare or endangered.

Prospects Pelajau timber is not in great demand, but it is sometimes used as a substitute for meranti which is, however, usually preferred. Although very little is known about silviculture, planting and propagation, prospects for the use of pelajau in timber plantations do not seem to be good.

Literature |1| Beaman, J.H., 1986. Allergenic Asian Anacardiaceae. Clinics in Dermatology 4(3): 191–203. |2| Browne, F.G., 1955. Forest trees of Sarawak and Brunei and their products. Government Printing Office, Kuching. pp. 52–53. |3| Burgess, P.F., 1966. Timbers of Sabah. Sabah Forest Records No 6. Forest Department Sabah, Sandakan. pp. 30–32. |4| Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd Edition. Vol. 1. Malayan Nature Society, Kuala Lumpur. pp. 122–123. |5| Desch, H.E., 1941. Manual of Malayan timbers. Malayan Forest Records No 15. Vol. 1. Federated Malay States Government, Kuala Lumpur. pp. 15–17. |6| Hou, D., 1978. Anacardiaceae. In: van Steenis, C.G.G.J. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Ser. 1, Vol. 8. Wolters-Noordhoff, Groningen. pp. 395–548. |7| Kochummen, K.M., 1989. Anacardiaceae. In: Ng, F.S.P. (Editor): Tree flora of Malaya. A manual for foresters. Vol. 4. Forest Research Institute Malaysia. Longman Malaysia SDN. Berhad, Petaling Jaya. pp. 9–57. |8| Malaysian Timber Industry Board, 1986. 100 Malaysian timbers. Kuala Lumpur. pp. 178–179. |9| Ng, F.S.P., 1991. Manual of forest fruits, seeds and seedlings. Vol. 1. Malayan Forest Record No 34. Forest Research Institute Malaysia, Kepong. pp. 18, 108–109. |10| Research Institute of Wood Industry, 1988. Identification, properties and uses of some Southeast Asian woods. Chinese Academy of Forestry, Beijing & International Tropical Timber Organization, Yokohama. p. 8.

Selection of species

Pentaspadon motleyi Hook.f.

Trans. Linn. Soc. Lond. 23: 168 (1860).

Synonyms *Pentaspadon officinalis* Holmes ex King (1896), *Pentaspadon moszkowskii* Laut. (1920), *Pentaspadon minutiflora* B.L. Burtt (1935).

Vernacular names Indonesia: plajau (Sumatra), kedondong (Dayak, Kalimantan), pilajau (Malay, Kalimantan). Malaysia: white pelong tree, pelong licin (Peninsular), empelanjau (Dayak, Sabah).

Distribution Peninsular Malaysia, Sumatra, Borneo, the Moluccas, New Guinea and the Solomon Islands.

Uses The wood is used as pelajau. The irritant oil is used medicinally against skin eruptions. The ripe seeds are eaten raw or boiled. The fruits are edible after boiling.

Observations A large tree up to 50 m tall, bole branchless for up to 20 m, up to 70 cm in diameter, with buttresses up to 5 m high, bark surface dippled to scaly, lenticellate, brown to grey-brown or grey-white, inner bark pink; leaflets glabrous below; inflorescence rachis flattened in the lower half, flowers white; fruit ovoid to ovoid-oblong, 3–5 cm long. *P. motleyi* is found up to 75(–300) m altitude and occurs scattered along rivers, in mixed swamp forest, in periodically inundated sites, but not on peat. The density of the wood is 480–800 kg/m^3 at 15% moisture content.

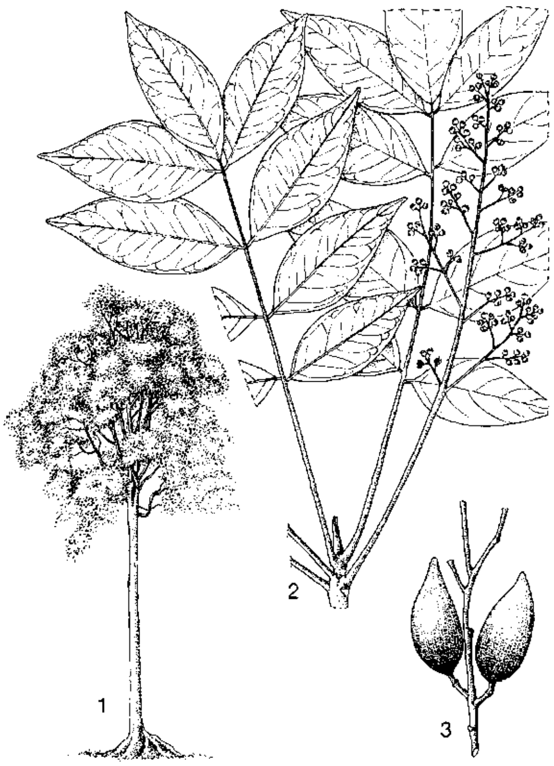
Selected sources 69, 78, 104, 162, 234, 463, 465, 466, 549, 705.

Pentaspadon velutinus Hook.f.

Fl. Brit. India 2: 28 (1876).

Synonyms *Microstemon velutina* Engl. (1881).

Vernacular names Indonesia: pelajau (Sumatra). Malaysia: pink pelong tree, pelong beludu, poko shingle (Peninsular). Thailand: toei-na (Satun), toei-nam (Ranong).



Pentaspadon motleyi Hook.f. – 1, tree habit; 2, flowering twig; 3, branchlet with fruits.

Distribution Peninsular Thailand, Peninsular Malaysia and Sumatra.

Uses The wood is used as pelajau.

Observations A large tree up to 60 m tall, bole up to 90 cm in diameter, with buttresses up to 2.5 m high, bark surface cracked and scaly, grey-green or reddish-brown, inner bark reddish-brown; leaflets velvety below; inflorescence rachis terete, flowers pink; fruit elliptical-oblong, c. 2.5 cm long. *P. velutinus* occurs up to 350 m altitude and is locally common on well-drained places, along rivers, or in periodically inundated places and swamp forest. The density of the wood is 485–825 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 77, 104, 140, 162, 526, 574, 705.

I. Soerianegara (general part),
N. Tonanon (properties),
R.H.M.J. Lemmens (properties),
J. Ilic (wood anatomy),
M.S.M. Sosef (selection of species)

Phyllocladus Rich. ex Mirbel

Mém. Mus. Hist. Nat. Paris 13: 76 (1825).
PODOCARPACEAE
$x = 9$; $2n = 18$ for several non-Malesian species

Trade groups Sempilor: lightweight to medium-weight softwood, a single species in Malesia, *Phyllocladus hypophyllus* Hook.f., Icon. Pl. n.s. 5: t. 889 (1852), synonyms: *Phyllocladus major* Pilger (1916), *Phyllocladus protractus* (Warb.) Pilger (1903).
The timber is traded as sempilor together with that of *Dacrydium* and *Falcatifolium*. In Indonesia, all *Podocarpaceae* timber is traded as 'melur'.

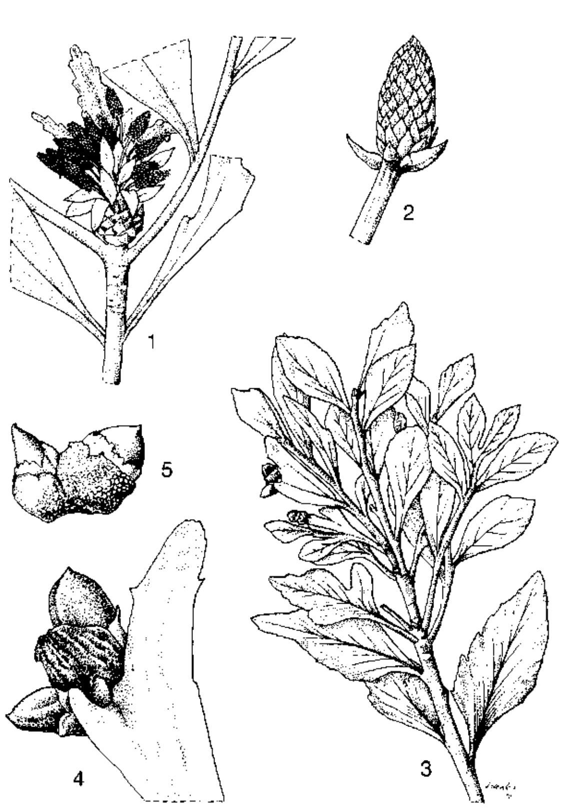
Vernacular names Sempilor: celery pine (En). Indonesia: bejalin (Moluccas), kayu empire (Sulawesi), kayu karongan (Kalimantan). Malaysia: phyllocladus (Sabah). Papua New Guinea: celery pine, Papua New Guinea celery-top pine (general). Philippines: dalung (Cebu Bisaya, Tinggian), galingkinga (Agusan), salumayag (Davao).

Origin and geographic distribution *Phyllocladus* consists of 5 closely related species, 3 of which occur in New Zealand, 1 in Tasmania and 1 (*P. hypophyllus*) in Borneo, Sulawesi, the Moluccas, the Philippines and New Guinea.

Uses The wood is used for light construction, light flooring, furniture, cupboards, mouldings, joinery, interior finish, boat building, turnery, carving, matches, veneer, plywood, and for special purposes such as laboratory bench tops, in storage batteries, reconditioning chambers and foundry patterns. Copal has been collected by tapping the trees.

Production and international trade No statistics are available on the trade of *Phyllocladus* timber; the amounts traded are probably insignificant. In Papua New Guinea, the export of logs of all *Podocarpaceae*, including *Phyllocladus*, is banned to encourage domestic processing of this highly valued timber.

Properties *Phyllocladus* yields a lightweight to medium-weight wood. The heartwood is pale pinkish-brown, buff-coloured or yellow-brown, with fawn streaks or without figure, indistinctly or distinctly demarcated from the straw-coloured to pale brown sapwood. The density is 550–610 kg/m^3 at 12% moisture content. The grain is straight, texture very fine and even. The wood is glossy and has no taste, but occasionally has an unpleasant odour like ramin (*Gonystylus* spp.).
There is no test on mechanical properties available, but the wood is reported to be moderately strong.
The rates of shrinkage are moderate to fairly high, up to 2.0% radial and 4.5% tangential from green to 15% moisture content, but for wood from Papua New Guinea a shrinkage of only 1.6% radial and 3.4% tangential has been reported from green to 12% moisture content. See also the table on wood properties. The wood seasons fairly well, but compression wood may occur, causing considerable longitudinal shrinkage and some distortion. Large initial moisture content variations may occur, resulting in a considerable final moisture range. Warping is often present, and the back-sawn stock may twist to a considerable degree, unless stacks are weighted down and closely spaced stickers are used. Boards 25 mm thick can be kiln dried from green to 12% moisture content in about 7 days. A high humidity treatment after drying is recommended. Movement of the wood in service is low.
The wood is moderately easy to very easy to work with hand and machine tools, planes to a smooth surface and peels excellently.
It is non-durable in contact with the ground or



Phyllocladus hypophyllus Hook.f. – 1, twig with male cones; 2, male cone; 3, twig with female cones; 4, phylloclade with female cones; 5, seeds.

when exposed and prone to termite and marine borer attack, but it is not susceptible to *Lyctus* attack. The sapwood is permeable, the heartwood probably resistant to preservatives when using a pressure treatment. The wood is resistant to chemical action and to hot and cold liquids.

The wood contains 52.6% cellulose, 25.2% lignin, 14.9% pentosan, 0.1% ash and 0.1% silica. The solubility is 2.0% in alcohol-benzene, 4.8% in cold water, 6.8% in hot water and 16.3% in a 1% NaOH solution.

Description A usually dioecious shrub or small to medium-sized tree up to 30 m tall; bole generally short, with a diameter up to 50(–100) cm; bark surface smooth, hard, with large lenticels, dark brown to reddish, breaking off in large more or less rectangular scales with age, inner bark pale brown to red-brown; primary branches tending to be in false whorls, secondary branching abundant. Foliar shoots flattened into phylloclades, usually consisting of 5–10 pinnately placed segments, these deeply lobed on young plants, becoming diamond-shaped to ovate with wavy margins on older individuals, then 1.5–6 cm × 1–3 cm. Pollen cones clustered in the axil of a scale of a secondary shoot, subtended by a mostly naked stalk and a few sterile scales, cylindrical, 8–15 mm × 3 mm; apex of microsporophyll triangular, irregularly toothed. Seed-bearing structure usually solitary, in an apical notch of a bilobed cladode or terminal on a reduced cladode or on a naked stalk, ovoid, more or less purple, with up to 15 scales; 1–3 scales fertile and becoming bright red when mature. Mature seed erect, shiny brown, 5–7 mm long, apiculate, the lower half enveloped by a rough-edged, papery, greyish scale. Seedling bearing spirally arranged, single-veined, linear, bifacially flattened leaves up to 1 cm long.

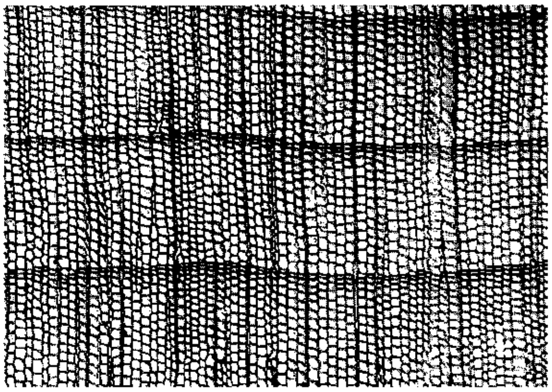
Wood anatomy

– Macroscopic characters:

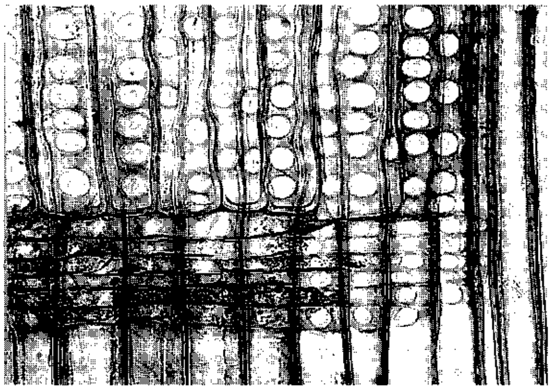
Heartwood pale pinkish-brown, creamy yellow-brown to brown, sometimes with brown streaks (usually near the pith and resulting from compression wood), usually clearly demarcated from the straw-coloured to pale brown sapwood. Grain straight. Texture very fine and even; wood with some lustre, occasionally with an unpleasant odour similar to ramin (*Gonystylus*). Growth rings very narrow and evenly spaced, resulting in some figure in the wood, sometimes growth rings indistinct; rays very fine, not visible to the naked eye.

– Microscopic characters:

Growth rings evident but not clearly marked, latewood tracheids rectangular, smaller, restricted to



transverse section (×25)



radial section (×150)

tangential section (×75)

Phyllocladus hypophyllus

(1–)2–3 rows, somewhat thicker-walled. Tracheids rounded, rectangular, polygonal to irregular in cross-section, radially aligned, tangential diameter approximately 50–65 μm, 3–4.5 mm long; intertracheid pits in single loose rows, paired and opposite in some wider tracheids, moderately large to large (20–25 μm in diameter), rounded; smaller pits in tangential walls mostly in latewood tracheids, c. 14–16 μm in diameter. Parenchyma absent. Rays 5–8/mm, predominantly uniseriate, (1–)6–8(–15) cells high, end walls smooth; ray-tracheid pits half-bordered, with a markedly reduced border, large, typically 18–22 μm in diameter, 1–2 per crossfield, rounded to oblique, crossfields often containing somewhat larger single pits occupying most of the crossfield area, smaller pits typically taxodioid. Ray tracheids absent, resin ducts absent. Little extraneous material present in ray cells.

Wood of *Agathis*, *Falcatifolium*, *Nageia*, *Podocarpus* and *Prumnopitys* can resemble *Phyllocladus*. *Agathis* differs from the other genera by having alternate intertracheid pits. *Prumnopitys* and *Phyllocladus* can be distinguished from the remaining genera by the absence of parenchyma. *Prumnopitys* has characteristically large window-like crossfield pits.

Growth and development The 2 cotyledons of the seedling are usually early deciduous, but may last for 2 years or more. The earlier formed cladodes are simple; these are gradually replaced by deeply lobed ones. The early-formed cladodes, however, are highly polymorphic with respect to shape, size, and dentation. Root nodules which contain symbiotic, nitrogen-fixing bacteria have been observed in seedlings.

The highly contrasting colours of the seed cones with bright red scales, a pale aril and chestnut-brown seed, are thought to indicate that the seed is dispersed by birds.

Other botanical information Some authors contend that *Phyllocladus* is significantly different from other *Podocarpaceae* and should have the status of a separate family, viz. the *Phyllocladaceae*. More recent opinions, however, do not support this view.

Ecology *Phyllocladus* occurs scattered, only locally common, as a subcanopy or canopy tree in moist montane or submontane forest at 900–2000 m altitude and occasionally in kerangas forest above 1000 m altitude. It may be more common at higher elevations, up to 4000 m, but is then much shorter. In New Guinea, it is often associated with other podocarps and *Nothofagus* spp.

Silviculture and management *Phyllocladus* has been observed as a pioneer in disturbed, pyrogenous, open land at 2500–3000 m altitude.

Harvesting Montane forest where *Phyllocladus* occurs is difficult to exploit due to the undulating to steep terrain. Conventional machinery cannot be used.

Handling after harvest Pit-saw teams convert logs into timber for construction in remote areas in Papua New Guinea.

Genetic resources In view of the fairly large area of distribution and the low pressure on natural forest in which *P. hypophyllus* is found, genetic resources are safeguarded satisfactorily.

Prospects For Irian Jaya *P. hypophyllus* is reported to have high-value export potential for furniture. Wood properties are rated as good, but it is unlikely that it will play an increasingly important role in the near future, due to the poor accessibility of montane forest.

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Other selected sources 71, 77, 117, 145, 213, 231, 268, 289, 291, 394, 404, 474, 482, 513, 527, 653.

E. Boer (general part, properties),
M.S.M. Sosef (general part),
J. Ilic (wood anatomy)

Podocarpus L'Hér. ex Persoon

Syn. pl. 2: 580 (1807).
PODOCARPACEAE
x = variable: 10–13, (16–)17–19

Trade groups Podocarp: lightweight to medium-weight softwood, e.g. *Podocarpus bracteatus* Blume, *P. neriifolius* D. Don, *P. rumphii* Blume.
The timber is traded as podocarp together with that of the genera *Dacrycarpus*, *Nageia* and *Prumnopitys*.

Vernacular names Podocarp (En, Fr). Indonesia: jamuju (general). Malaysia: podo (general), rempayan (Sabah). Papua New Guinea: low mountain podocarp. Philippines: malakauayan. Burma (Myanmar): thitmin. Laos: ka dong. Thailand: phayamai (general).

Origin and geographic distribution *Podocarpus* consists of about 95 species which are distributed throughout the tropics (often in the highlands) and in temperate forests of the southern hemisphere. Within Malesia 30 species are present; the highest biodiversity is found in New Guinea (15 species) and Borneo (13 species). All other areas within Malesia have much less species, on average about 5.

Uses The wood of *Podocarpus* is used for high-grade construction, light framing, beams, boat construction, oars, spars, masts, carving, flooring, moulding, cupboards, furniture, cabinet work, interior trim, joinery, drawer sides, weatherboards, shingles, boxes, household utensils, cooperage, matchsplints and veneer.
A decoction of the leaves has medicinal properties and the fruits of some species are edible. *P. polystachyus* is cultivated as an ornamental.

Production and international trade Only small amounts of podocarp timber are traded. In Indonesia and Malaysia, podocarp is a much less important softwood than damar minyak (*Agathis*). In 1987, only 20 m^3 of round logs of podocarp were exported from Sabah, but the wood is considered as valuable and ranked in class A; in 1987 the average price was US$ 86/m^3. In Papua New Guinea, podocarp timber attracts high prices and the export of logs is banned to encourage domestic processing.

Properties Podocarp is a lightweight to medium-weight softwood. The heartwood is greyish-yellow or pale brown to golden-brown and often not clearly demarcated from the paler sapwood. The density is 415–790 kg/m^3 at 15% moisture content. The grain is usually straight, texture fine and even; wood with little or no figure, lustrous.
A test of wood of *P. neriifolius* from Fiji at 12% moisture content showed the following mechanical properties: the modulus of rupture 98.5 N/mm^2, modulus of elasticity 10 765 N/mm^2, compression parallel to grain 56 N/mm^2, compression perpendicular to grain 11 N/mm^2, shear 13 N/mm^2, cleavage 32 N/mm radial and 40.5 N/mm tangential, Janka side hardness 5050 N and Janka end hardness 7920 N.
The rates of shrinkage of podocarp wood are fairly low: from green to 12% moisture content 2.3% radial and 4.1% tangential, and from green to oven dry 3.3% radial and 5.7% tangential. The wood is easy to dry without significant defects, but face checking and twist are common problems in unweighted boards, whereas juvenile wood checks badly. On average it takes 23 days to dry 25 mm thick boards of *P. neriifolius* to 15% moisture content. The recommended kiln drying schedule specifies a temperature of 54–82°C with corresponding relative humidity of 76% to 30%. In Malaysia, it is recommended to dip the stock in an anti-stain solution immediately after conversion and before drying. Boards 25 mm thick are dried to 15% moisture content within 8 days by using the Malaysian kiln-drying schedule G.
Podocarp wood is easy to saw, but softer boards show a tendency to crumble on end grain. The wood can be planed, shaped, turned, mortised and sanded with good results and to a smooth finish, but the results of boring are sometimes rated as moderate. Generally, the wood holds nails well, but large nails may cause some splitting. The gluing, staining, varnishing and painting properties are satisfactory. The peeling properties are rated as good with a negligible degrade upon drying; pretreatment is not needed.
Podocarp wood is classified as non-durable when used in contact with the ground or exposed to the weather. It is susceptible to attacks of termites, pinhole borers, longhorn beetles and marine borers, but not to *Lyctus* beetles. The sapwood is permeable, but the heartwood is moderately resistant to impregnation.

Description Usually dioecious, medium-sized or large trees up to 45 m tall, rarely shrubs; bole cylindrical, up to 100 cm in diameter; bark surface more or less fissured and peeling in vertical strips, yellowish to reddish-brown, soft and fibrous; crown broadly conical or dome-shaped; branching of the main stem tending to produce false whorls; apex of leafy shoots with distinct resting buds. Leaves arranged spirally, bifacially flattened, with a single vein, narrowed at base into a short petiole; stomata usually present on the lower surface only. Pollen cones axillary or occasionally terminal, solitary or grouped, sessile or on a short naked peduncle, cylindrical, up to 4 mm in diameter, with a few scales at the base usually shed together with the pollen cone. Seed-bearing structure axillary, with a naked peduncle surmounted by 2(–5) thickened adnate bracts forming a receptacle; receptacle often becoming enlarged and fleshy upon maturity; one to several subterminal bracts fertile; ovule inverted, completely enclosed by a leathery structure often forming a crest at the base of the ovule, the resulting structure exposed above the receptacle. Seed usually more or less green when mature, rarely becoming fleshy or reddish. Seedling with epigeal germination (*P. neriifolius*).

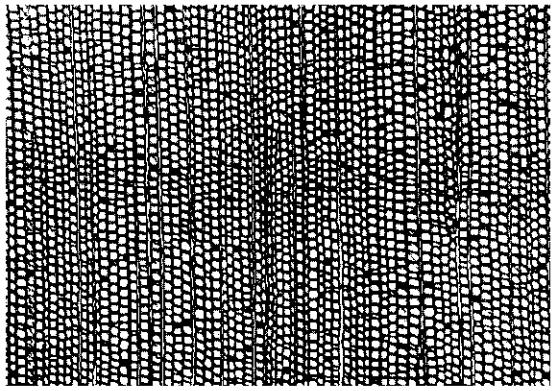
Wood anatomy

– Macroscopic characters:

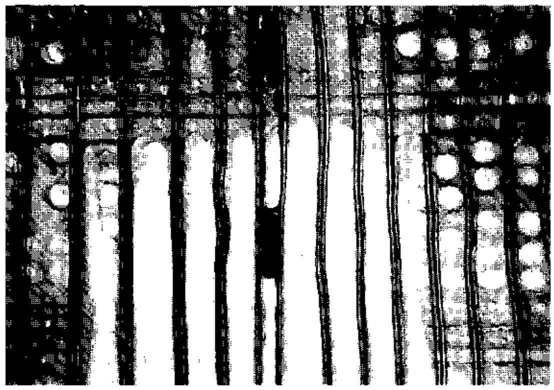
Heartwood greyish-yellow, pale brown or golden-brown, often not clearly demarcated from the paler sapwood. Grain usually straight. Texture fine and even; wood with little or no figure, occasionally with darker streaks near the pith resulting from compression wood, lustrous. Growth rings generally indistinct, sometimes marked by narrow, dense latewood bands; diffuse parenchyma rarely evident to the naked eye; rays very fine, not visible to the naked eye.

– Microscopic characters:

Tracheids square, rounded, polygonal to irregular in cross-section, radially aligned, tangential diameter approximately 40–65 μm, 2–6 mm long, latewood restricted to 2–3 layers of rectangular, somewhat thicker-walled tracheids in some samples, more extensive in *P. neriifolius*; intertracheid pits mainly in radial walls, opposite, in a single row, sometimes paired near tips, moderately large, 16–20 μm in diameter, and rounded, rarely flattened; pits in tangential walls in latewood tracheids smaller. Parenchyma diffuse, moderately abundant to abundant, with smooth end walls. Rays 4–8/mm, predominantly uniseriate, biseriate rays rare, (1–)8–15(–25) cells high; ray cells with smooth end walls; ray-tracheid pits half-bordered,



transverse section (×25)



radial section (×150)

tangential section (×75)

Podocarpus neriifolius

cupressoid to taxodioid, medium-sized, 10–14 μm in diameter, 1–2 per crossfield, crossfields of marginal cells usually containing somewhat larger single pits, usually with a markedly reduced border. Ray tracheids absent, resin ducts absent. Reddish-brown extraneous material abundant in parenchyma cells, less pronounced in ray cells.

Species studied: *P. brassii*, *P. neriifolius*, *P. pilgeri*, *P. polystachyus*, *P. rumphii*.

Wood of *Agathis*, *Falcatifolium*, *Nageia*, *Phyllocladus* and *Prumnopitys* resembles that of *Podocarpus*. *Agathis* differs by having alternate intertracheid pits. In *Phyllocladus* and *Prumnopitys* parenchyma is absent. However, *Falcatifolium* and *Nageia* are very similar.

Growth and development Growth of *P. neriifolius* is slow; the mean annual diameter increment in India is reported to be only 3 mm. A 35-year-old tree of *P. teysmannii* Miq. (a usually small tree from Peninsular Malaysia and Sumatra) at the arboretum of the Forest Research Institute Malaysia was 17 m tall and 25 cm in diameter.

Growth is by flushes, with new leaves sometimes distinctly red rather than pale green. Distinct resting buds are formed at the apex of the leafy shoots and consist of two kinds of usually deciduous scales: primary scales covering the resting shoot apex and secondary scales surrounding the newly growing shoots.

Nodules are regularly present on the roots but their function is unclear. They contain endotrophic mycorrhizae; nitrogen fixation is only limited. Growth without mycorrhizae is possible.

P. neriifolius flowers in Java in November and December and fruits ripen from March to June. Pollination is by wind. Dispersal of the seeds is by birds and fruit-eating bats, and seedlings are found widely scattered.

Other botanical information During the last 30 years, several sections of the large genus *Podocarpus* have been raised to the genus level (e.g. *Dacrycarpus*, *Nageia*, *Prumnopitys*). This action is disputed by some authors, which may cause confusion as some species are cited with different names depending on the authors' opinions. Similarly, some authors write about *Podocarpus* in the broader sense, others in the narrower sense. The timber of the newly created genera does not differ much from that of *Podocarpus* proper. As the treatment in Flora Malesiana applies the narrow genus concept, it seems best to follow that line in the present publication.

The genus *Podocarpus* (in the narrower sense) is divided into two subgenera based on features of the ovule-bearing shoot and the leaf epidermis. Only subgenus *Foliolatus* de Laubenf. is represented within the Malesian area; it is mainly characterized by the presence of 2 lanceolate bracts below the receptacle and is further divided into 9 sections.

Ecology Most species of *Podocarpus* occur in montane forest, especially mixed Fagaceous and mixed conifer forest. Individual species are also found in kerangas, in swamp forest on acid soils, but also on limestone hills. *P. polystachyus* is the only species of this genus occurring on coastal sands. Some other species also occur down to sea-level, but most are distributed between 750 and 2500 m altitude and may constitute characteristic elements of the vegetation. Several species are found in alpine shrub vegetation up to 3750 m.

Propagation and planting *Podocarpus* can be propagated by seed. There are about 4500 dry seeds of *P. polystachyus* in 1 kg. *P. neriifolius* seed germinates for 90% in 20–67 days. Seed may not be viable after more than 3 months of storage.

The seedlings are transplanted into the field when 30–40 cm tall. Usually, planting holes spaced 4 m × 5 m are prepared one week earlier.

Silviculture and management Natural regeneration of *P. neriifolius* is sparse in heath forest, although it regularly produces seeds.

Diseases and pests Glomerella blight or brown lesion disease in *P. neriifolius* is caused by *Glomerella cingulata*.

Harvesting Podocarp timber is harvested from natural stands with tree diameters of at least 40–50 cm. The logs are cut into pieces of 3–4 m long and transported by truck or by river.

Yield In natural forest in Central Sulawesi, 2.4–6.0 *P. neriifolius* trees/ha were found in the diameter class 35–49 cm (producing 3.4–10.1 m^3/ha) and about 2.4 trees/ha with a diameter of 50 cm or more (producing 6.8 m^3/ha). On Peleng Island, Central Sulawesi, 1.2 *P. neriifolius* trees/ha with a diameter of over 100 cm and an estimated timber volume of 8.2 m^3/ha were found.

Genetic resources *Podocarpus* does not seem particularly endangered as it is widespread and is often common in forest on ridges and mountains which are not easy to reach for logging. Individual species may be liable to genetic erosion, either because they are rare or local endemics (e.g. *P. lophatus* de Laubenf. and *P. rotundus* de Laubenf. in the Philippines, *P. gibbsii* N.E. Gray and *P. brevifolius* (Stapf) Foxw. in Borneo), or because they occur in lowland forest which is often subject to logging (e.g. *P. rumphii*).

Prospects As the wood quality of podocarp timber (including also *Dacrycarpus*, *Nageia* and *Prumnopitys*) is excellent, the prospects for increased use are promising, even though only small quantities may reach the market. Podocarp wood can be considered as a valuable substitute for kauri (*Agathis*), whose populations have been reduced in many areas. Research on propagation, planting, growth and development, and silviculture is desirable.

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Selection of species

Podocarpus archboldii N.E. Gray

Journ. Arn. Arb. 39: 452 (1958).

Vernacular names Indonesia: mu, soa (Kebar, Irian Jaya).

Distribution New Guinea.

Uses The wood is probably used as podocarp.

Observations A medium-sized to fairly large tree up to 40 m tall, branchless for up to 24 m, up to 100 cm in diameter; foliage buds, globular, with slightly spreading scales; juvenile leaves broadly acute, adult leaves 7–12 cm × 1–1.4 cm, midrib prominent on upper surface, 0.5 mm wide; pollen cones solitary, sessile or on a peduncle up to 4 mm long, c. 4 cm × 0.4 cm; receptacle red when mature. *P. archboldii* occurs scattered and locally common as a canopy tree in mixed lower montane or montane rain forest with *Castanopsis* spp. at 700–2200 m altitude.

Selected sources 117, 130, 145, 162, 190, 268.

Podocarpus bracteatus Blume

Enum. pl. Javae 1: 88 (1827).

Synonyms *Podocarpus neriifolius* D. Don var. *brevipes* (Blume) Pilger (1903), *Podocarpus neriifolius* D. Don var. *bracteatus* (Blume) Wasscher (1941).

Vernacular names Indonesia: bima, ki merak (Java), kayu unung unung (Sumatra).

Distribution Rare in Sumatra, more common in Java and Flores.

Uses *P. bracteatus* is an important source of podocarp timber.

Observations A medium-sized to fairly large tree up to 40 m tall, bole cylindrical, up to 100 cm in diameter; foliage buds ovate and acute, with recurved acute scales; juvenile leaves acute, adult leaves 6–14 cm × 0.9–1.4 cm, midrib above a sharp ridge of 0.4 mm wide; pollen cones solitary, sessile but on a scaly peduncle up to 8 mm long when mature, 3.5–6 cm × 0.3–0.4 cm; receptacle red when mature. *P. bracteatus* occurs as a canopy tree in moist montane forest at (400–)1000–2600 m altitude. It is the most common *Podocarpus* species of the montane forests of Java.

Selected sources 117, 162, 190, 685.

Podocarpus brassii Pilger

Bot. Jahrb. Syst. 68: 246 (1937).

Distribution New Guinea.

Uses The wood is probably used as podocarp.

Observations A small to medium-sized tree up to 30 m tall, bole up to 75 cm in diameter; foliage buds globular, with erect acute scales; juvenile leaves acute or apiculate, adult leaves 10–25 mm × 5–7.5 mm, midrib above a low ridge of 0.2 mm wide; pollen cones solitary, sessile, 25–30 mm × 6–7 mm; receptacle passing from red to dark purple when maturing. Two varieties are distinguished: var. *humilis* de Laubenf. differs from var. *brassii* in the length of the microsporophyll being less than 1 mm long (over 2 mm in var. *brassii*). *P. brassii* occurs commonly and is sometimes dominant near the tree line, often as an emergent in alpine shrub vegetation. It is commonest at 3000–3750 m altitude but reaches larger dimensions with more straight boles at lower altitudes (down to 2000 m). The density of the wood is about 530 kg/m^3 at 15% moisture content.

Selected sources 117, 162, 190, 268, 474, 685.

Podocarpus crassigemmis de Laubenf.

Blumea 26: 141 (1980).

Distribution New Guinea.

Uses The wood is probably used as podocarp.

Observations A medium-sized to fairly large tree up to 38 m tall, bole occasionally fluted, up to 75 cm in diameter; foliage buds globular, strongly curving outward; juvenile leaves acute, adult leaves 3–11 cm × 0.5–1.2 cm, midrib above a sharp ridge, 0.2–0.4 mm wide; pollen cones solitary or occasionally in pairs, on a 2–7 mm long peduncle, 1.8–2.0 cm × 0.4 cm; receptacle changing from deep red to near black when maturing. *P. crassigemmis* occurs scattered but commonly or even dominant as a canopy or emergent tree in high montane mossy forest, often in *Nothofagus* or *Phyllocladus* forest, at (1800–)2100–3400 m altitude.

Selected sources 130, 162, 268.

Podocarpus insularis de Laubenf.

Blumea 30: 266 (1985).

Distribution New Guinea, New Britain, Vanuatu and the Solomon Islands.

Uses The wood is probably used as podocarp.

Observations A small to medium-sized or fairly large tree up to 39 m tall, bole branchless for up to 24 m, up to 60 cm in diameter; foliage buds with strongly spreading scales; juvenile leaves acute, adult leaves 5.5–9 cm × 0.7–0.9 cm, midrib prominent above, 0.3 mm wide; pollen cones solitary or in threes, sessile or on a short peduncle; receptacle red when mature. *P. insularis* has been recognized as a separate species only recently. It is a good-sized lesser canopy tree and occurs scattered but is locally common in rain forest and in *Nothofagus* forest, from sea-level up to 1700 m altitude.

Selected sources 131, 162, 268.

Podocarpus laubenfelsii Tiong

Blumea 29: 523 (1984).

Distribution Northern Borneo (Sabah, Sarawak, East Kalimantan).

Uses The wood is probably used as podocarp.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 60 cm in diameter, bark surface almost smooth, pale brown; foliage buds globular, with spreading scales; juvenile leaves acuminate, adult leaves 7–19 cm × 1–1.8 cm, midrib above a blunt ridge of 0.8–1.2 mm wide; pollen cones in groups of (3–)4(–5), usually on a short peduncle, 20–40 mm × 2.5–3.5 mm. *P. laubenfelsii* was only recently recognized as a distinct species related to *P. rumphii*. It occurs scattered in non-dipterocarp primary rain forest, but may be dominant in heath forest, also occurring in *Agathis* forest on waterlogged acid soil, at 600–1600 m altitude.

Selected sources 162, 643.

Podocarpus ledermannii Pilger

Bot. Jahrb. Syst. 54: 210 (1916).

Synonyms *Podocarpus idenburgensis* N.E. Gray (1958).

Vernacular names Indonesia: bebieai (Kapauko, Irian Jaya), sua (Irian Jaya).

Distribution New Guinea and New Britain.

Uses The wood is probably used as podocarp.

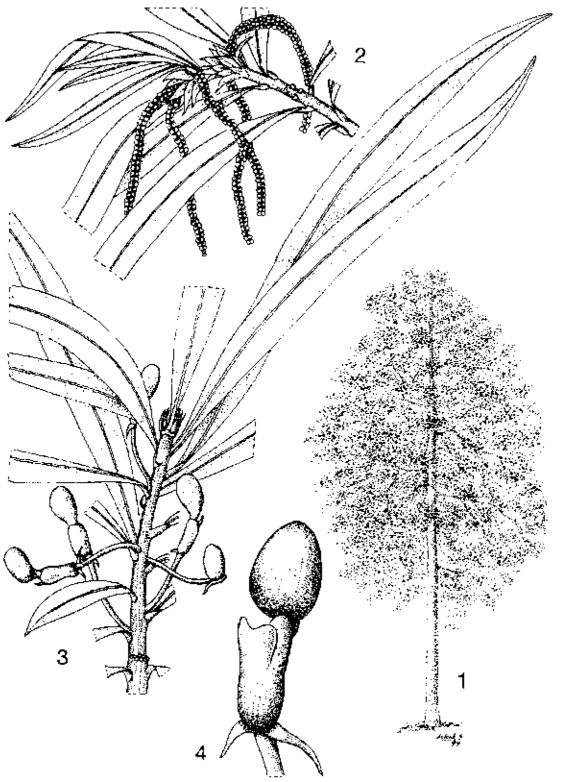
Observations A medium-sized tree up to 33 m tall, bole up to 60 cm in diameter; foliage buds ovate, with more or less spreading scales; juvenile shade leaves acuminate, sun leaves acute to slightly acuminate, adult leaves 11–22 cm × 2–2.4 cm (sun leaves only 1.6–1.8 cm wide), midrib above rounded, 1.5–2 mm wide; pollen cones usually in threes on a 3–4 mm long peduncle, c. 4.5 cm × 0.4 cm; receptacle red when mature. *P. ledermannii* occurs scattered but is locally common in the understorey of primary rain forest up to 1800(–2200) m altitude.

Selected sources 117, 130, 162, 190, 268, 685.

Podocarpus neriifolius D. Don

Descr. Pinus 2: 21 (1824).

Synonyms *Podocarpus discolor* Blume (1849), *Podocarpus leptostachya* Blume (1849), *Podocarpus neglecta* Blume (1849), *Podocarpus decipiens* N.E. Gray (1955), *Podocarpus polyantha* (Wasscher) Gaussen (1976).



Podocarpus neriifolius D. Don – 1, habit of young tree; 2, twig with male inflorescences; 3, twig with seeds; 4, mature seed with receptacle.

Vernacular names Indonesia: antok (Java), beberas (Sumatra), kayu cina (Irian Jaya). Malaysia: podo bukit, jati bukit (Peninsular), ki beling (Sabah). Philippines: mala adelfa (general). Burma (Myanmar): thitmin. Laos: ka dong. Thailand: phayamai (general), phailamton (north-eastern), khunmai (eastern).

Distribution *P. neriifolius* is the most widespread species of the genus, occurring from Nepal, India, Indo-China and Thailand, throughout Malesia, towards the Solomon Islands and Fiji; also planted in gardens.

Uses *P. neriifolius* is one of the main sources of podocarp timber; the wood is often used for furniture and cabinet work. The fruit is edible. A decoction of the leaves has been used against rheumatism and arthritis. Juice from the leaves is used against sores infested with maggots in Papua New Guinea.

Observations A medium-sized to fairly large tree up to 35(–45) m tall, bole columnar, branchless for up to 22 m, up to 100 cm in diameter, rarely spurred or even buttressed, bark surface greyish-brown; foliage buds ovate, acute or blunt, often with spreading scales; juvenile leaves acuminate, adult leaves (7–)8–18 cm × (1.0–)1.1–1.8 cm, midrib above abruptly raised, (0.4–)0.6–0.8 mm wide; pollen cones solitary or in twos or threes, sessile; receptacle red when mature. *P. neriifolius* is a variable species not always easily distinguishable from *P. polystachyus*. It occurs scattered but may be locally common in primary rain forest, generally on rocky hilltops, on sandstone or latosols (Java) or on ultrabasic soils, also near rivers, from sea-level up to 2100 m altitude. It usually appears as an understorey tree with occasional specimens emerging into the canopy, but it is normally encountered as a canopy tree, e.g. on Java. The density of the wood is 415–790 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 55, 61, 71, 77, 98, 104, 117, 123, 129, 145, 162, 185, 190, 234, 268, 289, 330, 404, 458, 465, 575, 597, 676, 685, 705.

Podocarpus pilgeri Foxw.

Philipp. Journ. Sci., Bot. 2: 259 (1907).

Synonyms *Podocarpus schlechteri* Pilger (1916), *Podocarpus wangii* Chang (1941).

Vernacular names Indonesia: bempop (Hattam, Irian Jaya). Philippines: lubang-lubang (Manobo). Thailand: phayamai-baisan.

Distribution Southern China, south-eastern Thailand, the Philippines, central and south-western Sulawesi and New Guina; possibly also in the Moluccas (Obi).

Uses The wood is reputed to be used as podocarp.

Observations A medium-sized tree up to 25 m tall, bole branchless for up to 12 m, up to 60 cm in diameter, rarely fluted; foliage buds ovate, acute, with erect or slightly spreading scales; juvenile leaves broadly acute and apiculate, adult leaves 2–4 cm × 0.4–0.8 cm, midrib slightly raised above, 0.2 mm wide; pollen cones solitary, subsessile, 5–12 mm × 3–7 mm; receptacle red or dark violet when mature. *P. pilgeri* occurs scattered but is locally common in moist and often mossy forest at (700–)1200–1300 m altitude. It is mainly an understorey tree of Fagaceous forest or in forest with *Phyllocladus* spp. and *Myrsine* spp. The density of the wood is 570–710 kg/m^3 at 15% moisture content.

Selected sources 117, 129, 162, 190, 268, 474, 575, 685, 715.

Podocarpus polystachyus R.Br. ex Endl.

Syn. conif.: 215 (1847).

Synonyms *Podocarpus thevetiifolia* Blume (1849), *Nageia thevetiaefolia* (Blume) F. v. Mueller (1877), *Nageia polystachyus* (R.Br. ex Endl.) O. Kuntze (1891).

Vernacular names Brunei: anggeriting. Indonesia: kayu serai (West Kalimantan), kayu karamat (Lingga), arbujin (Maibrat, Irian Jaya). Malaysia: podo laut (Peninsular), landin (Bintulu, Sarawak), kandabang (Bajau I'tan, Sabah). Philippines: dilang-bukiti (Tagalog). Thailand: sonbailek (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, the Riau and Lingga Archipelago, Bangka Island, Borneo, the Philippines including Palawan and western New Guinea; also planted outside its natural distribution area in gardens and parks.

Uses *P. polystachyus* is a fairly important source of podocarp timber; it is also cultivated as an ornamental.

Observations A small to medium-sized tree up to 20(–40) m tall, bole generally branchless for c. 6 m, occasionally up to 25 m, up to 45 cm in diameter, sometimes fluted, bark surface shallowly fissured, greyish-brown to deep brown; foliage buds ovate, acute to blunt, with erect scales; juvenile leaves acute, adult leaves 3–10 cm × 0.6–1.3 cm, midrib above a sharp ridge of 0.3–0.4 mm wide; pollen cones in groups of up to 5, sometimes more, sessile, 2–4.5 cm × c. 0.3 cm; receptacle passing from red to purple when maturing. *P. polystachyus* occurs mainly in three different habitats: often gregariously along the high-water mark of sandy beaches or sandy ridges in the mangrove, often frequently in lowland coastal kerangas, and on inland limestone hills up to 1000 m altitude. The density of the wood is 555–640 kg/m^3 at 15% moisture content.

Selected sources 69, 77, 104, 117, 140, 162, 190, 527, 572, 575, 597, 685, 705.

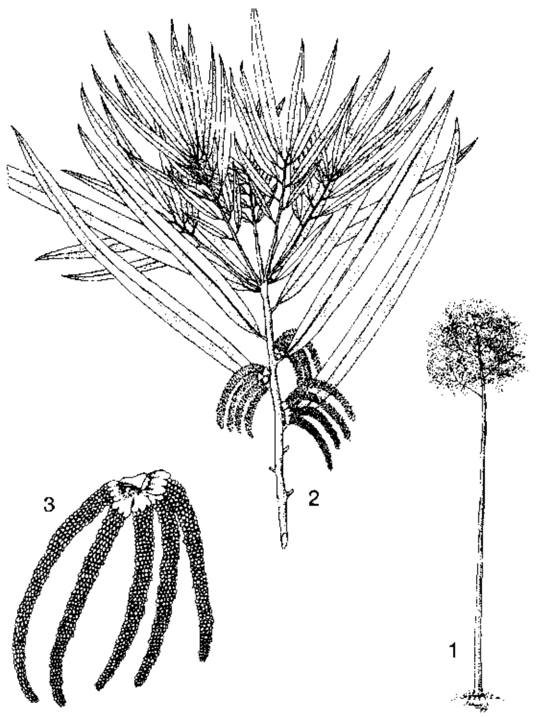
Podocarpus rumphii Blume

Rumphia 3: 214 (1849).

Synonyms *Podocarpus koordersii* Pilger ex Koord. & Valeton (1904), *Podocarpus philippinensis* Foxw. (1911).

Vernacular names Indonesia: sandu (Malili, Sulawesi), mermolas (Flores), kayu cina (Moluccas). Malaysia: kayu china (Sabah). Philippines: malakauayan (Luzon).

Distribution Hainan, Peninsular Malaysia, central Java, Bawean Island, Borneo (Sabah), the Philippines (Luzon), Sulawesi, the Lesser Sunda Islands, the Moluccas and New Guinea. *P. rumphii* occurs rather scattered in widely separate localities.



Podocarpus rumphii Blume – 1, habit of young tree; 2, twig with male inflorescences; 3, male inflorescence.

Uses The wood is used as podocarp, formerly especially for canoes, house construction, household utensils and carving.

Observations A medium-sized to large tree up to 45 m tall, bole up to 75 cm in diameter; foliage buds globular, with 1 or 2 scales bent outward apically; juvenile leaves acute or slightly acuminate, adult leaves 12–22 cm × 1.1–1.9 cm, midrib above a blunt ridge of 0.7–1.2 mm wide; pollen cones in groups of 2–8, sessile, 3.5–4.5 cm × 0.2–0.3 cm; receptacle red when mature. *P. rumphii* is locally common in primary rain forest from sea-level up to 600(–1550) m altitude; in Java it occurs on limestone. The density of the wood is 450–675 kg/m^3 at 15% moisture content.

Selected sources 27, 77, 117, 129, 145, 162, 190, 234, 268, 527, 715.

R.E. Nasution (general part, selection of species),
D.S. Alonzo (properties),
J. Ilic (wood anatomy)

Prumnopitys Philippi

Linnaea 30: 731 (1860).
PODOCARPACEAE
$x = 15, 18, 19$; *P. amara*: $2n = 38$

Trade groups Black podocarp: lightweight softwood, a single species, *Prumnopitys amara* (Blume) de Laubenf., Blumea 24: 190 (1978), synonyms: *Podocarpus amara* Blume (1827), *Podocarpus eurhyncha* Miq. (1856), *Stachycarpus amara* (Blume) Gaussen (1974), *Sundacarpus amara* (Blume) C.N. Page (1989).
The timber is often traded as podocarp together with that of *Dacrycarpus*, *Nageia* and *Podocarpus*.

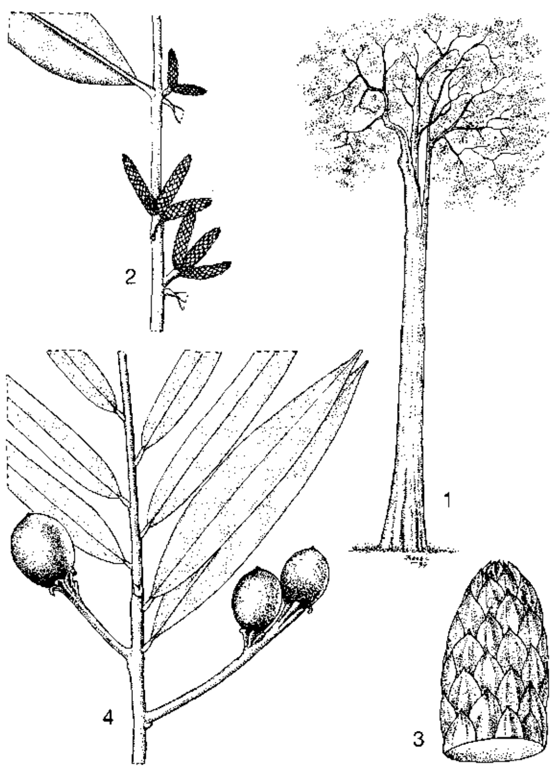
Vernacular names Black podocarp: black pine (En). Indonesia: sitobu (Sumatra), ki merak, ki pait (Java). Malaysia: sempilau (Sabah). Philippines: pasuig (Igorot).

Origin and geographic distribution *Prumnopitys* consists of 10 species and is distributed from Chile to Venezuela and Costa Rica in South America, and in New Zealand, New Caledonia, north-eastern Queensland (Australia) and Malesia. Only one species occurs in Malesia, where it is found throughout the region except for Peninsular Malaysia; in Borneo it occurs in Sabah only.

Uses The wood of black podocarp is used for house building (but not suitable for exterior use unless treated with preservative), light framing, light construction, shingles, moulding, cabinet work, furniture, panelling, joinery, crates, match-splints, matchboxes, pencils, rulers, household utensils, beehives, boat building and veneer. Furthermore, it is used as wood of the podocarp trade group for high-grade construction, beams, oars, spars, masts and for flooring. The pulp is very suitable for paper manufacture.

Production and international trade In Papua New Guinea, black podocarp timber attracts high prices, but only small amounts of this timber are exported. The export of logs of all podocarp species has been banned.

Properties Black podocarp is a lightweight softwood. The heartwood is pale pinkish-brown or golden-brown, gradually merging into the straw-coloured sapwood. The density is 410–430 kg/m^3 at 12% moisture content. The grain is straight or wavy, texture fine and even. Generally the wood has no distinct figure, but occasionally irregular grain may show as a silky mottled pattern; it has no distinct odour or taste.
A test of wood from New Guinea at 12% moisture content showed the following mechanical properties: the modulus of rupture 64.5 N/mm^2, modulus of elasticity 9520 N/mm^2, compression parallel to grain 40.5 N/mm^2, shear 10 N/mm^2, cleavage 46 N/mm tangential and Janka side hardness 2005 N. See also the table on wood properties.
The rates of shrinkage are low: from green to 12% moisture content 1.3% radial and 3.4% tangential. The timber seasons well, but occasionally pronounced warping may occur. Stacks must be weighted down and the stickers closely stacked. The wood can be kiln dried from green to 12% moisture content in about 3 days. It is very stable in service.
Black podocarp is easy to saw and planes to a smooth, silky surface. It moulds, turns and bores well. The fine dust may cause dermatitis.
The wood is rated as non-durable. The sapwood is not susceptible to *Lyctus* beetles. The resistance to termite attack is rated as poor to moderate. The heartwood is moderately easy to treat with preservatives, the sapwood easy.
The relatively long fibres compared to other gymnosperm species make it a very suitable species for paper manufacture.



Prumnopitys amara (Blume) de Laubenf. – 1, tree habit; 2, twig with pollen cones; 3, part of a pollen cone; 4, twig with seeds.

Description A dioecious, large to very large tree up to 60(–65) m tall; bole straight and cylindrical, often of large dimensions, up to 200 cm in diameter, sometimes spurred at the base; bark smooth, breaking off in irregular, more or less quadrangular plates on older trees, with scattered lenticels, reddish to yellowish-brown, weathering to grey, inner bark reddish-brown with white specks; crown dome-shaped, branching dense, subverticillate. Leaves arranged spirally but appearing distichous due to the twisted bases, bifacially flattened, mature leaves longer and narrower than the juvenile ones, 5–15 cm × 0.6–1.4 cm, decurrent at base, often narrowing abruptly at the apex into an elongated drip tip, 1-veined, midrib with a distinct groove above, broadly raised below; leaves without a hypoderm, with stomata on the lower surface only. Pollen cones usually on a short, 1–7 mm long peduncle, solitary or grouped, cylindrical, 15–35 mm × 2.5–3.5 mm; apex of microsporophyll triangular, acute. Seed-bearing structure solitary, consisting of 1 terminal to several lateral ovules which are scattered along a 3–5 cm long scaly shoot; ovule inverted, completely covered by a fleshy scale, the resulting structure ovate, with an apical crest, longer than the preceding fertile bract, dark blue, glaucous. Mature seed nearly spherical, c. 25 mm in diameter, becoming reddish and finally dark purple, the fleshy cover becoming wrinkled upon drying and often falling off.

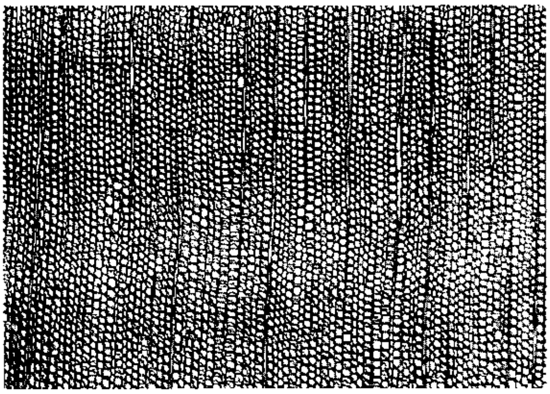
Wood anatomy

– Macroscopic characters:

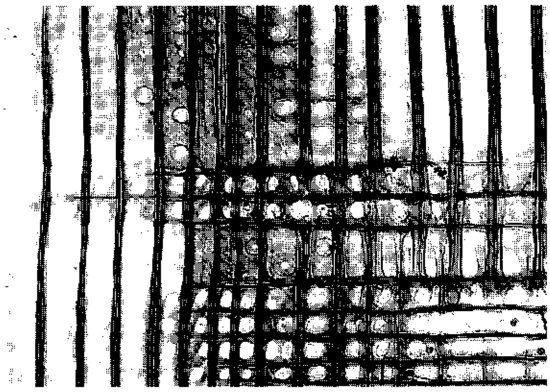
Heartwood pale pinkish-brown to golden-brown, often not clearly demarcated from the pale-coloured sapwood. Grain straight or wavy. Texture fine and even; wood with little or no figure, but sometimes a stripy lustre present due to variations in grain angle. Growth rings indistinct; parenchyma absent; rays very fine, not visible to the naked eye.

– Microscopic characters:

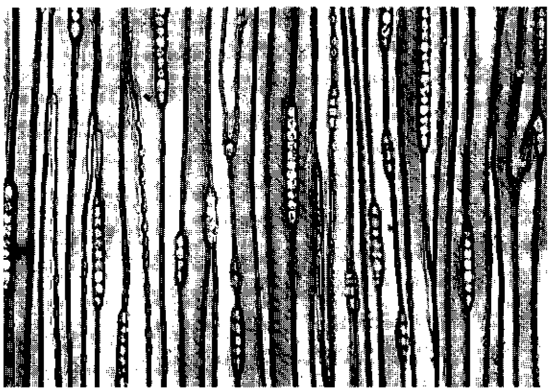
Tracheids polygonal, square or rounded to irregular in cross-section, radially aligned, tangential diameter approximately 50–70 μm, 2.5–6 mm long; intertracheid pits mainly in radial walls, opposite, in 1–2 rows, large and rounded, 18–20 μm in diameter, rarely flattened, when crowded crassulae present; pits in tangential walls rare and smaller. Parenchyma absent to very sparse, with smooth end walls. Rays 6–9/mm, predominantly uniseriate, biseriate rays rare, (1–)12–20(–30) cells high, biseriate part, when present, 1–2(–3) cells high; ray cells with smooth end walls; ray-tracheid pits



transverse section (×25)



radial section (×150)



tangential section (×75)

Prumnopitys amara

half-bordered with a reduced border, appearing virtually simple particularly in marginal cells, circular to lemon-shaped, large, 15–18 μm in diameter, 1(–2) per crossfield. Ray tracheids and resin ducts absent. Brownish extraneous material occasionally present in ray cells.

The wood of *Agathis*, *Falcatifolium*, *Nageia*, *Phyllocladus* and *Podocarpus* is very similar to that of *Prumnopitys*. *Agathis* can be distinguished by its alternate intertracheid pitting, and *Prumnopitys* differs from the other genera (except *Phyllocladus*) by the lack of parenchyma and the large lemon-shaped crossfield pits. The wood of *Phyllocladus* is yellowish to orange, sometimes with an unpleasant odour, and the crossfield pits have a more defined border.

Growth and development In natural forest in Java, 3-year-old *P. amara* seedlings measured 25 cm in height. In an experimental garden in Java, 8.5-year-old trees measured 10.8 m in height and 14.8 cm in diameter. In Java, black podocarp flowers in October and November. Mature seeds are found in March to June.

Other botanical information *Prumnopitys* was recently separated from the larger genus *Podocarpus*. It differs from the latter genus by having a groove running over the midrib above, by the absence of a hypoderm and by the fertile structures being positioned on scaly shoots. *Prumnopitys* is divided into 2 sections; the only Malesian species belongs to the monotypic section *Sundacarpus* (Buchholz & N.E. Gray) de Laubenf. This section has recently been raised to the generic level (genus *Sundacarpus*) but this will probably not gain much support in the future as the distinction is based on vegetative characters only.

Very large trees may be buttressed or spurred, which is rare within *Podocarpaceae*.

Ecology Black podocarp occurs scattered but is often common in both primary and secondary rain forest. In New Guinea it is often very common in Fagaceous forest or in association with *Dysoxylum*, *Macaranga* and *Ficus* spp. It usually occurs as a canopy tree, but it is sometimes emergent. It prefers latosols but has been found on sandy or marshy soils at (0–)500–2000(–3000) m altitude. In North Sumatra it thrives in mixed Fagaceous forest.

Propagation and planting Black podocarp can be propagated by seed. There are approximately 340 dry seeds in 1 kg.

Silviculture and management Natural regeneration of black podocarp is reported to be very difficult, but close to the mother tree it is sometimes satisfactory. Slight mortality of seedlings has been observed after selectively opening the canopy to create gaps of less than 1000 m^2. *P. amara* is shade tolerant and may be planted under faster growing trees. If it is to develop propably it must be protected from weeds.

Harvesting Pit-saw teams convert logs of black podocarp into boards used for construction of government buildings in the remote montane areas of Papua New Guinea.

Genetic resources No information is available on the collection and the conservation of genetic material of *P. amara*. There seems to be no direct danger of genetic erosion, as *P. amara* is widespread and locally very common.

Prospects As the wood quality of podocarp timber (including the genera *Dacrycarpus*, *Nageia* and *Podocarpus* as well) is excellent, the prospects for increased use are promising, although only small quantities reach the market. Research on propagation, planting, growth and development, and silviculture is desirable. Very little is known about *P. amara*.

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Other selected sources 39, 135, 166, 213, 218, 226, 234, 259, 268, 332, 333, 476, 597.

E. Boer (general part),
M.S.M. Sosef (general part),
R.H.M.J. Lemmens (properties),
J. Ilic (wood anatomy)

Pterocymbium R.Br.

Benn., R.Br. & Horsf., Pl. jav. rar. 3: 219 (1844).
STERCULIACEAE
x = unknown; $2n$ = unknown

Trade groups Amberoi: lightweight hardwood, e.g. *Pterocymbium beccarii* K. Schumann, *P. tinctorium* (Blanco) Merr., *P. tubulatum* (Masters) Pierre.

Vernacular names Amberoi. Indonesia: kelumbuk, papita (general). Malaysia: melembu (Peninsular), teluto (Sabah), keluak (Malay, Sarawak). Philippines: taluto (Filipino). Burma (Myanmar): sawbya. Thailand: oi-chang, po-ikeng, pokradang.

Origin and geographic distribution *Pterocymbium* consists of 6 or 7 species and is confined to Burma (Myanmar), the Nicobar and Andaman Islands, Indo-China, Thailand, and throughout the Malesian region and Fiji.

Uses Amberoi has uses similar to *Scaphium* wood (kembang semangkok), particularly for rotary veneer (both face and core veneer) and plywood, but also for temporary construction, scantlings, mouldings, interior finish, furniture, concrete shuttering, packing cases, fishing boats, fish-net floats, matchsplints and matchboxes, wooden shoes, pulp and paper, and wood-wool boards.

The bark of *P. tinctorium* is used to improve black dyeing of cotton cloth. Strips of the bark are used locally for making rope.

Production and international trade The export of round logs from Sabah in 1987 was 19 000 m^3 with a value of US$ 1.3 million (US$ 69/m^3), and in 1992 the total export of amberoi from Sabah was 9100 m^3 (61% as sawn timber, 39% as logs) with a total value of US$ 1.3 million (US$ 194/m^3 for sawn timber, US$ 69/m^3 for logs).

In Papua New Guinea, amberoi is an important export timber. It is ranked in MEP (Minimum Export Price) group 4; in 1992 saw logs fetched a minimum price of US$ 43/m^3. It is imported in Japan mainly from Papua New Guinea, and in 1987 constituted 2.3% of the total timber import from Papua New Guinea.

Pterocymbium timber is traded in Thailand domestically together with the timber of other fast-growing species such as *Bombax anceps* Pierre, *Lannea coromandelica* (Houtt.) Merr. and *Tetrameles nudiflora* R.Br.

Properties Amberoi is a lightweight hardwood. The heartwood is yellowish-white or greyish-white, and not distinctly demarcated from the white sapwood. The density is (230–)240–380 (–450) kg/m^3 at 12% moisture content. The grain is straight, texture moderately coarse to coarse. The wood is not lustrous, but an attractive oak-like figure is present on quarter-sawn surfaces.

At 12% moisture content, the modulus of rupture is 46–54 N/mm^2, modulus of elasticity c. 8405 N/mm^2, compression parallel to grain 30 N/mm^2, shear 4–7.5 N/mm^2, cleavage 23 N/mm radial and 23–34.5 N/mm tangential, and Janka side hardness 1625 N.

The rates of shrinkage are moderate: from green to 12% moisture content 1.9% radial and 5.0% tangential, and from green to oven dry 2.9% radial and 7.6% tangential. The wood air dries readily without much degrade. The moisture content of green timber is about 60%. The wood kiln dries fairly readily, but occasional end-splitting and twisting may occur. A temperature of 60–70°C gives good results. Boards 25 mm thick can be kiln dried to 12% moisture content in about 2 days. A high-humidity treatment is recommended after drying.

Amberoi has good sawing characteristics (silica is absent), and is easy to work, provided the wood is well seasoned, but it requires sharp tools to make a smooth cut, especially across the grain. A good finish can be obtained with both machine and hand tools. The nail-holding properties are moderate, but the wood glues fairly well. The steam bending properties are satisfactory. Amberoi is well suited for veneer and plywood, less suited for particle board and fibreboard making, and not suited for cement board production. The pulp is only of moderate quality.

Amberoi is non-durable. It is highly perishable in exposed situations and highly susceptible to termite, *Lyctus* and ambrosia beetle attack, and should only be used under cover. The wood is very prone to staining. Both sapwood and heartwood are permeable to preservatives when using a pressure treatment.

The wood contains 67–80% holocellulose, 18.2–25.5% lignin, 13–17.6% pentosan and 0.8–2.5% ash. The solubility is 1.4–3.3% in alcohol-benzene, 6–11% in hot water and 23.5–23.9% in a 1% NaOH solution. The wood is not suitable for making charcoal.

Description Medium-sized to large, monoecious, deciduous trees up to 50 m tall; bole straight, branchless for up to 33 m, up to 90(–120) cm in diameter, with short rounded buttresses extending up the trunk as low ribs; bark surface smooth, hoop-marked, conspicuously dotted with dark warty protuberances, pale grey to orange-brown or pinkish-brown or dark brown, inner bark soft, fleshy red with white streaks, with yellowish exudate. Stellate hairs or scales present. Leaves arranged spirally, distinctly petiolate; blade simple and entire, ovate or broadly ovate, base cordate to truncate, apex acuminate, glabrescent, pinnately veined but with 3(–7) palmate veins at base, tertiary venation scalariform, slightly prominent below; stipules subulate, small, caducous. Inflorescence axillary or terminal, slightly pendulous, paniculate. Flowers unisexual, 5-merous, regular; calyx bell-shaped or tubular, hairy along the margin; petals absent; male flowers with a staminal column topped by 8–10 sessile anthers; female flowers with 5 superior, free, sessile, pubescent pistils on top of an androgynophore, each ovary with 2 ovules, style with recurved stigmas. Fruit consisting of 4–5 follicles within a persistent calyx, follicle papery, splitting open before ripening, boat-shaped with a prominent dorsal lobe. Seed 1 at the base of each follicle, not winged.

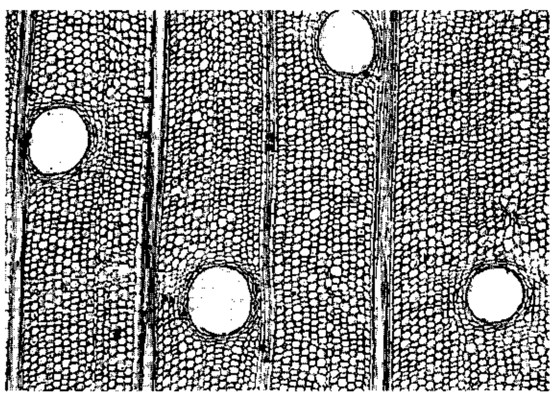
Wood anatomy

– *Macroscopic characters:*

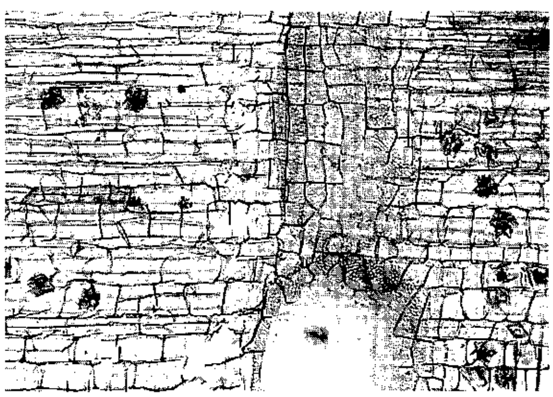
Heartwood yellowish-white to pale yellow, not distinctly demarcated from the sapwood. Grain generally straight. Texture coarse; silver grain prominent on radial surfaces due to the wide rays. Growth rings indistinct to fairly distinct; vessels visible to the naked eye; large rays distinct to the naked eye on all surfaces; ripple marks distinct because of storied small rays and other elements.

– *Microscopic characters:*

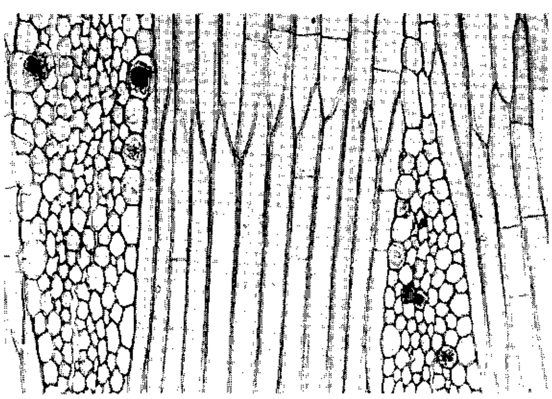
Growth rings generally indistinct, if fairly distinct, marked by the interrupted arrangement of



transverse section (×25)



radial section (×75)



tangential section (×75)

Pterocymbium beccarii

small flattened pores. Vessels diffuse, 1–2(–4)/mm^2, predominantly solitary, occasionally in radial multiples of 2–3, round or oval, up to 350 μm in tangential diameter; perforations simple; intervessel pits alternate, c. 6 μm in diameter; vessel-ray and vessel-parenchyma pits almost similar to intervessel pits but half-bordered; deposits and tyloses absent or scarce. Fibres 1.1–2.1 mm long, very thin-walled (walls 1–2 μm thick), with numerous minutely bordered to simple pits in the radial walls. Parenchyma abundant, diffuse-in-aggregates and narrowly vasicentric, in 2–4 celled strands. Rays 2–4/mm, of 2 distinct sizes, 1–2-seriate and up to 12(–20)-seriate, broad rays up to 5 mm (occasionally more) high, heterocellular with more than one row of square and/or upright marginal cells (Kribs type heterogeneous III or II); sheath cells present. Crystals present as druses, numerous, in sheath cells and also in other enlarged ray parenchyma cells, occasionally as prismatic crystals in procumbent ray cells. Silica inclusions absent. Traumatic axial canals with dark contents sometimes present in short arcs. All elements, except the broad rays, storied.
Species studied: *P. beccarii*, *P. tinctorium*.

Growth and development Amberoi trees are fast growing. In an 11-year-old plantation of *P. tinctorium* in the Philippines, trees had a mean height of 25.4 m, a bole branchless for 17.6 m on average and a mean diameter of 35.2 cm. A mean annual diameter increment of 2 cm has been reported over a period of 30 years.
Flowering occurs on the bare crown and trees are often leafless until fruit is set. The period between flowering and fruiting for *P. tinctorium* is extremely short, being only about 3 weeks.

Other botanical information *Pterocymbium* is readily distinguishable by its characteristically shaped follicles, which is at the same time the main distinctive feature towards the closely related genus *Scaphium*. There is some dispute about species delimitation, because some authors value the variation in colour, size and form of the flowers at species level, while others lump the plants that are very similar in other respects into a single, variable species.

Ecology Amberoi is usually locally common but scattered in tropical evergreen to moist mixed deciduous forest. It is most common in the lowland but may extend to lower montane forest at 1000 m altitude. Amberoi occurs on a wide range of soils, varying from sandy alluvial flats to loamy or clayey soils.

Propagation and planting Amberoi is propagated by seed. One kg contains about 8000 dry follicles of *P. tinctorium* and about 9200 dry seeds. Seed germinates readily and rapidly; fresh seed of *P. tinctorium* has 100% germination in 1–2 weeks, whereas seed stored for 1–2 months has 65–75% germination in 1–3 weeks. Seed is sown under shade and seedlings are pricked out and transferred to polybags. After 6 months the seedlings are 50 cm tall and ready for planting out in the field. Spacings applied are 2 m × 3 m and 4 m × 4 m. *P. tinctorium* should not be planted on soils with a periodically high water table.

Silviculture and management Natural regeneration is generally good. Being a pioneer species, amberoi needs plenty of light, especially in the seedling stage. Plantations need to be weeded during the first 1–3 years and should be thinned 5 and 10 years after planting. The rotation of amberoi in plantations is 30 years or less.

Diseases and pests In the nursery damping-off is a risk, but it can be prevented by avoiding excessive watering and allowing for air ventilation. Although larvae of the moth *Arthroschista hilaralis* have been found to damage terminal buds and *Meloidogyne* nematodes may destroy roots of amberoi trees, these pests are never very serious.

Harvesting Logs should be extracted from the forest within a day after felling as the timber is very susceptible to attacks by *Lyctus*, ambrosia beetles, and blue stain. The cut ends of logs should therefore be coated with tar or lime to prevent damage.

Yield In Papua New Guinea, the estimated maximum timber volume of *P. beccarii* is 2.6 m^3/ha, but in New Britain it is 17.6 m^3/ha. In the evergreen forest of Burma (Myanmar), approximately 0.65 amberoi trees/ha are found, with a timber volume of 0.88 m^3/ha. For Thailand a mean annual increment of 2 m^3/ha has been recorded, but this seems to be very low as amberoi is known for its rapid growth.

Handling after harvest Logs of amberoi float in water and can be transported by rivers. Amberoi is used for floating heavier timber in rafts.

Genetic resources Amberoi does not seem to be in immediate danger of genetic erosion. It is often a pioneer and it regenerates readily after logging, and some species (especially *P. tinctorium*) are common over large areas. However, some species are much less common and widespread (e.g. *P. tubulatum*), and plantations have only been established as trials on a small scale.

Prospects Amberoi seems to have promising prospects for planting in logged-over forest and for reforestation, as it grows fast and is adapted to open and fairly dry soil conditions. Rotations of less than 30 years are needed to produce fair amounts of timber, which is particularly suitable for manufacturing veneer.

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Selection of species

Pterocymbium beccarii K. Schumann

Bot. Jahrb. Syst. 24, Beibl. 58: 21 (1897).

Synonyms *Pterocymbium stipitatum* C.T. White & Francis (1927).

Vernacular names Papua New Guinea: amberoi (general). Thailand: po-ikeng.

Distribution New Guinea, the Kai Islands and New Britain.

Uses The wood is used as amberoi.

Observations A large tree up to 50 m tall, bole branchless for up to 33 m, up to 120 cm in diameter, buttresses absent or with spur roots or with tall buttresses up to 4 m high, bark surface shallowly fissured, sparsely pustulate, grey to almost black, inner bark fibrous, reddish to straw-coloured with prominent orange to dark red flames; leaves broadly cordate, base cordate, glabrous to sparsely pilose below, with 5–7 palmate basal veins; flowers tubular, the lobes much shorter than the tube, bluish-green or greenish-white. *P. beccarii* is found in lowland rain forest, especially on ridges or on alluvial or swampy soils, sometimes on the inner edge of mangroves, up to 750 m altitude. The density of the wood is 230–420(–450) kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 12, 60, 115, 145, 267, 289, 307, 608, 613, 660.

Pterocymbium splendens Kosterm.

Reinwardtia 2: 363 (1953).

Distribution East Kalimantan, the Moluccas and New Guinea.

Uses The wood is reputed to be used as amberoi.

Observations A medium-sized tree up to 30 m tall, bole branchless for up to 20 m, up to 60 cm in diameter, bark surface shallowly cracked, dark chocolate-brown, inner bark pale brown; leaves ovate, base cordate, densely velvety tomentose below, with 3(–7) palmate basal veins; flowers funnel-shaped, the lobes shorter than the tube, red in the basal part, yellow with red ribs in the upper part. *P. splendens* is found in lowland forest, up to 150 m altitude.

Selected sources 308, 320, 660.

Pterocymbium tinctorium (Blanco) Merr.

Bur. Govt. Lab. 27: 24 (1905).

Synonyms *Pterocymbium javanicum* R.Br. (1844), *Pterocymbium columnare* Pierre (1889), *Pterocymbium viridiflorum* Koord. (1898).

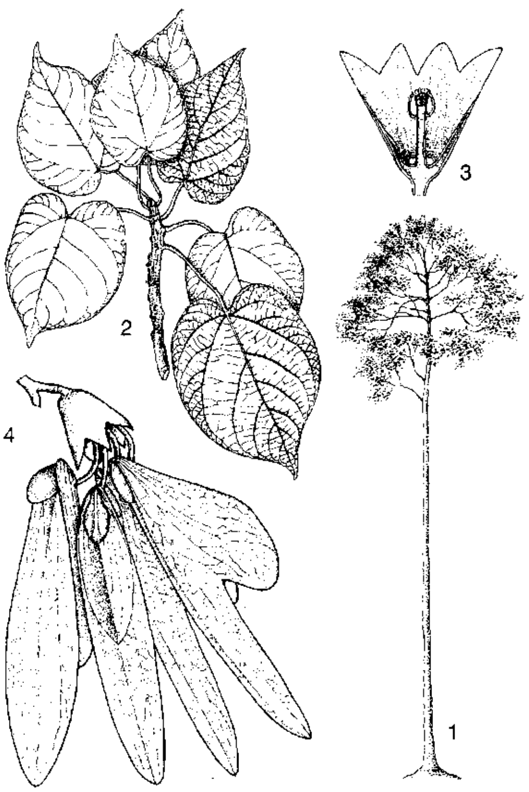
Vernacular names Indonesia: gelumbah (Sumatra), tongtolok (Sundanese), tolutu (Sulawesi). Malaysia: melembu (Peninsular), teluto (Sabah). Philippines: taluto (Filipino). Laos: oy[2] sang[2]. Thailand: po-khihaet (northern), po-khiliat (Chiang Mai), pong (Pattani).

Distribution Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi, the Lesser Sunda Islands, and the Philippines.

Uses The wood is used as amberoi, e.g. for construction, matches and floats, but also for the production of veneer and sometimes pulp. The bark has been used in intensifying black dye and for the manufacture of rope.

Observations A medium-sized to fairly large tree up to 40(–50) m tall, bole branchless for up to 30 m, up to 90 cm in diameter, bark surface finely cracked, greyish; leaves broadly cordate to ovate, base cordate to truncate, pilose below, with 5–7 palmate basal veins; flowers bell-shaped, the lobes at least half as long as the tube, greenish to violet or red. It is still uncertain whether *P. javanicum* should be regarded as a separate variety or even a separate species. *P. tinctorium* is most common on alluvial flats, also found in evergreen or deciduous or even open forest in periodically dry locations, up to 1000 m altitude. The density of the wood is about 415 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 78, 99, 125, 148, 167, 218, 234, 303, 307, 320, 413, 454, 464, 482, 490, 497, 527, 574, 676, 705.



Pterocymbium tinctorium (Blanco) Merr. – 1, tree habit; 2, twig with leaves; 3, sectioned female flower; 4, fruit.

Pterocymbium tubulatum (Masters) Pierre

Fl. forest. Cochinch. 3: tab. 193–195 (1889).

Synonyms *Sterculia tubulata* Masters (1874), *Pterocymbium parviflorum* Merr. (1929).

Vernacular names Indonesia: bajur-talang, kelumbuk (Sumatra), borang karung (Dayak, Kalimantan). Malaysia: kluet (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as amberoi.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 60 cm in diameter, with short buttresses; leaves ovate to elliptical-oblong, base rounded, glabrescent except sometimes along the midrib below, pinnately veined or with 3 palmate basal veins; flowers tubular, the lobes almost half as long as the tube, pale green. *P. tubulatum* occurs locally, often in small groups or scattered at the foot of hills, in valleys, or along rivers, usually in the lowland but ascending up to 1000 m altitude.

Selected sources 26, 99, 307, 705.

C. Phengklai (general part),
S.I. Wiselius (properties),
S. Sudo (wood anatomy),
M.S.M. Sosef (selection of species)

Quercus L.

Sp. pl. 2: 994 (1753); Gen. pl. ed. 5: 431 (1754).

FAGACEAE

x = 12; $2n$ = 24 for the majority of species throughout the world, *Q. castaneifolia* A. Camus: $2n = 28$, *Q. lineata*: $n = 12$

Trade groups Mempening: medium-weight to heavy hardwood, e.g. *Quercus argentata* Korth., *Q. gemelliflora* Blume, *Q. lineata* Blume.

Mempening includes the timber of *Lithocarpus* spp. as well as of *Quercus* spp.

Vernacular names Mempening: oak, Sunda oak (En). Chêne (Fr). Indonesia: pasang (general). Thailand: ko (general).

Origin and geographic distribution *Quercus* consists of about 600 species, most of which are northern temperate. They occur from North America towards north-western South America, in Europe and from North Africa across the Middle East and the Himalayas towards eastern Asia, north-eastern India across Indo-China to Thailand, and the western Malesian area where 19 species are found. The Malesian species are distributed as follows: Peninsular Malaysia (8 species), Sumatra (10 species), West and Central Java (5 species), Borneo (18 species) and Palawan (1 species). Many fossils dating back as far as the Upper Cretaceous have been reported, mainly from North America including Canada and Alaska, Greenland and Europe, but also from Japan, Korea, Manchuria and India.

Uses The timber is used for medium to heavy construction, provided that it is not in contact with the ground, e.g. for beams, posts and boards in house and bridge construction, poles for carts, tool handles, furniture and carpentry. It is also suitable for interior finish, panelling, parquet flooring and decorative veneer, and is also used as firewood.

The bark sometimes yields tannin. In Borneo, logs of some species have been tried for the cultivation of mushrooms. *Q. lineata* has proved useful for erosion control of steep slopes in montainous regions.

Production and international trade In South-East Asia *Quercus* timber is traded together with that of *Lithocarpus*, which is much more abundant, as mempening. In 1987, the export of mempening round logs from Sabah was about 650 m^3 with a value of US$ 45 000, but in 1992 the export had increased considerably to 12 750 m^3 (17% as sawn timber and 83% as logs) with a total value of US$ 1.1 million (US$ 187/m^3 for sawn timber, US$ 70/m^3 for logs). However, the wood is mostly consumed by local people. Japan imports comparatively small amounts of mempening, mainly from Sabah and Sarawak.

Properties *Quercus* wood is medium-weight to heavy and moderately hard to hard. The heartwood is grey-brown to dark brown-red, sometimes with a yellow tinge, and clearly demarcated from the paler sapwood. The density is (520–)815–1100 kg/m^3 at 15% moisture content. The grain is straight or slightly wavy, texture coarse.

At 15% moisture content, the modulus of rupture is 120–127 N/mm^2, modulus of elasticity 17 740–18 100 N/mm^2, compression parallel to grain 53–62.5 N/mm^2, compression perpendicular to grain c. 12 N/mm^2, shear 9–16 N/mm^2, cleavage 78–92 N/mm radial and 66 N/mm tangential, and Janka side hardness 5735–10 640 N.

The wood air dries rather slowly and is liable to some bowing, end checking and splitting; it may suffer from staining. Conversion of green timber into planks and close piling during drying may prevent heavy degrade. Boards 15 mm thick take about 2 months to air dry, boards 40 mm thick take 5 months.

Mempening wood is slightly difficult to resaw and cross cut, especially when air dry. Planing and boring are generally easy with smooth finish, but turning is difficult with rough finish. The resistance to splitting when nailed is rated as moderate. Good veneer can be obtained at a peeling angle of 92°30' without pretreatment.

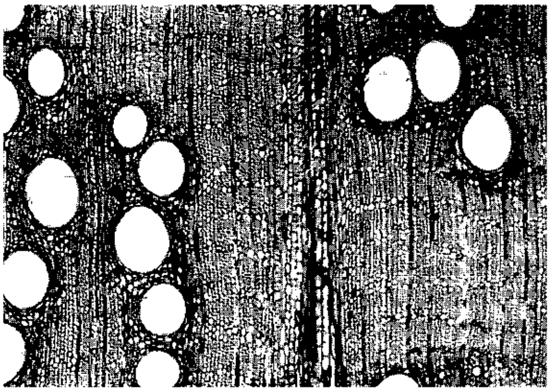
The wood is rated as moderately durable. Mempening test stakes showed an average service life in contact with the ground of 3.7 years in Malaysia. The wood is reputed to be attacked by termites when in contact with the ground. The heartwood is probably difficult to impregnate because of the presence of tyloses.

Description Monoecious, evergreen, small to fairly large trees up to 40 m tall, sometimes forming clumps; bole up to 130 cm in diameter, sometimes buttressed with thick, equal to steep buttresses up to 2.5 m high, or basally fluted, rarely stilt-rooted; bark surface smooth to shallowly fissured or scaly, with prominent lenticels, pale yellow to greyish-brown, inner bark with broad hard rays penetrating the cambium, cream to orange or red to brown. Leaves arranged spirally, simple, margin entire or minutely serrate in the apical half, glabrous to densely pubescent or tomentose at least below; petiole thickened at base; stipules extrapetiolar, linear-acute, caducous. Inflorescence unisexual, spicate; male inflorescence solitary in the axils of lower leaves or in paniculate clusters on the lateral or subterminal young shoots, pendulous, simple or branched; female inflorescence solitary in the axils of higher leaves, erect, simple, few- to many-flowered. Male flowers in clusters of 3–4; perianth segments (4–)6, connate at base, densely tomentose; stamens (4–)6(–9), with slender filaments and large basifixed anthers; pistillode absent or replaced by a tuft of hairs. Female flowers solitary; perianth segments (4–)6(–9), connate at base; staminodes 0 or 5–7; styles 3–4(–6), free or connate at base, stigmas broadly capitate; ovary cells as many as the styles.

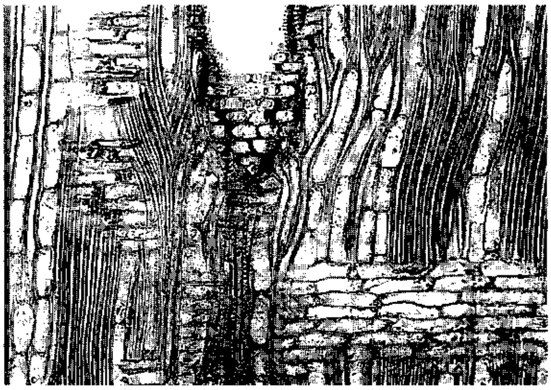
Cupule cup- or saucer-shaped, with raised ring-like flanges, hairy on both sides. Fruit an indehiscent nut (acorn), 1 per cupule, glabrous to densely tomentose, apex umbonate, the umbo with many rings. Seed 1, exalbuminous; cotyledons flat-convex. Seedling with hypogeal germination; leaves conduplicate, alternate-spiral at the first few nodes or replaced by scales.

Wood anatomy
– Macroscopic characters:
Heartwood grey-brown to dark brown-red, sometimes with a yellow tinge, clearly demarcated from the paler sapwood. Grain straight or slightly wavy. Texture coarse. Growth rings absent to distinct (depending on provenance of the species); vessels visible to the naked eye, in radial to diagonal pattern; parenchyma barely visible with a hand lens; broad rays conspicuous and causing silver grain on quarter-sawn surfaces.
– Microscopic characters:
Growth rings absent in equatorial tropical species, but distinct in species from other areas (e.g. Vietnam). Vessels in a diagonal to radial pattern, 5–8(–10)/mm^2, exclusively solitary, very rarely in pairs due to overlapping ends, round to oval, average tangential diameter 100–200 μm; perforations simple; intervessel pits not observed; vessel-ray and vessel-parenchyma pits typically elongated and simple or with reduced borders; helical thickenings and deposits absent; tyloses usually present. Vasicentric tracheids abundant, forming radial, oblique or flame-like tissue bands together with the vessels. Fibres 900–2200 μm long, non-septate, medium to very thick-walled, with minutely bordered pits mainly confined to the radial walls. Parenchyma apotracheal, typically diffuse, diffuse-in-aggregates and in short uniseriate lines, in 6–8-celled strands. Rays of two distinct sizes, uniseriate rays 10–12/mm, 5–12 cells high, multiseriate rays many (up to over 20) cells and 0.2–0.6 mm wide and 2–6(–12) mm high, often compound or intergrading with ray aggregates, typically homocellular, composed of procumbent cells, but broad rays sometimes weakly heterocellular and with square to upright marginal cells; some ray cells extremely thick-walled and fibre-like. Crystals prismatic, in chambered axial parenchyma and ray cells.
Species studied: *Q. gemelliflora*, *Q. lineata*, *Q. oidocarpa*.

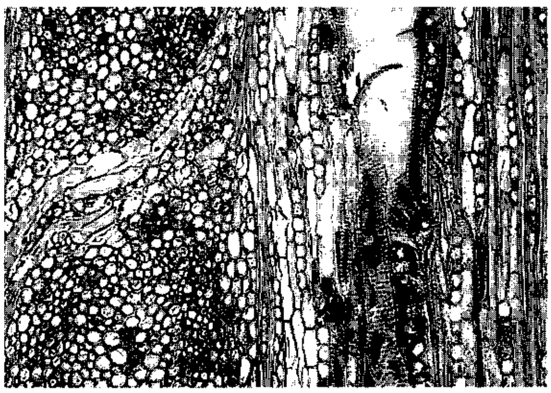
Growth and development In seedlings shoot growth is intermittent after the first few nodes, with the leaves clustered at the top of each flush. Under favourable conditions in Java, seedlings



transverse section (×25)



radial section (×75)



tangential section (×75)

Quercus lineata

may attain a height of 0.5 m after 1 year, 2 m after 3 years and 3 m after 5 years.

A *Q. gemelliflora* tree planted in an arboretum in Malaysia reached a height of 18 m after 38 years, with a bole branchless for 6.5 m and a diameter of 24 cm, i.e. a mean annual diameter increment of 0.6 cm.

As in most, or perhaps all *Fagaceae*, the trees seem to live in symbiosis with ectotrophic mycorrhiza (*Agaricales*). Flowering usually coincides with young flushes, often at the beginning of the rainy season. Pollination is by wind. The comparatively large and heavy fruits fall close to the mother tree; they do not float in water.

Other botanical information *Quercus* and *Lithocarpus* were formerly considered as a single genus because of their similar cupules. This similarity, however, is the result of convergent evolution. In *Quercus* a cupule develops below a 3-flowered dichasium (a dichasium cupule) but the 2 lateral flowers are reduced, resulting in a solitary flower in the cupule. Within *Lithocarpus* a cupule develops below each female flower in a 3–7-flowered dichasium (a flower cupule). In some species the lateral flowers reduce, resulting in a similar but ontogenetically different solitary flower. Actually, *Quercus* and *Lithocarpus* are considered as evolutionarily far apart. Furthermore, *Quercus* differs from *Lithocarpus* particularly by its unisexual inflorescences, its pendulous male inflorescences, and its male flowers usually having 6 stamens with basifixed large anthers. *Lithocarpus* has uni- or bisexual inflorescences, erect male inflorescences, and male flowers usually with 12 stamens with dorsifixed small anthers.

All Malesian species of *Quercus* belong to the subgenus *Cyclobalanopsis* (Oersted) Schneider, which is confined to eastern and south-eastern Asia.

Ecology In Malesia, *Quercus* often constitutes canopy and subcanopy elements of primary evergreen lowland and especially of lower montane rain forest. Species occur from sea-level up to 3350 m altitude, with a preference for the region between 600 and 1500 m, in various types of forest, i.e. mixed dipterocarp forest, swamp forest, kerangas, and ridge forest. They are usually found on sandy clay or sandy loam soils, but are also reported from ultrabasic soil overlying sandstone or granite. In lower montane forest in North Sumatra *Quercus* is found on a yellowish-brown andosol with ultrabasic volcanic ash and a pH of 4.5–6.5, and growing together with *Calophyllum*, *Castanopsis*, *Cinnamomum*, *Endospermum*, *Litsea* and *Syzygium* species. In a lowland peat-swamp forest dominated by *Shorea* spp. in Riau, Sumatra, *Quercus* was found together with *Alstonia*, *Cratoxylum*, *Durio*, *Gonystylus* and *Palaquium* species.

Propagation and planting *Quercus* can be propagated by seed, including direct sowing, and wildling collection. The number of nuts per kg is about 165 for *Q. lineata*. Seed needs shade for germination. In a small germination trial conducted for *Q. oidocarpa* 12 of the 20 seeds sown germinated in 12–37 days.

Seedlings can be planted when 25–30 cm tall, but great care must be taken during transport to avoid damaging the main root. Damage may cause root rot. Stumping has been attempted in *Q. lineata* with stumps of 20 cm long and 0.5 cm diameter but none of the stumps planted survived. A spacing of 3 m × 2 m is recommended for planting.

Wildling collection is known from Sumatra and the application of the growth hormone rootone F stimulated height and diameter increment. Survival of wildlings was 50–60%. Direct seeding is possible for cleared fields. Natural regeneration in primary forest is generally sparse.

Silviculture and management An inventory of natural regeneration of *Quercus* in North Sumatra revealed that there were seedlings and saplings in abundance. Therefore, *Quercus* has been incorporated in a local reforestation project instead of the *Pinus* and *Acacia* species used previously. In these pure stands it is expected that clear cutting with natural regeneration can be applied with a rotation of 60 years. *Q. lineata* has been used to underplant *Pinus merkusii* Junghuhn & de Vriese plantations in Java. Like other Malesian *Fagaceae*, *Quercus* is not resistant to fire nor does it regenerate under pyrogenous conditions.

Diseases and pests Attacks by the fungus *Fomes pinicola*, the beetle *Coraebus dorsalis* and the caterpillar *Zeuzera multistrigata* have been reported in *Q. lineata*. Monkeys, pigs and wild boars are known to feed on the fruits, thus limiting the potential for natural regeneration in silvicultural management.

Handling after harvest The timber should be treated with anti-stain chemicals immediately after sawing.

Genetic resources *Quercus* does not seem to be very liable to genetic erosion. Together with *Lithocarpus* spp., *Quercus* spp. dominate or codominate in mid-montane forest in western Malesia. The economic value of the timber is slight in most regions, and selective logging on a larger scale is practised only locally in Borneo. Several species, however, occur only very locally and need protection (e.g. some species are found only or mainly on Mount Kinabalu, Sabah, other species only very locally in Sarawak, and one species very locally in North Sumatra). *Quercus* trees are planted on a very small scale in South-East Asia, especially in botanical gardens.

Prospects It is unlikely that *Quercus*, like *Lithocarpus*, has great prospects as a timber plantation tree. The trees are comparatively slow growing, and the timber is often refractory in drying and working. However, it is considered as promising in sustainably managed forests in mountainous areas, where more favourable timber-producing species such as *Shorea* spp. do not grow well.

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Selection of species

Quercus argentata Korth.

Temminck, Verh. Natuurl. Gesch. Overz. Bez., Bot., Kruidk.: 215, t. 47, fig. 1–17 (1844).

Synonyms *Quercus pinanga* Blume (1850), *Cyclobalanopsis argentata* (Korth.) Oersted (1867), *Quercus wilhelminae* von Seemen (1906).

Vernacular names Indonesia: mempening (Bangka), pasang bungkus, pasang pinang (Sumatra). Malaysia: mempening (general), pening pening, pinang pinang (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra, Bangka, the Anambas Islands, West Java and Borneo (not in Brunei).

Uses The wood is used as mempening; it has been used for house building.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 100 cm in diameter, sometimes fluted at base, with buttresses up to 2 m high, bark surface smooth, pale grey, inner bark laminated to granular, pale brown; leaves elliptical-oblong to lanceolate-oblong, 6–22 cm × 3–7 cm, margin entire, with 10–17 pairs of secondary veins, midrib sunken above, silvery stellate-tomentose below, tertiary venation obscure; rachis male inflorescence 5–10 cm long, rachis female one 2–3 cm long, many-flowered; cupule cup-shaped, 1–1.5 cm across, with 8–10 lamellae; fruit elongated conical to ovoid-globose, 3–3.5 cm × 1.5 cm. *Q. argentata* is uncommon in lowland to montane forest, often on swampy locations, up to 2700 m altitude. The density of the wood is about 920 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 78, 82, 99, 162, 234, 364, 705.

Quercus elmeri Merr.

Univ. Calif. Publ. Bot. 15: 43 (1925).

Distribution Peninsular Malaysia, central Sumatra and Borneo.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 60 cm in diameter, occasionally with plank buttresses, bark surface with longitudinal rows of lenticels or scaly, greyish-brown, inner bark fibrous, reddish-brown; leaves elliptical-lanceolate to elliptical-oblong, 5-14 cm × 1-5 cm, margin remotely serrulate towards the apex, with 5-12 pairs of secondary veins, midrib flat above, densely rufous tomentose below, tertiary venation obscure on both surfaces; male inflorescence unknown, rachis female one 2.5-5 cm long, few-flowered; cupule shallowly cup- or saucer-shaped, 2-2.5 cm across, with 5-7 lamellae; fruit ovoid-conical to conical-cylindrical, 2-3 cm × 1.5-2 cm. *Q. elmeri* is uncommon in lower montane forest, up to 1400 m altitude, on sandy loam or ultrabasic soils.

Selected sources 77, 82, 162, 581, 705.

Quercus gaharuensis Soepadmo

Gard. Bull. Sing. 21: 384, fig. 3 (1966).

Synonyms *Quercus oidocarpa* non Korth. sensu Hook.f. (1888).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sarawak and Sabah).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 30 m tall, bole up to 100 cm in diameter, with spreading buttresses up to 0.7 m high, bark surface smooth, hoop-marked, mottled, inner bark orange-brown; leaves elliptical-lanceolate to elliptical-oblong, 5-23 cm × 2-9 cm, margin entire or remotely serrulate towards the apex, with 8-15 pairs of secondary veins, midrib raised above, densely stellate-pubescent but glabrescent below, tertiary venation distinct below; rachis male inflorescence 1.5-3.5 cm long, rachis female one 1-1.5 cm long, with 2-5 flowers; cupule deeply cup-shaped, 2-2.5 cm across, with 6-8 lamellae; fruit ovoid-conical, 2-3 cm × 2 cm. *Q. gaharuensis* is found in lowland mixed dipterocarp forest to submontane forest, up to 1400 m altitude.

Selected sources 162, 580, 581, 705.

Quercus gemelliflora Blume

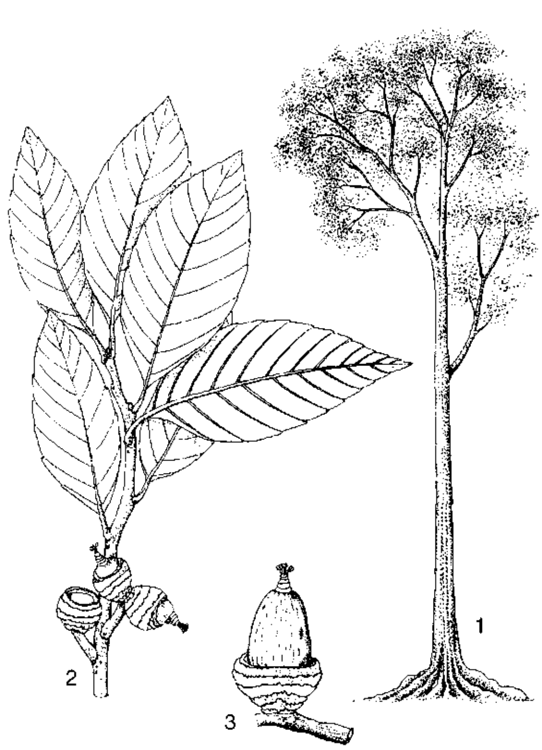
Verh. Batav. Genootsch. Kunsten 9: 222, t. 6 (1823).

Synonyms *Quercus turbinata* Blume (1826), *Quercus horsfieldii* Miq. (1856), *Quercus crassilamellata* (Gamble) A. Camus (1931).

Vernacular names Indonesia: pasang jambe (Javanese, Java), pasang hiris (Sundanese, Java), karamayo batu (Tapah, Simeuluë). Malaysia: mempening, medang tahi ulat (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra, Bangka, West and Central Java and Borneo.

Uses The wood is used as mempening, e.g. for house building. The bark yields tannin.



Quercus gemelliflora Blume – 1, tree habit; 2, fruiting branch; 3, fruit.

Observations A medium-sized tree up to 30 m tall, bole up to 80 cm in diameter, with steep buttresses up to 2 m high, bark surface smooth or finely fissured, hoop-marked, greyish-brown, inner bark granular, dull brown to orange; leaves elliptical-lanceolate to elliptical-oblong, 5-15 cm × 2-5.5 cm, margin remotely serrulate in the upper half, with 8-10 pairs of secondary veins, midrib slightly raised above, densely pubescent but glabrescent below, tertiary venation distinct below; rachis male inflorescence 5-6 cm long, rachis female one 3-4 cm long, 2-7-flowered; cupule cup-shaped, 1.5-2.5 cm across, with 7-8 lamellae; fruit conical-cylindrical, 2-5.5 cm × 1-2 cm. *Q. gemelliflora* is found in lowland to montane forest, up to 2150 m altitude, often along streams, on red sandy clay or ultrabasic soil overlying sandstone or granite. The density of the wood is 520-1050 kg/m^3 at 15% moisture content.

Selected sources 78, 82, 99, 162, 234, 369, 466, 474, 581, 705.

Quercus kerangasensis Soepadmo

Gard. Bull. Sing. 22: 399, fig. 12 (1968).

Distribution Borneo (Sarawak and Brunei).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 30 m tall, bole up to 50 cm in diameter, fluted and with small buttresses, bark surface smooth to rough, grey; leaves elliptical-lanceolate, 4–11 cm × 2–4 cm, margin entire, with 7–10 pairs of secondary veins, midrib slightly prominent above, glaucous and glabrous except for the midrib below, tertiary venation obscure below; rachis male inflorescence 1–2 cm long, rachis female one unknown; cupule cup-shaped, 1.5–2 cm across, with 5–7 lamellae; fruit ovoid-conical to ovoid-cylindrical, 2–3 cm × 1.2–1.5 cm. *Q. kerangasensis* is found in primary kerangas forest, up to 100 m altitude.

Selected sources 162, 581.

Quercus lineata Blume

Bijdr. fl. Ned. Ind.: 523 (1826).

Synonyms *Quercus oxyrhyncha* Miq. (1861), *Cyclobalanopsis lineata* (Blume) Oersted (1867), *Quercus hendersoniana* A. Camus (1932).

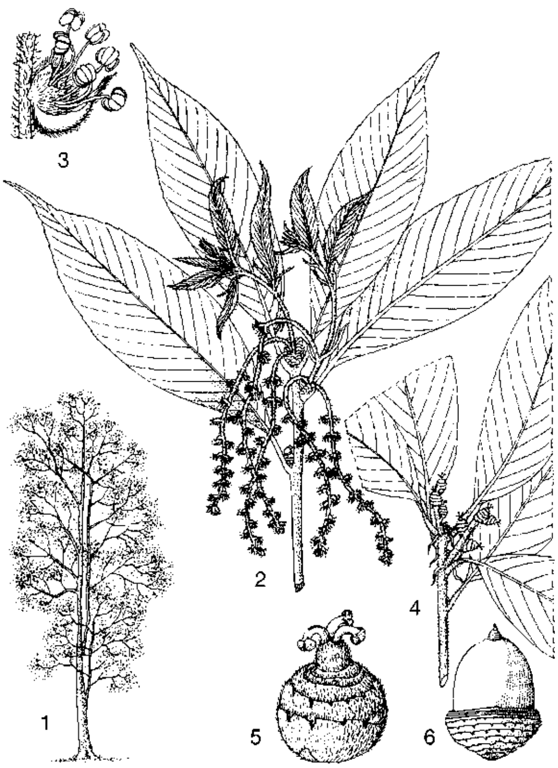
Vernacular names Indonesia: pasang (general), pasang emprit, pasang jambe (Javanese). Malaysia: mempening batu (Peninsular).

Distribution Peninsular Malaysia, Sumatra, West and Central Java and Borneo (Sarawak and Sabah).

Uses *Q. lineata* is an important source of mempening wood, e.g. for general construction. Perhaps more important is its use to control erosion when planted on steep slopes in montainous regions.

Observations A medium-sized tree up to 30 m tall, bole up to 80 cm in diameter, with steep buttresses up to 1.2 m high, sometimes suckering, often stilt-rooted, bark surface smooth, grey, inner bark fibrous, cream to reddish-brown; leaves ovate-elliptical to ovate-lanceolate, 5–16 cm × 2–6 cm, margin remotely serrulate in the upper half, with 10–23 pairs of secondary veins, midrib raised above, densely appressed pubescent below, tertiary venation obscure; rachis male inflorescence 5–10 cm long, rachis female one 1.5–2 cm long, with 5–6 flowers; cupule cup-shaped, 2–2.5 cm across, with 8–10 lamellae; fruit conical-cylindrical, 2–3 cm × 1–2 cm. *Q. lineata* is found in lower and upper montane forest on yellow sandy or ultrabasic soils, at 1000–2000(–2500) m altitude. The density of the wood is 815–1100 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 66, 82, 99, 140, 162, 218, 303, 397, 403, 474, 522, 581, 705.



Quercus lineata Blume – 1, tree habit; 2, twig with male inflorescences; 3, male flower; 4, twig with female flowers; 5, female flower enclosed by cupule; 6, fruit.

Quercus oidocarpa Korth.

Temminck, Verh. Natuurl. Gesch. Overz. Bez., Bot., Kruidk.: 216, t. 47, fig. 18 (1844).

Synonyms *Cyclobalanopsis oidocarpa* (Korth.) Oersted (1867), *Quercus brevistyla* A. Camus (1933).

Vernacular names Indonesia: pasang pinang (Sumatra). Malaysia: berangan antan, ginting simpah, mempening (Peninsular). Thailand: komuak.

Distribution Peninsular Thailand, Peninsular Malaysia, western central Sumatra and Java.

Uses The wood is used as mempening, e.g. for house building.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, with thick buttresses up to 1.5 m high, bark surface scaly with rectangular pieces, grey, inner bark fibrous to granular, mottled, yellow to brown; leaves oblong-lanceolate to elliptical-oblong, 7–17 cm × 3–7 cm, margin remotely serrulate, with 9–15 pairs of secondary veins, midrib sunken above, sparsely stellate-tomentose below, tertiary venation distinct below; rachis male inflorescence 5–7 cm long, rachis female one 3–7 cm long, 3–7-flowered; cupule deeply cup-shaped, 3–3.5 cm across, with 9–11 lamellae; fruit ovoid-globose, 2.5–3.5 cm × 2–3 cm. *Q. oidocarpa* occurs in hill and submontane forest on sandy clay, sandy loam or granitic soils, at 150–1500 m altitude.

Selected sources 78, 82, 162, 234, 463, 465, 581, 705.

Quercus sumatrana Soepadmo

Gard. Bull. Sing. 21: 387, fig. 4 (1966).

Distribution Sumatra and Borneo.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 130 cm in diameter, with buttresses up to 2.5 m high, bark surface rough, grey; leaves elliptical-lanceolate, 8–24 cm × 2–8 cm, margin entire and undulate to remotely serrulate towards the apex, with 8–13 pairs of secondary veins, midrib slightly prominent above, sparsely hairy and glaucous below, tertiary venation obscure below; male and female inflorescences unknown; cupule shallowly cup-shaped, 2–2.5 cm across, with 4–5 lamellae; fruit ovoid-conical, 1.8–2 cm × 1.5–2 cm. *Q. sumatrana* is a still imperfectly known species of forest on sandy loam or basalt-derived soils, up to 1300 m altitude.

Selected sources 162, 580, 581.

Quercus treubiana von Seemen

Bull. Dép. Agr. Ind. Néerl. 1: 3 (1906).

Synonyms *Cyclobalanopsis treubiana* (von Seemen) Schottky (1912).

Distribution Southern Sumatra and Borneo (Sabah and Kalimantan).

Uses The wood is reputed to be used as mempening.

Observations A medium-sized tree up to 30 m tall, bole irregular, up to 60 cm in diameter, with buttresses up to 1 m high, bark surface rough, peeling off in rectangular pieces, rusty, inner bark laminated; leaves linear-lanceolate to elliptical-lanceolate, 3–10 cm × 1–3 cm, margin remotely serrulate towards the apex, with 5–10 pairs of secondary veins, midrib prominent above, densely pubescent but glabrescent below, tertiary venation obscure below; male and female inflorescences incompletely known; cupule cup-shaped, 1–2 cm across, with 10–12 lamellae; fruit cylindrical-globose, 2–3 cm × 1.5–2 cm. *Q. treubiana* occurs in hill and montane forest, sometimes on sandy waterlogged soils, at 600–2100 m altitude.

Selected sources 99, 162, 581.

Quercus valdinervosa Soepadmo

Gard. Bull. Sing. 22: 404, fig. 14 (1968).

Synonyms *Quercus mespilifolia* Wallich ex A.DC. var. *borneensis* Heine (1951).

Distribution Borneo.

Uses The wood is reputed to be used as mempening.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 60 cm in diameter, bark surface smooth, grey; leaves elliptical to obovate-oblong, 8–15 cm × 3–6 cm, margin remotely serrulate in the apical half, with 10–15 pairs of secondary veins, midrib flattened to sunken above, densely pubescent but glabrescent below, tertiary venation distinct below; rachis male inflorescence 5–10 cm long, rachis female one 1–1.5 cm long, with 4–6 flowers; cupule cup-shaped, 1–2.5 cm across, with 7–8 lamellae; fruit cylindrical-conical to ellipsoid, 3–3.7 cm × 1.3–1.7 cm. *Q. valdinervosa* occurs locally frequently in submontane and montane forest at 1200–2300 m altitude.

Selected sources 99, 162, 581.

B. Sunarno (general part, selection of species),
W.C. Wong (properties),
Nguyen Dinh Hung (wood anatomy),
M.S.M. Sosef (selection of species)

Santiria Blume

Mus. Bot. Lugd.-Bat. 1: 209 (1850).

BURSERACEAE

x = unknown

Trade groups Kedondong: lightweight to medium-weight hardwood, e.g. *Santiria laevigata* Blume, *S. oblongifolia* Blume, *S. tomentosa* Blume.

Kedondong is the standard trade name for all timber of the family *Burseraceae*, hence including next to *Santiria* timber also that of *Canarium, Dacryodes, Garuga, Protium, Scutinanthe* and *Triomma*.

Vernacular names Kedondong. Brunei: upi. Indonesia: kenari, kerantai. Malaysia: kerantai (Sabah), upi, seladah (Sarawak).

Origin and geographic distribution *Santiria* consists of 22 species, 6 of which are restricted to western Africa, and the rest in the Malesian area, predominantly in western Malesia. The 16 Malesian species are distributed as follows: Peninsular Malaysia (8 species), Sumatra (7 species), Borneo (14 species of which 8 endemic), Sulawesi (2 species), and the Philippines, the Moluccas and New Guinea (each with 1 species).

Uses The timber is suitable for application under cover only, e.g. for light construction, planking, cladding, flooring, door and window frames, mine timber, furniture, drawers, turnery, parangs, handles, rifle butts, packing cases, pallets, particle board, plywood and rotary veneer. It is also used for beams and posts. The wood of the buttresses of *S. tomentosa* shows interlocked grain and is frequently used in Peninsular Malaysia for sheaths for parangs.

Fruits and seeds of some species are edible and an edible oil is extracted from the pericarp of *S. tomentosa* fruits.

Production and international trade *Santiria* timber is usually not traded separately but is mixed with the timber of other *Burseraceae* genera and sold as kedondong. In 1983, 16 350 m^3 of kedondong sawlogs was exported from Peninsular Malaysia (69% to Singapore, 19% to South Korea and 12% to Hong Kong) with a total value of US$ 675 000, and in 1984 9500 m^3 (99% to Singapore and 1% to Japan) with a value of US$ 395 000 (US$ 42/m^3). The export of round logs from Sabah was only 1170 m^3 with a value of US$ 75 000 (US$ 64/m^3) in 1987, but by 1992 kedondong timber exports from Sabah had risen to 15 000 m^3 (17% as sawn timber, 83% as logs) with a total value of US$ 1.3 million (US$ 170/m^3 for sawn timber and US$ 69/m^3 for logs). Japan imports small amounts of *Santiria* timber, mainly from Sarawak.

Properties *Santiria* wood is lightweight to medium-weight and moderately hard. The heartwood is yellowish-brown, greenish-brown to pinkish-brown or reddish-brown and distinctly demarcated from the paler sapwood. The density is 470–1070 kg/m^3 at 15% moisture content. The grain is shallowly to deeply interlocked, texture moderately fine.

Wood tested at green condition showed the following mechanical properties: the modulus of rupture 54–90.5 N/mm^2, modulus of elasticity 11 200–15 700 N/mm^2, compression parallel to grain 31–53 N/mm^2, shear 8 N/mm^2, Janka side hardness 2575–5390 N and Janka end hardness 2695–6245 N.

The rates of shrinkage are moderate to fairly high: for *S. laevigata* wood from green to 15% moisture content 1.8% radial and 3.2% tangential, and for *S. griffithii* wood from green to oven dry 4.8% radial and 8.2% tangential. Timber of *S. laevigata* air dries without serious degrade. Slight end-splitting may occur but end-coating can prevent this; slight bowing and cupping may also occur. In Malaysia, boards 15 mm thick are reported to require 2–3 months to reach air-dry condition, and boards 40 mm thick require 5–6 months.

The wood may blunt saw teeth very badly due to the presence of silica, interlocked grain and an often moderate density. Wood of *S. laevigata* is reported in Malaysia as very difficult to resaw and cross-cut, difficult to bore with a slightly rough surface, and slightly difficult to plane and turn with moderately smooth surfaces. However, tests on the machining properties of *S. rubiginosa* and *S. tomentosa* wood in Indonesia showed good results except for planing and turning in *S. rubiginosa*.

The wood of most *Santiria* species is classified as non-durable. Graveyard tests in Malaysia showed an average service life in contact with the ground of 2.1 years for stakes of *S. laevigata* wood. However, the wood of some species such as *S. griffithii* and *S. rubiginosa* is moderately durable. Laboratory tests in Indonesia showed that the resistance to dry-wood termites is poor, and that the resistance to wood-rotting fungi is quite variable (*S. griffithii* and *S. rubiginosa* were found to be resistant, *S. laevigata*, *S. oblongifolia* and *S. tomentosa* resistant to non-resistant depending on the fungus species used). The heartwood is very difficult to treat with preservatives when using the full-cell process or an open tank treatment, but the sapwood is more permeable. Cold soaking of *S. griffithii* and *S. tomentosa* wood in BFCA solution for 5 days showed a good side penetration (up to 50 mm), but the retention was quite low, up to 10 kg/m^3.

The wood contains 41–49% cellulose, 27–30% lignin, 10.5–15.5% pentosan, up to 1.6% ash and up to 0.8% silica. The solubility is 1.2–5.1% in alcohol-benzene, 1.0–3.6% in cold water, 2.0–4.9% in hot water, and 8.9–13.5% in a 1% NaOH solution.

Description Dioecious, evergreen, medium-sized to large trees up to 35(–45) m tall; bole usually branchless for a considerable length, up to 120 cm in diameter, buttresses small or absent; bark surface smooth to fissured, scaly, or flaky, with many small or large lenticels, dark brown, fawn, or grey, inner bark either soft, laminated and pink, or hard, mottled and granular and yellow-white, with white to colourless exudate darkening on drying; pith of the branches usually without vascular strands. Leaves arranged spirally, usually tending to crowd towards the end of twigs, imparipinnate, with (1–)5–15 entire leaflets with a slightly oblique base and acuminate apex; petiole either terete or the upper surface flat or channelled; stipules absent. Inflorescence axillary, rarely terminal, paniculate. Flowers actinomorphic, 3-merous; sepals free or united; petals with a usually slightly thickened and inflexed apex; stamens 3 or 6, glabrous; disk intrastaminal, glabrous; ovary superior, 3-celled, each cell with 2 axillary ovules, stigma sessile or subsessile. Fruit an irregularly globose or ellipsoid, more or less oblique drupe, usually seated on a persistent calyx, brightly coloured, with an excentric or sometimes nearly basal stigma remnant; pericarp thin and firm, almost smooth when dry, stone thinly woody, containing 1 fertile and 2 sterile cells. Seed subglobular; cotyledons pinnate, variously folded. Seedling with epigeal or hypogeal germination; first 2 leaves opposite, simple or pinnate, subsequent leaves alternate and then arranged spirally.

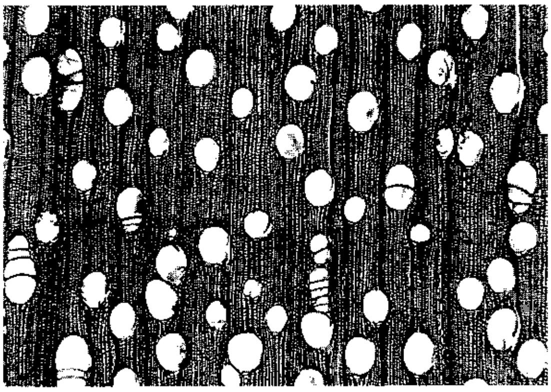
Wood anatomy

– Macroscopic characters:

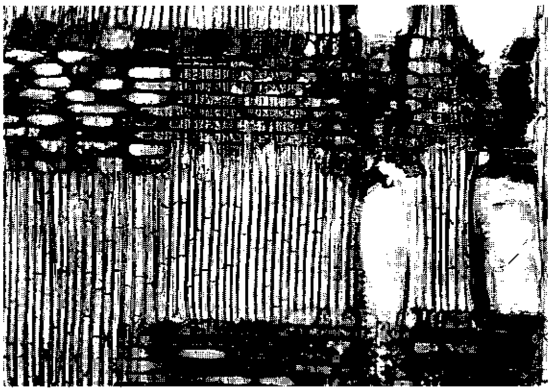
Heartwood pale reddish to greyish-brown, distinctly demarcated from the pale yellowish-brown sapwood. Grain slightly to moderately interlocked. Texture moderately fine; wood weakly lustrous. Growth rings indistinct; vessels medium-sized to rather large, visible to the naked eye, tyloses sparse to moderately abundant; parenchyma indistinct; rays almost invisible to the naked eye; ripple marks absent.

– Microscopic characters:

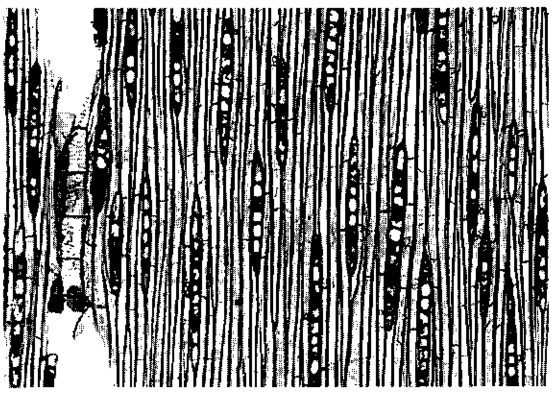
Growth rings absent or indistinct with occasional tangential series of thick-walled fibres or marginal parenchyma. Vessels diffuse, 12–15/mm^2, solitary (30–75%) or in multiples of 2–6, generally oval, average tangential and radial diameters 90–125 μm and 105–135 μm respectively, maximum tangential and radial diameters 140–190 μm and 155–220 μm respectively, walls 2–3 μm thick; perforation plates simple; intervessel pits alternate, with a pit-border diameter of 8–12 μm; vessel-ray pits with much reduced borders to almost simple, horizontal to vertical, 5–25 μm in diameter; tyloses sparse to moderately abundant. Fibres 0.8–1.5 mm long, septate, 5–27 μm in tangential diameter, thin-walled (1.5–2.5 μm), with sparse minutely bordered pits mainly confined to the radial walls. Axial parenchyma scanty paratracheal and rarely in irregular apotracheal bands of 2–4 cells wide, strand length 2–4 cells. Rays uniseriate, occasionally partly biseriate, mostly less than



transverse section (×25)



radial section (×75)



tangential section (×75)

Santiria tomentosa

0.6 mm high, heterocellular with 1–2 rows of square to upright marginal cells. Crystals absent. Silica bodies abundant in fibres and ray cells. Intercellular canals absent.
Species studied: *S. griffithii*, *S. laevigata*, *S. megaphylla*, *S. tomentosa*.

Growth and development Germination is epigeal in *S. laevigata* and *S. oblongifolia*, with emergent, 5-lobed and fleshy cotyledons, and elongated hypocotyl; the first leaves are simple. Germination is hypogeal in *S. griffithii* and *S. rubiginosa*, with cotyledons not emergent, hypocotyl undeveloped and all leaves pinnate.
Young plants usually grow slowly, but growth is usually much faster after a few years. *S. laevigata* seedlings reach about 60 cm tall after 16 months and seedlings of *S. rubiginosa* 70 cm tall after 30 months. The mean annual diameter increment of *S. laevigata* trees in natural forest in Sabah was recorded as 0.8 cm.
S. laevigata is an aseasonal tree and it usually flowers and fruits every year. Fruits ripen about 4 months after flowering and are eaten by many vertebrates.

Other botanical information *Santiria* is most closely related to *Haplolobus* and *Dacryodes*. It is characterized by its 3-merous flowers, leaves without stipules, and especially by the asymmetrical fruit with a lateral stigma vestige. It is sometimes difficult to assign material without fruits to one of the 3 genera.
The genus *Santiria* is divided into 3 sections. Section *Santiriopsis* (Engl.) H.J. Lam is restricted to Africa, the other 2 are confined to Malesia. Section *Santiria* has a calyx with distinct tube and short lobes, and 6 stamens with basi- or dorsifixed anthers. Section *Icicopsis* Bennett is characterized by a concave receptacle, nearly free sepals, and 3 or 6 stamens with anthers entirely adnate to the filament.

Ecology Trees of *Santiria* are usually found in primary evergreen lowland to montane rain forest, up to 1650(–1950) m altitude. They occur both on well-drained locations, along gullies, on ridges, and in swamp forest, but rarely in peat-swamp forest. They form a common component of lowland forest in central and southern Peninsular Malaysia where they occur as main canopy trees or rarely as emergents.

Propagation and planting *Santiria* is not used for commercial planting. Fresh seed is not very viable. In experiments in Malaysia 15% of the fruits of *S. griffithii* germinated in 126–177 days, 2–30% in 26–67 days for *S. laevigata*, 35% in 27–54 days for *S. oblongifolia*, and 30% in 41–116 days for *S. rubiginosa*.

Silviculture and management In Sarawak, natural regeneration of *Burseraceae*, including *Santiria* spp., is generally rather abundant. *S. laevigata* has been reported to regenerate well in logged-over forest in Sulawesi and Riau. It was one of the dominant species 5 years after logging, and seems to have some pioneer species features.

Harvesting Trees are usually free from defects although stain and ambrosia beetle attack cause severe damage if the timber is not quickly extracted from the forest.

Yield Inventories in different forest complexes in East Kalimantan indicate that the total harvestable volume of *S. tomentosa* and *S. griffithii* ranges from 1.1–11.7 m^3/ha.
In a plot of 50 ha in lowland forest in central Peninsular Malaysia 5 *S. griffithii* trees of over 50 cm diameter were counted, 16 *S. laevigata* trees, 1 *S. rubiginosa* tree, and 2 *S. tomentosa* trees. On average this is slightly less than 1 large *Santiria* tree per 2 ha.

Handling after harvest Logs usually float in water and can thus be transported by river when desirable.

Genetic resources In selective logging systems *Santiria* trees are not of primary importance and often are left in logged-over forest. Regeneration seems fair in undisturbed forest, and is so for at least one species (*S. laevigata*) in logged-over forest, but little is known about the natural regeneration and growth of *Santiria* trees in logged-over forest. Research on regeneration is desirable to determine the risk of genetic erosion caused by different logging systems.

Prospects Very little is known about *Santiria*, but it is unlikely that it will have prospects as timber-producing tree of economic importance as it is found scattered in the forest and the quality of the timber is only moderate for many purposes.

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Selection of species

Santiria apiculata Bennett

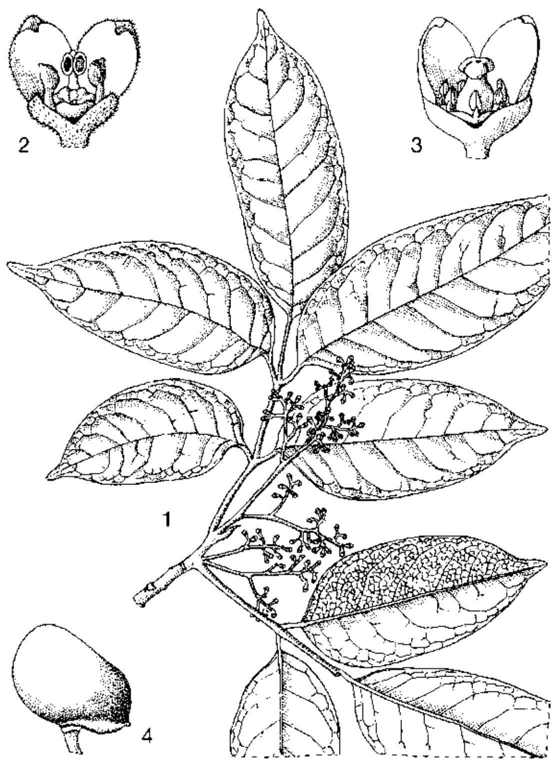
Hook.f., Fl. Brit. India 1: 537 (1875).

Vernacular names Indonesia: babi kurus, kedondong tunjuk, kerantai batu (Sumatra). Malaysia: kedondong kerantai (general), kerantai batu (Peninsular), pelajah bukit (Sabah). Philippines: kurig (Tagalog, Sambali).

Distribution Peninsular Malaysia, Sumatra, Borneo, Sulawesi, the Moluccas and the Philippines.

Uses The timber is used as kedondong, e.g. for rifle butts, house construction and as a mine timber.

Observations A small to medium-sized tree up to 20(–40) m tall, bole up to 60(–100) cm in diameter, fluted to different degrees, with short buttresses, bark surface rough to flaky, grey, inner bark cream-coloured; leaves with (1–)3-9 leaflets, petioles terete or only slightly flattened at base, leaflets ovate to elliptical, 5.5-16(-20) cm × 2-6(-9.5) cm, lower surface glabrous, secondary veins 6-14 pairs without transverse veins, reticulations inconspicuous above and distinct below; flowers 2–2.5 mm long, yellowish, stamens 6; fruit (8–)10–18 mm × 6–13 mm, red when ripe, stigma usually more than 90° excentric. *S. apiculata* is divided into 3 varieties. Var. *apiculata* (synonyms: *Santiria lagunensis* Merr., *Santiria minutiflora* Ridley, *Santiria brachystachys* Ridley) covers the complete area of distribution of the species. Var. *rubra* (Ridley) Kalkman (synonym: *Santiria rubra* Ridley) differs from the typical variety by its red flowers and its petiole being strongly flattened at base, and is found in Peninsular Malaysia and Borneo. Var. *pilosa* (Engl.) Kalkman (synonym: *Santiria pilosa* Engl.) has all veins pubescent on the lower leaf surface, and occurs in Borneo. *S. apiculata* is found in primary or sometimes secondary forest on well-drained locations, rarely in swampy places, up to 750(–1600) m altitude. The density of the wood is 660–735 kg/m³ at 15% moisture content.



Santiria apiculata Bennett – 1, flowering twig; 2, opened male flower; 3, opened female flower; 4, fruit.

Selected sources 77, 78, 99, 162, 234, 277, 474, 544, 595, 705.

Santiria conferta Bennett

Hook.f., Fl. Brit. India 1: 537 (1875).

Synonyms *Santiria wrayi* King (1894).

Vernacular names Indonesia: babi kurus, lalan, merdondong (Sumatra). Malaysia: kedondong kerantai (general), kedondong bulau, kerantai merah (Peninsular). Thailand: buk-yuak (Nakhon Si Thammarat).

Distribution Peninsular Malaysia, southern

Sumatra, and Borneo (Sabah); possibly also in peninsular Thailand.

Uses The wood is reputed to be used as kedondong.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 70 cm in diameter, with buttresses up to 1.5 m high, bark surface scaly-fissured, with small lenticels, grey or grey-brown to yellowish-brown, inner bark laminated, pale yellow with a pink tinge, exuding pale resin; leaves with 3–15 leaflets, petiole strongly channelled at base, leaflets lanceolate to oblong, 6.5–26 cm × 3–10 cm, densely pubescent but glabrescent below, secondary veins (9–)11–19 pairs with or without transverse veins, reticulations more distinct above than below; flowers 2–4 mm long, red, stamens 6; fruit 10–18 mm × 7–15 mm, white to bluish-black, stigma lateral to near the pedicel. *S. conferta* occurs in lowland to montane forest, mainly on slopes, up to 1800 m altitude. The density of the wood is 595–660 kg/m^3 at 15% moisture content.

Selected sources 77, 162, 277, 474, 574, 705.

Santiria griffithii (Hook.f.) Engl.

Bot. Jahrb. Syst. 1: 43 (1881).

Synonyms *Trigonochlamys griffithii* Hook.f. (1860), *Santiria bornensis* Engl. (1881).

Vernacular names Indonesia: kedondong (Sumatra), penyantong (Bangka), celankap laki gunung (south-eastern Kalimantan). Malaysia: kedondong kerantai (general), kedondong pasir (Peninsular), pamutalun (Sabah).

Distribution Peninsular Malaysia, Sumatra, Bangka and Borneo.

Uses The wood is used as kedondong, e.g. for doors, windows and plywood.

Observations A medium-sized to fairly large tree up to 35(–45) m tall, bole branchless for up to 25 m, up to 80(–120) cm in diameter, with buttresses up to 2 m high, bark surface dippled and scaly, pale greenish-grey or greenish-brown, inner bark gritty, straw-coloured, with pale exudate; leaves with (7–)11–21(–31) leaflets, petiole hardly or sometimes strongly flattened at base, leaflets elliptical-lanceolate to oblong-lanceolate, 3–10 (–17.5) cm × 1–3.5(–4.5) cm, usually pubescent on the veins below, secondary veins 11–15(–20) pairs without transverse veins, reticulations faint above; flowers 4–10 mm long, with reddish calyx and yellowish-white petals, stamens 6; fruit 8–13 mm × 8–16 mm, blue, stigma about 90° excentric. *S. griffithii* is fairly common in primary and secondary forest on dry or rarely swampy locations, up to 700 m altitude. The density of the wood is 600–920 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 77, 162, 196, 401, 463, 465, 474, 485, 506, 705, 743.

Santiria laevigata Blume

Mus. Bot. Lugd.-Bat. 1: 211 (1850).

Synonyms *Santiria rufescens* Blume (1850), *Santiria violacea* H.J. Lam (1932).

Vernacular names Indonesia: pegah kabu-kabu (Sumatra), kambajau burung (south-eastern Kalimantan), tapi-tapi (central Sulawesi). Malaysia: kedondong kerantai lichin (general), kerantai (Sabah), berambang (Sarawak).

Distribution Peninsular Malaysia, Sumatra, Borneo, central Sulawesi and the Philippines (Mindanao).

Uses *S. laevigata* is one of the principal sources of kedondong timber; the wood is used for e.g. posts and planks, furniture and parang handles. The fruits are edible.

Observations A medium-sized to large tree up to 45 m tall, bole up to 90 cm in diameter, with buttresses up to 4 m high, bark surface flaking, lenticellate, rusty red, fawn or grey, inner bark finely laminated, pinkish, with sparse creamy white resinous exudate; leaves with 3–11 leaflets, petioles channelled to terete at base, leaflets ovate to oblong, 5–26(–35) cm × 2–8(–11) cm, glabrous or sometimes sparsely hairy on the veins below, secondary veins 8–22 pairs without transverse veins, reticulations distinct on both surfaces; flowers 2 mm long, green to white, stamens 6; fruit 10–20 mm × 7–20 mm, turning yellow and red and finally black, stigma up to 90° excentric. *S. laevigata* is common in lowland forest, sometimes in peat-swamp forest, up to 1500 m altitude. Two forms are recognized: forma *laevigata* with 5–15 mm thick branchlets and channelled to sharply flattened petioles, and forma *glabrifolia* (Engl.) H.J. Lam (synonym: *Santiria glabrifolia* Engl.) with 3–6 mm thick branchlets and more or less terete petioles. The density of the wood is 470–860 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 9, 77, 78, 99, 162, 196, 277, 386, 402, 410, 455, 463, 465, 474, 485, 549, 562, 618, 619, 705.

Santiria megaphylla Kalkman

Blumea 7: 533, fig. 10 (1954).

Distribution Northern Borneo (Sarawak and Sabah).

Uses The wood is reputed to be used as kedondong.

Observations A medium-sized tree up to 25 m tall; leaves with 7–11 leaflets, petiole channelled at base, leaflets elliptical-ovate to elliptical-oblong, (15–)24–47 cm × (5.5–)11–18 cm, completely glabrous, secondary veins 8–14 pairs, reticulations prominent below; flowers about 2 mm long; fruit 15-18 mm × 10–12 mm, stigma near the pedicel. *S. megaphylla* occurs locally frequently in Sabah on sandy soils and associated with *Dryobalanops beccarii* Dyer.

Selected sources 99, 162, 277.

Santiria mollis Engl.

A.DC., Monogr. phan. 4: 156, t. 3, fig. 37-38 (1883).

Synonyms *Canarium hirtipetalum* Ridley (1930).

Vernacular names Indonesia: kumbajau burung (south-eastern Kalimantan).

Distribution Borneo.

Uses The wood is reputed to be used as kedondong.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 70 cm in diameter, buttressed, bark surface scaly, lenticellate, yellowish-brown; leaves with 5–9(–11) leaflets, petiole not or hardly flattened at base, leaflets ovate to oblong, 5.5–14.5 cm × 3–4.5 cm, usually tomentose below, secondary veins 9–15 pairs without transverse veins, reticulations prominent below; flowers 3–4 mm long, stamens 6; fruit 15–18 mm × 12–14 mm, stigma 90° or more excentric. *S. mollis* occurs infrequently in primary forest, up to 250 m altitude.

Selected sources 99, 162, 277.

Santiria oblongifolia Blume

Mus. Bot. Lugd.-Bat. 1: 211 (1850).

Synonyms *Santiria maingayi* Bennett (1875), *Santiria caesia* Engl. (1883), *Santiria latifolia* Stapf ex Ridley (1930).

Vernacular names Indonesia: kedundung tetatunjuk (western Sumatra), kedondong pergam (Palembang), asem garunggang (south-eastern Kalimantan). Malaysia: kedondong (general), kerantai (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The wood is used as kedondong.

Observations A medium-sized to fairly large tree up to 35(–42) m tall, bole branchless for up to 22 m, up to 90(–120) cm in diameter, with buttresses up to 4 m high, bark surface scaly, grey-brown, often with black resin, inner bark pinkish or yellow-brown; leaves with (5–)7–11 leaflets, petiole terete or slightly flattened at base, leaflets ovate to oblong, (6–)8–17(–25) cm × (1.5–)3–6(–10) cm, glabrous or sometimes slightly pubescent on the midrib below, secondary veins 9–16 pairs without transverse veins, reticulations more distinct above than below; flowers 2.5–3 mm long, green to yellowish, stamens 6; fruit 10–25 mm × 10–20 mm, blue when ripe, stigma less than 90° excentric. *S. oblongifolia* occurs in primary or secondary lowland to montane forest, usually on dry or rarely on periodically inundated locations, up to 1950 m altitude. The density of the wood is 500–720 kg/m^3 at 15% moisture content.

Selected sources 77, 78, 99, 162, 277, 402, 463, 465, 474, 504, 705.

Santiria rubiginosa Blume

Mus. Bot. Lugd.-Bat. 1: 213 (1850).

Vernacular names Indonesia: punggung kijang (Palembang), mertukul (Bangka), buno putih (Kalimantan). Malaysia: kedondong (general), salak gading, asam (Sarawak).

Distribution Peninsular Malaysia, Sumatra, Borneo and New Guinea.

Uses The wood is used as kedondong.

Observations A medium-sized, sometimes large tree up to 30(–45) m tall, bole up to 60 cm in diameter, buttressed, bark surface smooth to rough and slightly scaly or dippled, yellowish-grey and fawn, inner bark mottled, orange-white, exuding clear to whitish resinous exudate and smelling of mango; leaves with 3–11(–13) leaflets, petiole more or less terete at base, leaflets elliptical or ovate to lanceolate-oblong, 3–11(–15) cm × 1–5.5 (–7) cm, glabrous or sometimes sparsely pubescent on the midrib below, secondary veins 9–15 pairs without transverse veins, tertiary venation fine and scalariform; flowers 2–3 mm long, green, stamens 3; fruit 8–13 mm × 7–9 mm, ripening through yellow to reddish-blue and eventually black, stigma less than 90° excentric. *S. rubiginosa* is divided into 3 varieties. Var. *rubiginosa* (synonyms: *Icicaster planchonii* (Bennett) Ridley, *Santiria lamprocarpa* Laut., *Santiria havilandii* Ridley) is found throughout the area of distribution of the species. Var. *pedicellata* (Ridley) Kalkman (synonyms: *Santiria pedicellata* Ridley, *Santiria minutiflora* Ridley) differs from the typical variety by its 2–6 mm long pedicels and occurs in western Borneo. Var. *nana* (H.J. Lam) Kalkman (synonym: *Santiria nana* H.J. Lam) has pilose

Santiria rubiginosa Blume – 1, tree habit; 2, flowering twig; 3, sectioned male flower; 4, sectioned female flower; 5, fruit.

lower leaf surfaces and is found in eastern Sumatra and Peninsular Malaysia. *S. rubiginosa* occurs in primary forest on dry land or sometimes on swampy or periodically inundated locations, up to 600(–1200) m altitude. The density of the wood is 660–1070 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 77, 99, 162, 196, 277, 284, 402, 410, 455, 463, 465, 474, 562, 705.

Santiria tomentosa Blume

Mus. Bot. Lugd.-Bat. 1: 211 (1850).

Synonyms *Santiria multiflora* Bennett (1875), *Canarium micrantherum* Stapf ex Ridley (1930), *Santiria mollissima* Ridley (1930).

Vernacular names Indonesia: serantai (Sumatra), asem-asem (Bangka), merangan merah (Kalimantan). Malaysia: kedondong kerantai bulu (general), kerantai merah, panggong (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Borneo and the Philippines.

Uses *S. tomentosa* is one of the principal sources of kedondong; the wood is used for e.g. indoor construction. The fruits are edible after boiling. An edible oil can be pressed out of the pericarp of the fruit.

Observations A medium-sized to fairly large tree up to 35 m tall, bole branchless for up to 25 m, up to 80 cm in diameter, rarely buttressed with buttresses up to 1.5 m high, bark surface scaly, lenticellate, greenish-grey, inner bark laminated, pinkish, with colourless exudate; leaves with 1–11 leaflets, petiole flattened to terete or channelled at base, leaflets ovate to oblong, 5.5–28(–34) cm × 2.5–9(–12.5) cm, woolly pubescent below, secondary veins (9–)11–26(–29) pairs with transverse veins, reticulations prominent below; flowers 2–3 mm long, whitish or green to yellow, stamens 6; fruit 12–20 mm × 7–20 mm, turning blue and eventually black, stigma less than 90° excentric. *S. tomentosa* is common in primary and secondary forest on dry or swampy to periodically inundated locations, up to 500(–1800) m altitude. The density of the wood is 490–810 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 9, 77, 78, 99, 162, 196, 234, 277, 284, 401, 402, 474, 485, 504, 705, 743.

K.M. Kochummen (general part, selection of species),
B. Sunarno (general part),
A. Martawijaya (properties),
S. Noshiro (wood anatomy)

Sterculia L.

Sp. pl. 2: 1007 (1753); Gen. pl. (ed. 5): 438 (1754).

STERCULIACEAE

$x = 9, 10$; *S. foetida*, *S. longifolia*, *S. rubiginosa*: $2n = 40$, for several African species $2n = 36$

Trade groups Sterculia: lightweight hardwood, e.g. *Sterculia cordata* Blume, *S. foetida* L., *S. macrophylla* Vent., *S. oblongata* R.Br., *S. parviflora* Roxb. ex G. Don, *S. shillinglawii* F. v. Mueller. The logs and wood are very similar to amberoi (*Pterocymbium* spp.), and care is needed when assigning them to assortments.

Vernacular names Sterculia. Brunei: biris. Indonesia: kepuk, pimping. Malaysia: kelumpang (Peninsular), melebu, buah ayam antu sebayan, pelajau (Sarawak), kalumpang (Sabah). Burma (Myanmar): letkok shaw-byu. Cambodia: samrong, samrang. Thailand: po-khanun, samrong. Vietnam: tr[oo]m.

Origin and geographic distribution *Stercu-*

lia is a large pantropical genus of about 200 species. In Malesia, about 50 species occur. Borneo and New Guinea are the richest (22 species each, 5 of these endemic in Borneo and 12 endemic in New Guinea), followed by Peninsular Malaysia (17), Sumatra (15), Sulawesi, the Moluccas and the Philippines (each 10), Java (9) and the Lesser Sunda Islands (4). *S. foetida* and *S. macrophylla* are the tree species with the largest areas of distribution; they are found throughout South-East Asia.

Uses The wood is used for light interior construction, packing cases, ceiling, veneer and plywood, concrete shuttering and heels of shoes. *Sterculia* wood is locally favoured for boat-building. It is suitable for pulp and paper manufacture.

The seeds of some species are edible; they are mostly roasted. *S. foetida* is the main source of edible seeds. The seeds contain oil or fat, which may serve for frying or illumination and is sometimes used in batik work.

The bark of some species (e.g. *S. oblongata*) yields silky and lustrous fibres which are in demand for making hats, handbags, place-mats and wallets.

Several parts of the plants are used in local medicine. An extract of *S. foetida* bark may serve as an abortivum, ash made from the fruit-walls may be used against venereal diseases, and crushed leaves have been used in the Moluccas on wounds and as a febrifuge. The seeds may serve as an aphrodisiac. The fruit rind was formerly used in dyeing baths for batik in Indonesia. Some species (e.g. *S. foetida*, *S. parviflora*) are planted as ornamental or roadside tree.

Production and international trade In Papua New Guinea *Sterculia* is considered as commercially important, although it is ranked in the lowest MEP (Minimum Export Price) group (5), fetching a minimum price of US$ 40/m^3 for saw logs. Japan imports some timber from Papua New Guinea, and only small amounts from elsewhere.

Properties *Sterculia* yields a lightweight and comparatively soft wood. The heartwood is straw-coloured, greyish-white to sometimes pale brown or pale pinkish-brown, and not distinctly demarcated from the paler sapwood. The density is (120–)250–600(–760) kg/m^3 at 15% moisture content. The grain is straight to shallowly interlocked, texture rather coarse and often uneven due to the presence of large rays. A silver-grain figure is often present on quarter-sawn surfaces. Usually the wood has no distinctive odour or taste, but *S. foetida* wood has a pungent odour. Logs sometimes have a distinct brittle heart, and the outer part of the wood is sometimes very blue-stained.

Tests in the Philippines, New Guinea and New Britain showed the following mechanical properties at 12% moisture content: the modulus of rupture 32–54 N/mm^2, modulus of elasticity 5975–7320 N/mm^2, compression parallel to grain 21–23.5 N/mm^2, compression perpendicular to grain 2.5 N/mm^2, shear 4 N/mm^2, cleavage 23.5 N/mm tangential, Janka side hardness 1115–1340 N and Janka end hardness 1950 N.

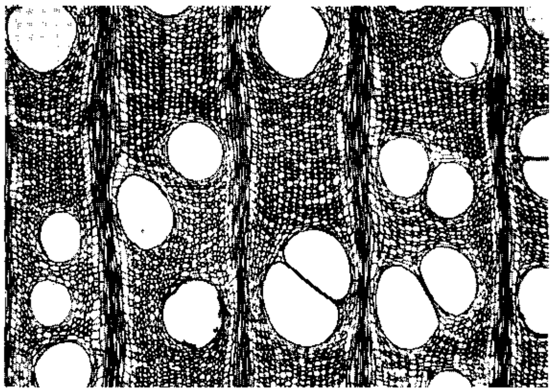
The rates of shrinkage are moderate: from green to 15% moisture content 0.8–1.3% radial and 3.2–4.2% tangential, and from green to oven dry 2.3–3.5% radial and 6.5–8.0% tangential. Air drying should be done carefully as the wood is sometimes prone to collapse, checking, cupping and warping, but too slow drying may cause serious degrade from staining; treating with anti-stain solution is recommended. Although *Sterculia* wood sometimes exhibits a very high initial moisture content (occasionally over 200%, e.g. in *S. vitiensis* Seem. from Fiji), boards dry rapidly without much degrade. A high-humidity treatment is recommended at the end of drying to relieve drying stresses. Wood of *S. macrophylla* from New Britain is reported as easy to kiln dry; checking and deformation is small to moderate and honeycombing small. Boards 25 mm thick can be kiln dried from 70% to 10% moisture content in 1.5–2 days. If dried properly, movement of the wood in service is moderate.

Sterculia wood is rather easy to work with machine and hand tools but it often has a woolly surface with a tendency to springing. It is easy and fast to saw. The wood is often brittle and fissile and is then not suitable for boring, mortising, scraping and turning. It planes well, but a cutting angle of 20° is recommended to reduce tearing of grain; it polishes, stains and sands well, but requires filler. The nailing properties are moderate to good, but sometimes the holding power is poor. The steam-bending properties of *S. macrophylla* wood are rated as poor. The gluing properties are satisfactory. The veneer has a fuzzy surface and requires a fairly long time to dry. It is suitable for core or back veneer in plywood. The wood is suitable for the production of sulphate pulp for paper making.

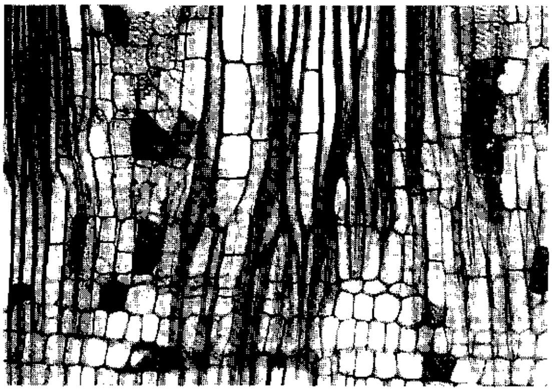
Sterculia wood is rated as non-durable in contact with the ground or exposed to the weather. It is easily attacked by pinhole borers, powder-post beetles, termites and marine borers. It is easy to moderately difficult to treat with preservatives.

Wood of *S. macrophylla* from Irian Jaya has been treated successfully with BFCA preservative (a mixture of boron, fluorine, chromium and arsenicum), but a dip diffusion treatment did not give satisfactory results. The retention of *S. macrophylla* wood from New Britain was 530–600 kg/m^3 using a pressure treatment. Heartwood is often resistant to preservatives due to the presence of tyloses occluding the vessels.
Wood of *S. macrophylla* contains 71–78% holocellulose, 41–48% α-cellulose, 15–26% lignin, 18% pentosan and 1.7% ash. The solubility is 0.9–1.1% in alcohol-benzene, 2.4% in cold water, 3.5% in hot water and 17.8% in a 1% NaOH solution. Wood of *S. ceramica* contains 67% holocellulose, 22% lignin, 18% pentosan and 2.8 % ash. The solubility is 2.9 % in alcohol-benzene, 5.6% in hot water and 21.4 % in a 1% NaOH solution.

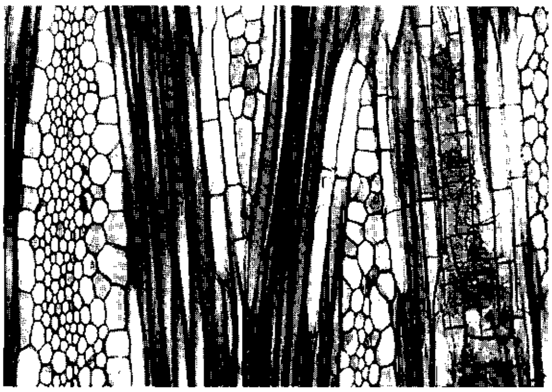
Description Shrubs or small to large, evergreen or briefly deciduous trees, large trees with tall straight to convex buttresses; bark surface smooth or in large trees with sparse square-section vertical fissures, more or less hoop-marked, usually pale brown or greyish-white, inner bark fibrous, often pale brown; crown irregular or in large trees dome-shaped; branches sympodial, often in false whorls at regular intervals, twigs thick or slender, sometimes swollen at apices. Leaves arranged spirally, often crowded at apices of twigs, usually simple and entire, but sometimes palmately compound (*S. foetida*), leaf blades rounded to acuminate at apex, pinnately or palmately veined, lower surface glabrous to densely stellate or peltate-stellate hairy or minutely scaly; petiole thickened at apex; stipules present, ovate, lanceolate or acicular, caducous or persistent. Inflorescences axillary, subterminal, lateral or cauliflorous, paniculate or racemose, mostly stellate pubescent, sometimes glabrous. Flowers actinomorphic, apetalous, with articulate pedicel, unisexual but female flowers apparently bisexual, male flowers numerous, female flowers fewer and usually terminating the inflorescence or its branches, generally larger than male flowers; calyx often reddish, with obconical, campanulate, urceolate or tubular tube, glabrous or hairy or with nectary glands inside, (4–)5(–6)-lobed, lobes valvate, spreading or coherent at apices; anthers in male flower in a globose head on top of a slender androphore, (4–)5–45 together, sessile; ovaries in female flower (3–)5(–6), superior and placed on top of a gynandrophore together with more or less rudimentary anthers, slightly coherent, mostly densely pubescent, 2–20-ovuled, styles free, coher-



transverse section (×25)



radial section (×75)



tangential section (×75)

Sterculia shillinglawii

ent or connate, stigmas free, mostly curved. Fruit consisting of 3–5 follicles; follicles free and mostly stellately spreading, leathery or woody, sessile or short-stalked, generally beaked, dehiscent, pink, scarlet or bright red, 1–20-seeded. Seed ellipsoid or obovoid, with blackish sarcotesta, dangling on long funicle before falling, albuminous; cotyledons usually thin; embryo situated opposite to the funicle. Seedling with epigeal germination, cotyledons usually (but not always) emerging from the seedcoat.

Wood anatomy

– Macroscopic characters:

Heartwood yellowish-white, pale yellowish or greyish-white, not distinctly demarcated from the paler sapwood. Grain generally straight. Texture coarse, silver-grain prominent due to wide rays. Growth rings sometimes fairly distinct; vessels visible to the naked eye; large rays distinct to the naked eye on all surfaces; ripple marks often distinct.

– Microscopic characters:

Growth rings sometimes fairly distinct due to interrupted light-coloured bands of parenchyma. Vessels diffuse, 2–3/mm^2 (*S. macrophylla*) to 4–12/mm^2 (*S. shillinglawii*), solitary and in radial multiples of 2–4(–6) and occasionally in clusters, the percentage of solitary vessels widely varying with samples and species, oval to slightly angular, 200–350 μm in tangential diameter; perforations simple; intervessel pits alternate, slightly angular, c. 6 μm in diameter; vessel-ray and vessel-parenchyma pits generally almost similar to intervessel pits but sometimes elongated and scalariform (*S. shillinglawii*); tyloses generally absent. Fibres 1.2–2.6 mm long, very thin-walled (wall c. 2 μm thick), with numerous simple to minutely bordered pits in radial walls, often storied. Parenchyma vasicentric, in broad sheaths, aliform and sometimes confluent to narrowly banded; apotracheal parenchyma diffuse-in-aggregates, abundant, in 2–4-celled strands. Rays 2–4/mm, of 2 distinct sizes, 1(–2)-seriate and 3–13-seriate (*S. macrophylla*) to 3–19-seriate (*S. shillinglawii*), up to 4.7 mm high in *S. macrophylla*, up to 7.5 mm high in *S. shillinglawii*, small rays usually storied, heterocellular often with several rows of upright and sometimes square marginal cells, Kribs type heterogeneous II(–III); sheath cells distinct, often in more than one layer. Prismatic crystals present, usually in chambered axial parenchyma cells, in chains of up to 6 or scarce (*S. macrophylla*), and also in sheath cells and marginal ray cells. All elements except large rays storied.

Species studied: *S. ceramica*, *S. macrophylla*, *S. shillinglawii*.

Growth and development The mean annual growth in a 15-year-old trial plantation of *S. foetida* in Java was 0.8 m in height and 1.1–1.3 cm in diameter. A single 22-year-old *S. parviflora* tree in the arboretum of the Forest Research Institute Malaysia was 10 m tall and 9.6 cm in diameter.

In some species which have entire leaves in mature trees, the leaves of saplings are deeply lobed; this is the case in *S. comosa*, *S. macrophylla* and *S. morobeensis*. Many *Sterculia* trees are evergreen, but often leaf change is in flushes; immediately after the old leaves are shed buds start sprouting and the trees are bare for no more than a few days. Some species are distinctly deciduous (e.g. *S. edelfeltii*, *S. foetida*, *S. macrophylla*, *S. parviflora* and *S. peekelii*).

The tree architecture of *S. foetida* (and several other species) is according to Aubréville's model, with a monopodial trunk with rhythmic growth and spiral phyllotaxis, and plagiotropic branches in tiers.

Sterculia seems to have male and bisexual flowers. However, the apparently bisexual flowers are probably functionally female, as the anthers are smaller than in male flowers and contain imperfect pollen. The mostly fragrant, but sometimes fetid-smelling (*S. foetida*) flowers are pollinated by insects such as flies and beetles. In Peninsular Malaysia a single *S. parviflora* tree studied did not flower every year, and only in some of the years of flowering and fruiting did it produce numerous seeds.

The fruits ripen in 4–6 months. The lustrous seeds with black sarcotesta are very conspicuous in the widely opened, often brilliant coral or crimson-coloured follicles and are eaten and distributed by birds (e.g. hornbills) and small mammals (e.g. squirrels), although there seems to be little to eat on the seeds except the sarcotesta. The seeds of *S. foetida*, which often grows near the coast, float in water and may be distributed by sea currents.

Other botanical information *Sterculia* belongs to the tribe *Sterculieae*, together with the Malesian genera *Brachychiton*, *Firmiana*, *Pterocymbium*, *Pterygota* and *Scaphium*. It differs from these genera mainly by its fruits and seeds. *Brachychiton* seems to be most closely related to *Sterculia*, differing only in a few seed characters. The African genus *Cola* also seems to be very close to *Sterculia*, but differs in its seeds lacking albumen and having thick cotyledons.

Ecology *Sterculia* occurs in lowland forest, from dryland to swampy forest, and usually not above 1500 m altitude. However, *S. monticola* and *S. tantraensis* may ascend in New Guinea to over 2000 m. Most species in South-East Asia are confined to rain forest in humid climates, but some species (e.g. *S. foetida*) also grow in seasonal climates and can well stand a distinct dry season. *Sterculia* trees usually occur scattered, apparently as distantly separated individuals in the understorey, but some species reach the canopy of the forest or are even emergent.

Propagation and planting *S. foetida* has 460–640 dry seeds/kg. Seed germinates rapidly; germination is 70% in 8–16 days in *S. cordata*, 80–100% in 8–19 days in *S. foetida*, 55–60% in 5–23 days in *S. parviflora* and 85% in 7–17 days after sowing in *S. rubiginosa*. Seed should be sown no deeper than 1 cm and in full light. *S. foetida* is successfully sown directly, using two seeds per planting hole, but seedlings are difficult to transplant due to their well developed taproot. The spacing applied in East Java is 1 m × 3 m, sometimes mixed with other species, with *S. foetida* at 1 m × 6 m.

Stumps coppice freely and the trees grow easily from cuttings. Fence posts root easily and sprout, to make a live fence.

Silviculture and management As light-demanding species, *Sterculia* should be given ample space to develop and a spacing of 1 m × 6 m proves better diameter growth than one of 1 m × 3 m. The self pruning capacity of the lower, heavy branches of *S. foetida* is satisfactory. Due to its open crown, weeds easily develop underneath.

Harvesting In the Philippines, bark of *S. oblongata* is stripped during the rainy season as the moist bark can be harvested without damage to the cambium. Strips covering half of the circumference of the tree are removed.

Yield In a 15-year-old trial of *S. foetida*, mean annual increment is 2.6–3.9 m^3/ha. The wood volume of a clear log (60 cm in diameter at breast height) of *S. macrophylla* from New Britain was 4.7 m^3.

Handling after harvest Logs should be extracted rapidly from the forest after logging as they are susceptible to blue stain and insect attack. The bark must be soaked in water for 10–12 days before the fibres can be separated.

Genetic resources *Sterculia* trees are rarely logged selectively because the timber is not in great demand and the trees do not occur gregariously in the forest but scattered. They do not seem to be particularly liable to genetic erosion.

Prospects *Sterculia* does not seem to have good prospects for timber production. The wood quality is rather poor and the applications are limited, as the wood is not strong and non-durable. *Sterculia* might be useful in plantations of fast-growing trees for pulp and low-quality timber, but research should first be focused on growth rate, propagation and planting, and silvicultural techniques.

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Selection of species

Sterculia ampla Bakh.f.

Journ. Bot. 61, Suppl.: 5 (1923).

Synonyms *Sterculia coggygria* Mildbr. (1929).

Distribution The Moluccas and New Guinea.

Uses The wood is reputed to be used.

Observations A medium-sized tree up to 25(–40) m tall, with bole up to 60 cm in diameter, buttressed, bark surface smooth, grey, inner bark red, twigs stout, 10–20 mm in diameter; leaves simple and entire, generally suborbicular, sometimes ovate, obovate or oblong-obovate, 15–35 cm × 8–32 cm, cordate at base, usually glabrous, petiole 5–20 cm long, stipules large and lanceolate, persistent; inflorescence axillary or subterminal, paniculate, many-branched and erect; calyx with urceolate or campanulate-urceolate tube, densely pubescent inside, and 5 triangular lobes much shorter than the tube, male flowers with 4–6 anthers; follicles 4, suborbicular or sometimes oblong, c. 5 cm long; seed ellipsoid, c. 1.2 cm long, black. *S. ampla* occurs in rain forest on sandy clay soils and coral limestone, up to 300 m altitude, also along rivers and in swamps.

Selected sources 145, 632, 660.

Sterculia ceramica R.Br.

Benn., R.Br. & Horsf., Pl. jav. rar. 3: 233 (1844).

Synonyms *Sterculia luzonica* Warb. (1904), *Sterculia glabrifolia* Merr. (1920).

Vernacular names Indonesia: lui (Talaud Island, Sulawesi), kafialwatan (Tanimbar Island, the Moluccas), komong dowong (Ternate, the Moluccas). Malaysia: biris (Sabah). Philippines: malakalumpang (general), balindagat (Palawan), uos (Bikol).

Distribution The Philippines, Borneo (Sabah), Sulawesi and the Moluccas.

Uses The wood is used, e.g. in the Philippines; the pulp is suitable for paper-making.

Observations A medium-sized tree up to 24 m tall, with bole up to 40 cm in diameter, twigs slender, up to 7 mm in diameter; leaves simple and entire, generally ovate, sometimes elliptical, 8–22 cm × 6–10 cm, cordate at base, usually glabrous, petiole 3–4 cm long, stipules caducous; inflorescence axillary or subterminal, paniculate, erect; calyx with urceolate or campanulate-urceolate tube, glabrous or sometimes pubescent inside, and 4 triangular or ligulate lobes shorter than the tube or sometimes equal to the tube, male flowers with c. 30 anthers; follicles 4–5, slightly obovoid or oblong, 3–5 cm long, scarlet; seed ellipsoid, 1.5–2 cm long, black. *S. ceramica* occurs in primary forest, also near the coast, on sandy clay soil and old coral cliffs, up to 100 m altitude. The wood is buff-coloured. See also the table on wood properties.

Selected sources 152, 414, 629, 632.

Sterculia comosa Wallich

Pl. asiat. rar. 2: 25, pl. 127 (1831).

Synonyms *Sterculia keyensis* K. Schumann (1891), *Sterculia philippinensis* Merr. (1904), *Sterculia ramosii* Merr. (1916).

Vernacular names Indonesia: bangilan, bingiladu (Sulawesi), kayu pani (Moluccas). Philippines: banilad (general), Ramos banilad (Filipino).

Distribution The Philippines, Sulawesi and the Moluccas.

Uses The wood is used for light construction. The fibres from the bark are used to make ropes.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole up to 100 cm in diameter, bark surface smooth and brown, inner bark pale brown, twigs stout, c. 24 mm in diameter; leaves simple and entire, ovate, rarely suborbicular, 15–30(–40) cm × 12–30(–40) cm, generally cordate at base, generally densely stellate or peltate-stellate appressed greyish hairy below, rarely glabrous, petiole 8–26 cm long, stipules caducous; inflorescence axillary or subterminal, paniculate, many-branched, erect; calyx with obconical or campanulate tube densely pubescent inside and 5 triangular or ligulate recurved lobes about as long as the tube, male flowers with 7–10 anthers; follicles 2–5, obovoid or oblong, c. 4.5 cm long, red; seed ellipsoid, c. 1.5 cm long, black. *S. comosa* occurs in primary lowland forest, up to 700 m altitude, on clayey, sandy or rocky soils.

Selected sources 125, 632.

Sterculia cordata Blume

Bijdr. fl. Ned. Ind. 2: 83 (1825).

Vernacular names Indonesia: gelumpang padang (Bangka), hantap heulang (Sundanese, Java), kayu binong (Javanese, Java), pimpin bulan (East Kalimantan). Malaysia: kalumpang, tuntun (Sabah), pelajau (Sarawak). Philippines: tapinagbundok (Tagalog).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra and adjacent islands, Java, Borneo and the Philippines (Luzon).

Uses The wood is reputed to be used. The seeds are used in traditional medicine.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole up to 60 cm in diameter, buttresses c. 1 m high and 1.5 m wide, bark surface smooth, finely cracked or sparsely vertically fissured, to roughish, pinkish-brown, pale brown to chocolate-brown, inner bark fibrous, pinkish-brown, pale brown to dark red, twigs slender, 3–5 mm in diameter; leaves simple and entire, ovate, elliptical to elliptical-oblong, (6.5–)

16–19(–30) cm × (3–)7–9(–19) cm, generally cordate at base, sometimes rounded, generally densely stellate appressed hairy below, petiole 1.5–4(–9) cm long, stipules lanceolate, caducous; inflorescence axillary or subterminal, paniculate, many-branched, drooping; calyx with obconical tube densely pubescent inside and 5 ligulate or lanceolate recurved or converging lobes slightly longer than the tube and sometimes coherent at apices, male flowers with 8–12 anthers; follicles 2–5, obovoid or sometimes oblong, 4.5–12 cm long, densely yellowish-brown tomentose; seed ellipsoid, 1–2.5 cm long, brown. Two varieties are distinguished; var. *montana* (Merr.) Tantra (synonyms: *Sterculia montana* Merr., *Sterculia borneensis* Ridley) is found in Borneo and the Philippines and differs from var. *cordata* (synonym: *Sterculia javanica* R.Br.) in its converging calyx lobes with coherent apices and its larger seeds. *S. cordata* occurs in primary and secondary forest up to 1200 m altitude; in Sarawak it is found on fertile clay-rich soils, on alluvium and lower slopes of hills. The wood is pale pinkish-brown darkening towards the centre of the log.

Selected sources 26, 35, 78, 99, 136, 234, 465, 632, 705.

Sterculia edelfeltii F. v. Mueller

Victorian Naturalist 3: 47 (1886).

Distribution Papua New Guinea.

Uses The wood is reputed to be used.

Observations A medium-sized to fairly large deciduous tree up to 35 m tall, with bole up to 75 cm in diameter, with plank buttresses up to 3 m high, bark surface rather smooth, greyish-brown or greyish striate, inner bark pinkish-brown and whitish streaked, twigs slender, c. 4 mm in diameter; leaves simple and entire, elliptical to obovate or lanceolate, 11–14 cm × 5–7 cm, tapering but obtuse at base, glabrous, sometimes stellate hairy along the midrib below, petiole 2–3 cm long, stipules caducous; inflorescence axillary or subterminal, racemose; calyx with urceolate tube glabrous inside and 5 ligulate converging lobes much shorter than the tube, male flowers with (18–)20(–23) anthers; follicles oblong or boat-shaped, 4.5–5.5 cm long, much compressed, orange-red; seed ellipsoid, c. 1 cm long, black. *S. edelfeltii* occurs in lowland primary rain forest, often on hills and ridges, also along rivers, up to 1000 m altitude. The wood is creamy, grading to pinkish-brown towards the centre of the log.

Selected sources 330, 632.

Sterculia foetida L.

Sp. pl. 2: 1008 (1753).

Synonyms *Sterculia polyphylla* R.Br. (1844).

Vernacular names Indonesia: kepoh (Javanese, Java), kabu-kabu (Batak, Sumatra), kalupat (Sulawesi). Malaysia: kelumpang jari (Peninsular). Philippines: kalumpang (general). Burma (Myanmar): letpan-shaw. Cambodia: samrong. Thailand: samrong (central, eastern), homrong (peninsular), chammahong (Chiang Mai). Vietnam: tr[oo]m.

Distribution Eastern Africa, India, Sri Lanka, Burma (Myanmar), Indo-China, Thailand, throughout the Malesian region (but not reported for Sarawak and Papua New Guinea), northern Australia and Hawaii.

Uses The wood is used for temporary construction, packing cases, concrete shuttering and similar uses. In the Philippines it is also used for house construction, particularly for sides, ceilings and partitions. The wood is stronger and more durable than most other *Sterculia* wood. The seeds are eaten as nuts (although they may be

Sterculia foetida L. – 1, tree habit; 2, flowering twig; 3, fruit; 4, follicle in longitudinal section.

slightly poisonous when fresh), and they are the source of an oil which is used for illuminating and painting. The flowers and leaves have medicinal value. The trees are planted for shade, and sometimes used as stakes for sirih (*Piper betle* L.). The rind of the fruit was formerly used in dyeing baths for batik.

Observations A medium-sized to fairly large deciduous tree up to 40 m tall, with bole up to 90(–120) cm in diameter, with buttresses up to 1.5 m high, bark surface sparsely cracked and peeling off into large pieces or slightly fissured and dippled, lenticellate, whitish-grey to greyish-brown, inner bark fibrous, brown or reddish-brown, twigs stout, c. 25 mm in diameter; leaves palmately compound with (5–)6–10 leaflets, petiole 10–25 (–45) cm long, stipules caducous, leaflets elliptical to lanceolate, (7–)12–15(–20) cm × (3–)4–6(–7) cm, acute at base, glabrescent; inflorescence axillary or subterminal, paniculate; calyx with obconical tube glabrous inside and 5 lanceolate spreading lobes much longer than the tube, male flowers with 14–15 anthers; follicles usually 5, suborbicular or boat-shaped, 8–14 cm long, red; seed ellipsoid, 2–3 cm long, black. *S. foetida* occurs in primary and secondary forest, often on river banks and on coral sandstone rocks along the coast, up to 1000 m altitude. The heartwood is pinkish and has a pungent smell. The density is 495–600(–760) kg/m^3 at 15% moisture content.

Selected sources 35, 78, 99, 104, 125, 140, 148, 216, 218, 234, 261, 330, 414, 458, 460, 465, 474, 526, 527, 632, 660, 705.

Sterculia gilva Miq.

Fl. Ind. Bat., Suppl. 1 (Prodr. Fl. Sum.): 401 (1861).

Synonyms *Sterculia bicolor* Masters (1874).

Vernacular names Indonesia: bakurung (Batak, Sumatra), selemah (Bengkalis, Sumatra), kelumpang paya (Bangka). Malaysia: kelumpang (Peninsular), kalumpang, biris-biris (Sabah). Thailand: kalupae (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra, the Riau Archipelago, Borneo and New Guinea.

Uses The wood is reputed to be used.

Observations A medium-sized to fairly large deciduous tree up to 40 m tall, with straight bole up to 60 cm in diameter, sometimes buttressed, bark surface smooth, hoop-marked, pale grey-brown to blackish-grey, inner bark fibrous and brittle, pink or pale brown to reddish-brown, mottled, twigs rather swollen, c. 6 mm in diameter; leaves simple and entire, ovate-elliptical to elliptical-oblong or obovate, (4.5–)9–12 cm × (2.5–)4–6 (–7.5) cm, rounded to subcordate at base, densely stellate or peltate-stellate hairy below, petiole 1–3.5(–5) cm long, stipules lanceolate, caducous; inflorescence axillary or subterminal, paniculate, pendulous; calyx with obconical or campanulate tube glabrous inside except at the base and 5 lanceolate, converging lobes at least as long as the tube and with coherent apices, male flowers with 7–12 anthers; follicles 3–5, obovoid, 2–3 cm long, orange-red or crimson; seed ellipsoid, c. 1 cm long, black. *S. gilva* is locally common in swampy areas and on peat soils, sometimes in association with *Combretocarpus* and *Salacca* spp. In Sarawak, it occurs locally even semi-gregariously in mixed peat-swamp forest near the coast and kerangas near streams. In New Guinea, it also occurs in primary forest on slopes, up to 1500 m altitude. The wood is yellowish-brown.

Selected sources 26, 99, 632, 705.

Sterculia insularis R.Br.

Benn., R.Br. & Horsf., Pl. jav. rar. 3: 232 (1844).

Synonyms *Sterculia treubii* Hochr. (1904), *Sterculia longituba* Adelb. (1945).

Vernacular names Indonesia: galungu, kalumpang cenda (Sulawesi), Soklat hutan (Moluccas).

Distribution Timor, Sulawesi, the Moluccas and Irian Jaya.

Uses The wood is reputed to be used. The rind of the fruit was formerly used in dyeing baths for batik.

Observations A medium-sized tree up to 30 m tall, with straight bole up to 60 cm in diameter, twigs slender, 2–6 mm in diameter; leaves simple and entire, elliptical to elliptical-oblong or oblong-obovate, 10–30 cm × 5–14 cm, rounded or obtuse at base, glabrous, petiole 1–4 cm long, stipules caducous; inflorescence axillary or subterminal, paniculate, many-branched; calyx with obconical or campanulate tube glabrous or pubescent inside and 5 lanceolate, spreading or converging lobes at least as long as the tube, male flowers with 8–11 anthers; follicles 4–5, oblong, 4–9 cm long, red; seed ellipsoid, c. 1.5 cm long, black. *S. insularis* occurs in primary forest up to 1000 m altitude.

Selected sources 234, 632.

Sterculia longifolia Vent.

Jard. Malmaison 2: in note sub pl. 91 (1805).

Synonyms *Sterculia spangleri* R.Br. (1844), *Sterculia sumatrensis* Ridley (1923).

Vernacular names Indonesia: hantap (Sundanese, Java), bengkuh (Javanese, Java).

Distribution Sumatra, Java and Borneo.

Uses The wood is reputed to be used.

Observations A small to medium-sized tree up to 25 m tall, but generally much smaller, with bole up to 30 cm in diameter, without buttresses, bark surface smooth, greyish-brown, inner bark brown but inner part whitish, twigs slender, 3–7 mm in diameter; leaves simple and entire, elliptical or oblong-obovate to lanceolate, 6–20(–30) cm × 3–9 cm, acute or obtuse at base, generally glabrous, petiole 1–9 cm long, stipules caducous; inflorescence axillary, paniculate or racemose; calyx with obconical or campanulate tube generally densely pubescent inside and 5 lanceolate, spreading or converging lobes slightly to much longer than the tube, male flowers with (9–)10(–11) anthers; follicles 3–5, oblong to lanceolate, 5–9 cm long, bright red; seed ellipsoid, c. 1.5 cm long, black. *S. longifolia* occurs in primary and secondary forest up to 1350 m altitude. In Sarawak, it is locally a main-canopy tree in mixed dipterocarp forest on basalt, granodiorite and limestone hills. The wood is whitish.

Selected sources 26, 35, 632.

Sterculia macrophylla Vent.

Jard. Malmaison 2: in note sub pl. 91 (1805).

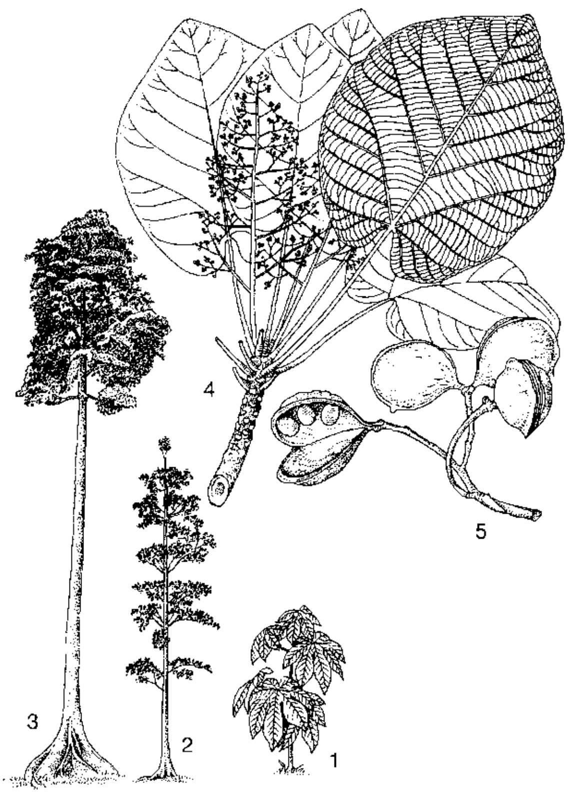
Synonyms *Sterculia oncinocarpa* F. v. Mueller & Forbes (1886), *Sterculia parkinsonii* F. v. Mueller (1887), *Sterculia pachyclados* K. Schumann (1897), *Sterculia crassiramea* Merr. (1905).

Vernacular names Indonesia: kelumpang (Riau Archipelago), kelumpang labi (Sumatra), hantap heulang (Sundanese, Java). Malaysia: kelumpang (Peninsular), kalumpang, tangkoranjoh (Sabah), pelajau (Sarawak). Philippines: tapinag, tapinag-laparan (Tagalog), balinad (Bisaya). Thailand: kletraet (Kanchanaburi).

Distribution Southern Thailand, throughout Malesia, except for the Lesser Sunda Islands, to New Britain and the Solomon Islands.

Uses *S. macrophylla* is an important source of *Sterculia* timber. The wood is suitable for temporary construction and interior work. It is traditionally used on the Solomon Islands for outrigger floats and bowls, and occasionally for floor joists. The seeds are edible, and occasionally used in traditional medicine.

Observations A medium-sized to fairly large deciduous tree up to 40 m tall, with bole up to 65(–150) cm in diameter, buttresses large, up to 3 m high and 3 m wide, bark surface smooth, becoming square-section fissured and slightly scaly or hoop-marked, greyish-white to greyish-brown with whitish spots, inner bark fibrous, pale pinkish-brown or yellowish-brown, mottled, twigs stout, 17–18 mm in diameter; leaves simple and entire, ovate or broadly elliptical to nearly orbicular, (8–)12–40 cm × (6–)10–35 cm, mostly deeply cordate at base, brownish or yellowish stellate hairy below, petiole (2–)4–20 cm long, stipules ovate or lanceolate, caducous; inflorescence axillary or subterminal, paniculate, many-flowered and erect; calyx with obconical or campanulate tube densely pubescent inside and 5 triangular or ligulate, erect or recurved lobes shorter than the tube to about as long, male flowers with 5–10 anthers; follicles (1–)3–5, suborbicular, 3–8 cm long, velvety brown, bright red or reddish-orange; seed ellipsoid or oblong, 1–2.3 cm long, black. *S. macrophylla* is common in primary and secondary forest, often in mixed dipterocarp forest, sometimes in swamp forest, on loamy and clayey soils but also on limestone rocks, up to 900 m altitude. The



Sterculia macrophylla Vent. – 1, seedling; 2, habit of young tree; 3, habit of mature tree; 4, flowering twig; 5, branchlet with fruits.

wood is whitish to pale pink. The density is (120–)250–450 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 4, 5, 12, 26, 35, 69, 78, 99, 104, 140, 229, 234, 294, 330, 337, 632, 705, 715, 731.

Sterculia megistophylla Ridley

Journ. Fed. Mal. St. Mus. 8: 21 (1917).

Synonyms *Sterculia hosei* Merr. (1922).

Vernacular names Indonesia: kalumpang (Palembang, Sumatra). Malaysia: buah ayan antu sebayan, biris merah (Sarawak).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sarawak, Brunei and Sabah).

Uses The wood is reputed to be used.

Observations A medium-sized tree up to 20 m tall, with bole up to 40 cm in diameter, buttresses absent or low and rounded, bark surface smooth, orange-brown, inner bark dark brown, twigs rather stout, c. 10 mm in diameter; leaves simple and entire, elliptical to oblong-elliptical or obovate to oblong-obovate, (22–)25–36(–54) cm × (5.5–)8–18 cm, subcordate to rounded, rarely acute at base, densely stellate hairy below, petiole (2–)4–14 cm long, stipules lanceolate, caducous or subpersistent; inflorescence cauliflorous, racemose to paniculate, pendulous; calyx with obconical or rarely campanulate tube glabrous inside and 5 lanceolate or ligulate, usually spreading lobes longer than the tube, male flowers with 8–10 anthers; follicles on stout woody peduncle on the upper part of the bole, oblong and very large, 15–22 cm long, brilliant vermillion or dark orange; seed ellipsoid, c. 2.5 cm long, dark greenish or brown. *S. megistophylla* occurs in primary forest up to 1500 m altitude. In Sarawak, it grows scattered in mixed dipterocarp forest on deep and moist clayey soils and deep yellow podzolic soils, and more frequently in kerangas on podzols where it is only a small tree. The wood is pinkish-brown.

Selected sources 26, 632.

Sterculia monticola Mildbr.

Bot. Jahrb. Syst. 62: 363 (1929).

Distribution Papua New Guinea.

Uses The wood is reputed to be used.

Observations A medium-sized tree up to 32 m tall, with bole up to 55 cm in diameter, buttresses up to 2.5 m high, bark surface smooth between shallow longitudinal and transverse cracks, lenticellate, greyish-brown, inner bark straw-coloured, twigs rather stout, 6–7 mm in diameter; leaves simple and entire, ovate, elliptical, oblong or oblong-obovate, (6–)10–18(–35) cm × (3–)7–8(–16) cm, obtuse or rounded at base, sparsely stellate or peltate-stellate hairy below, petiole 2–4 cm long, stipules ovate, caducous; inflorescence axillary, racemose; calyx with obconical or campanulate tube glabrous but sometimes hairy inside and 5 lanceolate, converging lobes, male flowers with 15–24 anthers; follicles 2–3, suborbicular or boat-shaped, 5–8 cm long, brown or brownish-green outside, red inside; seed ellipsoid, c. 1.5 cm long, black. Three varieties have been distinguished, mainly based on the size of the leaves and hairiness of the inner side of the calyx tube. *S. monticola* occurs in mixed forest on hills and montane forest together with *Nothofagus* spp. up to 2150 m altitude. The wood is orange-straw coloured, becomiing dark purplish-brown towards the centre of the bole.

Selected sources 632.

Sterculia morobeensis Tantra

Pengumuman Lembaga Penelitian Hutan 102: 54 (1976).

Distribution Papua New Guinea.

Uses The wood is reputed to be used.

Observations A medium-sized to fairly large deciduous tree up to 35 m tall, with bole up to 45 cm in diameter, buttressed, bark surface smooth, pale grey, inner bark pale brown mottled creamy with purplish annular bands, twigs rather stout, c. 10 mm in diameter; leaves simple and entire, ovate to oblong, 15–20 cm × 10–12 cm, mostly cordate at base, glabrous but sometimes stellate hairy at base and midrib below, petiole 3–7 cm long, stipules very narrowly lanceolate, caducous; inflorescence axillary or subterminal, paniculate, pendulous; calyx with urceolate or campanulate-urceolate tube densely woolly inside and 5 triangular or ligulate, recurved lobes much shorter than the tube, male flowers with 5 anthers; follicles 2–3, suborbicular or boat-shaped, 5–8 cm long, brown or brownish-green outside, red inside; seed ellipsoid, c. 1.5 cm long, black. *S. morobeensis* occurs in primary dipterocarp forest up to 800 m altitude. The wood is whitish.

Selected sources 632.

Sterculia oblongata R.Br.

Benn., R.Br. & Horsf., Pl. jav. rar. 3: 232 (1844).

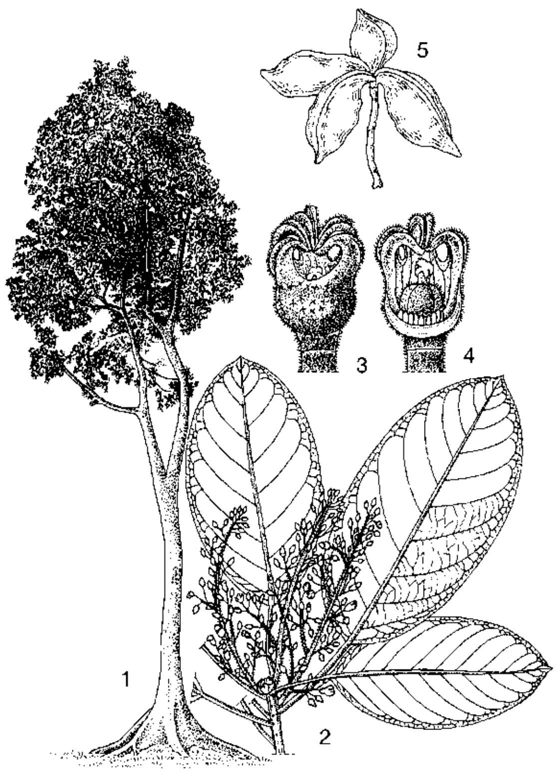
Synonyms *Sterculia spectabilis* Miq. (1861), *Sterculia kunstleri* King (1891), *Sterculia forbesii* Warb. (1923), *Sterculia urceolata* auct. non J.E. Smith.

Vernacular names Indonesia: kalumpang (Sumatra), hantap (Sundanese, Java), lomes (Sulawesi). Malaysia: kalumpang, biris, melabu (Sarawak). Philippines: malabuho, balinad (general), saripongpong (Bikol).

Distribution Peninsular Malaysia, Sumatra, Java, the Lesser Sunda Islands (Bali, Sumbawa, Flores), Borneo, Sulawesi and the Philippines.

Uses The wood is used for house construction, particularly for sides, ceilings and partitions, and is also suitable for pulp and paper manufacture. The fibres in the bark are used for the manufacture of elegant hats, handbags, place-mats and wallets. The seeds are edible.

Observations A medium-sized to large tree up to 50 m tall, with bole up to 150 cm in diameter, with small or large buttresses up to 6 m high and 2 m wide, bark surface smooth or profusely and irregularly scaly, lenticellate, grey, inner bark fibrous, yellowish-brown to purplish or reddish-brown, twigs slender, 3–5 mm in diameter; leaves simple and entire, ovate to oblong or oblong-elliptical, sometimes slightly obovate, (7–)9–24(–36) cm × (3–)4–11(–27) cm, rounded to subcordate at base, rarely acute, glabrous, petiole 2–7(–11) cm long, stipules caducous; inflorescence axillary or subterminal, paniculate, erect and many-branched; calyx with urceolate (sometimes campanulate) tube glabrous inside and 5 lanceolate, converging lobes at most as long as the tube with coherent apices, male flowers with 6–8(–10) anthers; follicles 2–3(–4), oblong, 4–8 cm long, reddish; seed ellipsoid, 1–2.5 cm long, dark brown or black. *S. oblongata* occurs in primary and secondary forest on flat land, ridges and hills up to 1550 m altitude. In Sarawak it is found in mixed dipterocarp forest on deep, relatively fertile clay-rich soils overlying volcanic and igneous, basic to slightly acidic rocks. The wood is buff-coloured, pinkish-white or pink. The density is 165–400 kg/m^3 at 15% moisture content.



Sterculia oblongata R.Br. – 1, tree habit; 2, flowering twig; 3, female flower; 4, opened female flower; 5, fruit.

Selected sources 26, 35, 99, 125, 140, 150, 234, 414, 527, 632, 705.

Sterculia parviflora Roxb. ex G. Don

Gen. hist. 1: 516 (1831).

Synonyms *Sterculia maingayi* Masters (1874), *Sterculia obscura* K. Schumann (1897), *Sterculia holttumii* Ridley (1926).

Vernacular names Malaysia: kelumpang burung (Peninsular). Thailand: po-khanun (Prachuap Khiri Khan). Vietnam: tr[oo]m hoa nho.

Distribution India, Indo-China, Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo (Sarawak, Sabah).

Uses The wood is reputed to be used. The tree is sometimes planted as an ornamental or along roadsides.

Observations A medium-sized to fairly large deciduous tree up to 35 m tall, with bole up to 100 cm in diameter, with plank buttresses up to 3 m high and 2 m wide, bark surface smooth, occasionally with small scales increasing in number towards the top of the trunk, inconspicuously lenticellate, greyish-brown or orange-brown to pinkish, inner bark fibrous, reddish-brown, twigs slender, 3–6 mm in diameter; leaves simple and entire, ovate, elliptical or elliptical-oblong to obovate-oblong, (6–)8–20(–27) cm × 4–10(–15) cm, mostly cordate at base, with scattered very minute peltate scales below, glabrescent, petiole 1.5–8(–10) cm long, stipules caducous; inflorescence axillary or subterminal, paniculate, erect and many-branched; calyx with urceolate tube glabrous inside and 5 lanceolate lobes about as long as the tube with coherent apices, male flowers with 10 anthers; follicles generally 5, oblong, 6–9(–13) cm long, scarlet or bright red; seed ellipsoid, 1–2 cm long, dark brown or black. *S. parviflora* occurs locally commonly in lowland primary forest, up to 650 m altitude, in Sarawak in mixed dipterocarp forest on basalt and calcareous shale. The wood is whitish.

Selected sources 26, 99, 104, 140, 410, 458, 460, 465, 466, 632, 705.

Sterculia peekelii Mildbr.

Notizbl. Bot. Gart. und Mus. Berlin-Dahlem 10: 281 (1928).

Distribution Papua New Guinea, including New Britain and New Ireland.

Uses The wood is reputed to be used.

Observations A medium-sized deciduous tree up to 25 m tall, with bole up to 40 cm in diameter, bark surface smooth but with long chains of pustular lenticels, pale grey, inner bark pinkish with white wedges, twigs slender, 2–3 mm in diameter; leaves simple and entire, elliptical to oblong, 8–17 cm × 5–7 cm, rounded or truncate at base, usually glabrous but sometimes peltate-stellate hairy at the base below, petiole 2–3 cm long, stipules lanceolate, caducous; inflorescence cauliflorous or ramiflorous, racemose to subcompound, lax; calyx with campanulate-urceolate tube glabrous inside and 5 triangular or ligulate, recurved lobes shorter than the tube, male flowers with 10 anthers; follicles oblong, 5–6 cm long, bright orange-red; seed ellipsoid-oblong, 1.6–1.7 cm long, black. *S. peekelii* is usually a tree of the second storey in primary and secondary forest up to 1000 m altitude, often associated with *Castanopsis* spp. The wood is pinkish.

Selected sources 632.

Sterculia rubiginosa Vent.

Jard. Malmaison 2: in note sub pl. 91 (1805).

Synonyms *Sterculia cuneata* R.Br. (1844), *Sterculia ferruginea* R.Br. (1844), *Sterculia stipularis* R.Br. (1844), *Sterculia rufa* Korth. (1848), *Sterculia translucens* Stapf (1894), *Sterculia rostrata* Ridley (1909), *Sterculia brachycarpa* Ridley (1918).

Vernacular names Indonesia: jilupang (Bangka), menong balah (Simeuluë), kayu gedang (Kalimantan). Malaysia: magapaga, belinsagut (Sabah). Philippines: malabunot (general), sinaligan (Ibanag, Iloko), bisong (Iloko). Thailand: cha, samkaeo, po fan (Trang).

Distribution Burma (Myanmar), southern Thailand, Peninsular Malaysia, Singapore, Sumatra and adjacent islands, Java, Borneo and the Philippines.

Uses The wood is sometimes used.

Observations A small to medium-sized tree up to 20(–25) m tall, but generally smaller, with bole up to 30 cm in diameter, buttresses up to 1 m high, bark surface smooth becoming minutely fissured or scaly, whitish or greyish-brown to red-brown, inner bark fibrous, pinkish to orange or reddish-brown, twigs slender, 3–5 mm in diameter; leaves simple and entire, lanceolate or elliptical or obovate to obovate-oblong, (4–)7–29 cm × (1–)3–13 cm, cuneate or obtuse to cordate at base, subglabrous to densely stellate hairy below, petiole 0.5–6 cm long, stipules lanceolate, generally persistent; inflorescence axillary or subterminal, paniculate or racemose, drooping; calyx with obconical or tubular tube glabrous to densely pubescent inside and 5 lanceolate, converging or spreading lobes as long as the tube to much longer, male flowers with (6–)10(–11) anthers; follicles 3–5, oblong, 3–10 cm long, brown or red; seed globose or ellipsoid, 1–2 cm long, black. *S. rubiginosa* is possibly conspecific with *S. balanghas* L. It is a variable species subdivided into 4 varieties. It occurs in primary and secondary forest, up to 1600(–2000) m altitude, in hill forest but also in swampy areas (e.g. in mixed peat-swamp forest in northern Borneo), often in mixed dipterocarp forest on clay-rich soils. The wood is whitish.

Selected sources 26, 35, 78, 99, 104, 140, 465, 632, 705.

Sterculia shillinglawii F. v. Mueller

Australas. Journ. Pharm., extra print (1887), Bot. Centralbl. 31: 21 (1887).

Vernacular names Indonesia: kayu sut, kwakas (Moluccas), sebonggawa (Manokwari, Irian Jaya).

Distribution The Moluccas, New Guinea, New Britain and New Ireland.

Uses *S. shillinglawii* is one of the major sources of *Sterculia* timber.

Observations A large deciduous tree up to 50 m tall, with bole up to 80 cm in diameter, with large plank buttresses up to 4 m high and 4 m wide, bark surface smooth, sometimes pustular or slightly cracked or finely vertically fissured, greyish-brown, pale brown to pinkish, inner bark pale brown or pale orange, twigs slender, 4–7 mm in diameter; leaves simple and entire, ovate, elliptical, oblong to oblong-obovate, 10–28 cm × 7–14 cm, mostly subcordate at base, sometimes rounded, densely stellate or peltate-stellate hairy below, petiole 2–8 cm long, stipules lanceolate, caducous; inflorescence axillary or subterminal, paniculate, many-branched; calyx with campanulate-urceolate tube generally glabrous inside and 5 lanceolate lobes about as long as the tube with coherent apices, male flowers with 10–11 anthers; follicles 2–5, oblong to linear, 4–8.5 cm long, bright orange, orange-red or dull scarlet; seed ellipsoid, c. 1 cm long, dark brown or black. Two subspecies have been distinguished; subsp. *malacophylla* (K. Schumann) Tantra (synonym: *Sterculia malacophylla* K. Schumann) differs from subsp. *shillinglawii* (synonym: *Sterculia conwentzii* K. Schumann) in having straight and fissured follicles. *S. shillinglawii* is common in primary and secondary forest on ridges, hills and flat country up to 900 m altitude. The wood is whitish to straw-coloured. The density is 155–440 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 12, 60, 145, 632, 660, 715.

Sterculia tantraensis Morat

Bull. Mus. Nat. Hist. Nat., ser. 4, sect. B, Adans. 8(4): 362 (1987).

Synonyms *Pterocymbium schumannianum* Lauterb. (1905), *Sterculia schumanniana* (Lauterb.) Mildbr. (1929) non (Schlechter) Guillaumin.

Distribution The Moluccas and New Guinea.

Uses The wood is reputed to be used.

Observations A medium-sized to fairly large tree up to 35 m tall, with bole up to 50 cm in diameter, buttresses up to 1.2 m high, bark surface smooth, soft, or with numerous prominent black lenticels, greyish-white, greenish or brownish, inner bark red or brown, twigs slender, 3–4 mm in diameter; leaves simple and entire, oblong-obovate or elliptical-oblong, rarely lanceolate, 8–27 cm × 4–11 cm, subcuneate to rounded at base, glabrous, petiole 2–5 cm long, stipules caducous; inflorescence generally cauliflorous or ramiflorous, rarely axillary or subterminal, racemose, lax and pendulous; calyx with tubulate tube glabrous inside and 5 lanceolate, converging lobes about as long as the tube, male flowers with 12–18 anthers; follicles 4–5, oblong and curved, 6–9 cm long, bright orange-red; seed ellipsoid, 1.6–1.7 cm long, black. *S. tantraensis* is a fairly common second-storey tree of primary and tall secondary rain forest on latosols, humid sandy clay and limestone pot-hole soils, up to 2000 m altitude. The wood is whitish to pink.

Selected sources 632, 660.

Sterculia urceolata J.E. Smith

Rees, Cycl. 34: Sterculia No 3b (1816).

Vernacular names Indonesia: bahenteng, kolilei, woline (Sulawesi).

Distribution Sulawesi, the Moluccas and New Guinea.

Uses The wood is reputed to be used.

Observations A medium-sized tree up to 30 m tall, with bole up to 60 cm in diameter, twigs slender, 4–8 mm in diameter; leaves simple and entire, ovate or elliptical to elliptical-oblong, 9–15(–25) cm × 4–9 cm, rounded at base, densely peltate-stellate hairy below, petiole 2–5.5 cm long, stipules caducous; inflorescence axillary, paniculate; calyx with urceolate tube glabrous inside and 5 lanceolate and converging lobes about as long as the tube with coherent apices, male flowers with 8–10 anthers; follicles 4–5, obovoid to oblong, 5–6 cm long, orange-red; seed ellipsoid, c. 1.3 cm long, dark brown or black. *S. urceolata* occurs in primary and secondary forest up to 200 m altitude. In Java, the name *S. urceolata* has been commonly used for *S. oblongata*.

Selected sources 632.

R.H.M.J. Lemmens (general part, selection of species),
D.S. Alonzo (properties),
S. Sudo (wood anatomy)

Swintonia Griffith

Proc. Linn. Soc., London 1: 283 (1846).

ANACARDIACEAE

x = unknown

Trade groups Merpauh: medium-weight hardwood, e.g. *Swintonia floribunda* Griffith, *S. schwenkii* (Teijsm. & Binnend.) Teijsm. & Binnend. ex Hook.f., *S. spicifera* Hook.f.

Vernacular names Merpauh. Malaysia: selan (Sarawak). Philippines: kaluis, lomarau. Burma (Myanmar): civit, taung-thayet, shitle. Cambodia: muom. Thailand: kayu-muyaeng (Malay, peninsular), khanthong (Krabi, Satun), priang (Pattani). Vietnam: muom.

Origin and geographic distribution *Swintonia* consists of about 12 species and occurs in Bangladesh, the Andaman Islands, Burma (Myanmar), Thailand, Cambodia, Laos, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Borneo and the Philippines. It is frequently encountered in Burma (Myanmar) and Bangladesh, but is usually uncommon elsewhere.

Uses Merpauh timber is used for light to medium-heavy general construction, boat building (especially suitable for hulls and keels), for packing cases, matchboxes and splints. The timber is suitable for interior finish, panelling, partitioning, flooring and furniture and is valued as a timber for veneer and plywood, especially in Bangladesh. The pulp made of merpauh is of good quality, and suitable for writing, printing and wrapping paper.

Production and international trade Merpauh has no real economic importance and is traded as 'mixed medium hardwood' or only used locally. In Burma (Myanmar), it has some local importance, elsewhere the supply is very limited.

Properties Merpauh is a medium-weight hardwood. The heartwood is generally greyish-white, pale red-brown or grey-brown with a pink tinge, but sometimes handsomely figured corewood (streaked with orange and red lines) is present; the sapwood is not clearly differentiated from the heartwood and is often pale grey-brown with a pink tinge. The density is 640–880 kg/m^3 at 15% moisture content. The grain is straight to interlocked, texture moderately coarse and even. Narrow pale stripes often occur on radial surfaces in addition to broader stripes caused by interlocked grain; a dark zig-zag figure present on tangential surfaces.

At 17% moisture content, the modulus of rupture is 97–108 N/mm^2, modulus of elasticity 15 700–18 100 N/mm^2, compression parallel to grain 47.5–56.5 N/mm^2, compression perpendicular to grain 6.5–7 N/mm^2, shear 12.5–13.5 N/mm^2, cleavage 43–54 N/mm radial and 53–71 N/mm tangential, and Janka side hardness 5340–6010 N.

The rates of shrinkage are moderate: from green to 15% moisture content 0.8–1.4% radial and 1.5–2.0% tangential, and from green to oven dry 3.2–4.8% radial and 5.8–8.3% tangential. In Malaysia, merpauh is reported to air dry fairly rapidly with slight bowing, twisting and end-checking, which can be minimized by end-coating. In Burma (Myanmar), the wood of *S. floribunda* reportedly does not split during seasoning, but it is very liable to staining; logs should be converted as soon as possible after felling and the sawn stock should be open-stacked under cover with good ventilation. Boards 25 mm thick can be air dried in 2–2.5 months, and boards 40 mm thick in 3.5–4.5 months. The wood can be kiln dried rapidly, but a mild kiln schedule is recommended. In Malaysia, kiln schedule C gives good results.

Severe tension wood is commonly present and this influences the working properties; it may cause woolly surfaces and jamming of saws. Apart from this tension wood, merpauh is usually comparatively easy to saw and it machines to a moderately smooth surface. It is easy to plane, producing a smooth finish, but boring and turning are generally difficult, with variable finish. The nailing properties are also variable, from very poor to good, but the wood holds nails well. The bending properties are good. Merpauh peels well without pretreatment, producing good-quality veneer which is easy to glue for plywood. The wood is well suited for the manufacture of particle board.

Merpauh heartwood is rated as non-durable in exposed conditions, but it is reported as moderately durable or durable under cover. It is reported to be resistant to powder-post beetle attack, but not to termites and marine borers. The heartwood is moderately resistant to preservative treatment, but the sapwood is permeable.

Merpauh wood contains about 0.4% silica. The black resin and green timber of some species cause irritation to eyes and skin. Seasoned timber is not irritant. Merpauh wood from Kalimantan is reported to contain 81% holocellulose, 26% lignin, 11% pentosan and 1.1% ash. The solubility is 1.5% in alcohol-benzene, 1.0% in cold water, 5.0% in hot water, and 14.8% in a 1% NaOH solution.

Description Small to large trees up to 40(–54) m tall; bole straight, branchless for up to 20(–25) m, up to 70(–120) cm in diameter, sometimes fluted at base, with steep buttresses; bark surface smooth or minutely dippled or scaly, sometimes deeply fissured, lenticellate, reddish-brown or greenish-brown, inner bark yellowish-brown or pink, slowly exuding creamy to pinkish sap which darkens on drying. Leaves arranged spirally, often in terminal pseudo-whorls, simple, entire, with a slightly thickened, marginal vein, often glaucous and papillose beneath, petioles rather long. Inflorescence axillary or terminal, paniculate, usually loosely flowered; bracts and bracteoles caducous. Flowers male and bisexual, or bisexual only, actinomorphic, 5-merous, often fragrant; calyx lobed; petals imbricate, persistent, partly or wholly puberulous on both surfaces, glabrescent, usually much enlarged and reflexed in fruit; stamens 5, filaments glabrous, anthers dorsifixed; disk 5-lobed, gland-like, confluent with the base of filaments or alternating with them; ovary superior, 1-celled, each cell containing a single ovule pendulous from a basal funicle, sparsely hairy, abortive in male flowers, style 1, lateral. Fruit a 1-celled drupe supported by the 5, usually much enlarged, reflexed, wing-like petals (often pink or red when fresh), endocarp coriaceous. Seed with testa adherent to the endocarp, embryo straight, cotyledons free, plano-convex. Seedling with hypogeal to semi-hypogeal germination; first pair of leaves opposite, subsequent leaves arranged spirally.

Wood anatomy

– Macroscopic characters:

Heartwood greyish-white, yellow-brown or pale red-brown, not clearly distinct from the sapwood. Grain straight to interlocked. Texture moderately coarse. Growth rings apparently distinct, delimited by marginal bands of parenchyma; vessels visible to the naked eye, tyloses common to infrequent or absent (apparently only present in heartwood); parenchyma visible with hand lens as marginal or irregular zonate bands; rays not visible with the naked eye; radial canals generally not distinct to the naked eye but visible with a hand lens on tangential surfaces as small dark spots; ripple marks absent.

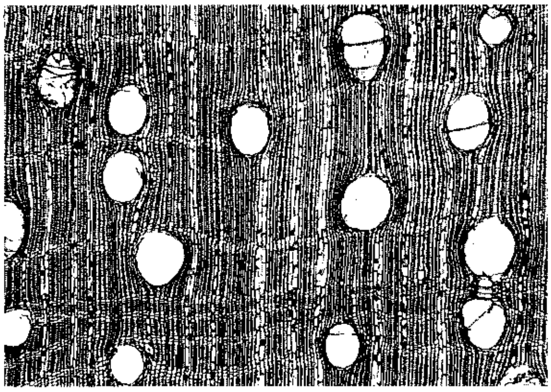
– Microscopic characters:

Growth rings apparently distinct, delimited by marginal bands of parenchyma, vessels and fibres not suggesting growth rings. Vessels diffuse, 2–8(–10)/mm^2, in short radial multiples, 180–300 (–350) μm in tangential diameter; perforation plates simple; intervessel pits non-vestured, alternate, circular or oval, (10–)12–14(–16) μm; vessel-ray pits simple with much reduced borders, enlarged, horizontally to vertically elongated or round; thin-walled tyloses common to infrequent or absent. Fibres (0.6–)0.7–1.0(–1.4) mm long, non-septate, thin-walled to thick-walled, with simple to minutely bordered pits. Axial parenchyma common as banded parenchyma, in either marginal or irregular zonate bands, bands mostly 2–4 cells wide, not typically reticulate but generally conforming to reticulate, mostly in 3–4-celled strands. Rays 5–7/mm, exclusively uniseriate, partly biseriate, or mostly biseriate, 300–800 μm high, homocellular to heterocellular with one row of upright and/or square marginal cells; storied structure absent. Prismatic crystals often present in chambered axial parenchyma (generally long chains of more than 5 crystals), one crystal per cell or chamber, and also in the rays. Silica present in ray cells, silica bodies small, generally less than 12 μm in diameter, scattered throughout upright and procumbent cells. Radial canals present, rays containing canals locally enlarged resulting in fusiform rays.

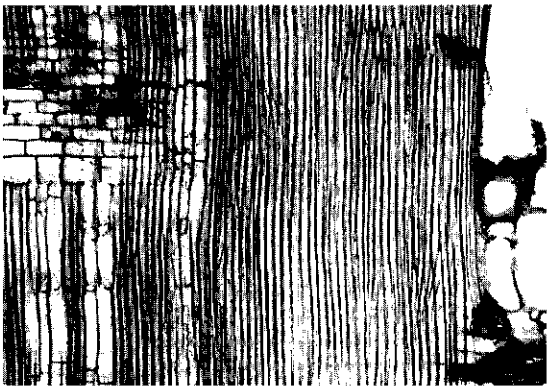
Species studied: *S. acuta*, *S. floribunda*, *S. foxworthyi*.

Growth and development In *S. schwenkii* in Peninsular Malaysia it was observed that two flushes of inflorescences were produced, separated by an interval of 8 weeks. The flowering-to-fruiting period is 5–6 months.

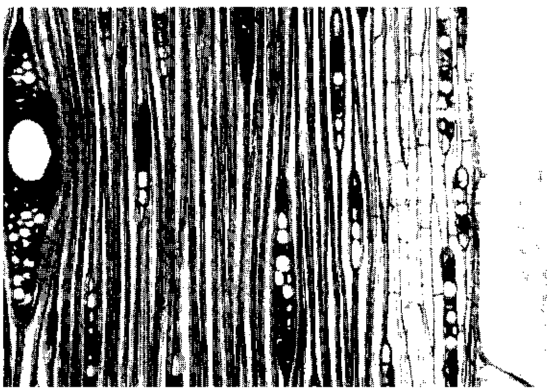
Other botanical information The genus



transverse section (×25)



radial section (×75)



tangential section (×75)

Swintonia floribunda

Swintonia belongs to the tribe *Anacardieae*, together with e.g. the genera *Anacardium, Bouea, Gluta* and *Mangifera*. *Swintonia* is probably most closely related to *Mangifera* or *Melanochyla* and is easily recognized by the petals which are persistent and enlarged in fruit.

Ecology Trees of *Swintonia* spp. grow in evergreen lowland and hill forest, also in swamp or peat-swamp forest (Borneo), rarely on limestone. The species may grow scattered but are also commonly found gregariously or even in almost pure stands on ridges, up to 750(–1000) m altitude.

Propagation and planting All fruits (without petals) of *S. schwenkii* germinated in 2–11 days. For *S. spicifera* 80% of the fruits (without petals) germinated in 11–36 days. Freshly fallen fruits of *S. spicifera* were already germinating before planting. Size grading of seeds of *S. floribunda*, as examined in Bangladesh, did not have a significant effect on the germination percentage. There are no known plantations of *Swintonia* species.

Harvesting Logs of *S. schwenkii* and *S. spicifera* with a diameter of 50–110 cm used for timber tests showed heart rot of up to 12 cm in diameter.

Genetic resources Merpauh is uncommon over large areas in Malesia. Therefore it may easily be liable to genetic erosion, but it is economically not important and generally not selectively cut. In areas where merpauh is more common, such as Burma (Myanmar) and Bangladesh, it is more often subject to logging for timber.

Prospects Information on merpauh is scarce. Its future as a timber-producing tree seems unpromising, as long as other medium-weight timbers with better workability and durability are available such as kapur (*Dryobalanops* spp.) and keruing (*Dipterocarpus* spp.).

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Selection of species

Swintonia acuta Engl.

Bot. Jahrb. Syst. 1: 44 (1880).

Synonyms *Swintonia luzoniensis* Merr. (1908), *Swintonia acuminata* Merr. (1923).

Vernacular names Brunei: bitoh (Iban). Indonesia: langhei (Kalimantan). Malaysia: maban, rengas petoh (Sarawak), medan (Sabah). Philippines: kaluis (Tagalog), langas (Bisaya).

Distribution Borneo and the Philippines.

Uses The wood is used as merpauh.

Observations A medium-sized tree up to 30(–45) m tall, bole up to 65(–95) cm in diameter, buttresses when present up to 3 m high, bark surface rather smooth or narrowly and shallowly fissured, flaking to reveal red-brown patches, grey, or blackish, inner bark rich pink; leaves elliptical to lanceolate, (5–)7–16 cm × (1.7–)2.7–6.0 cm, glabrous, not papillose on the veins below, petioles 1.5–5 cm long, flat to bicanaliculate above; calyx divided almost to the base, petals 2.5–3.5 mm long, cuneate to obtuse at base, sparsely puberulous in the apical part on both surfaces; drupe ellipsoid, 10–20 mm long, enlarged petals 4–6 cm long. *S. acuta* occurs often semi-gregariously in lowland forest, frequently on clayey river banks, occasionally on flat swampy land, or coral limestone, up to 750 m altitude.

Selected sources 162, 544, 576.

Swintonia floribunda Griffith

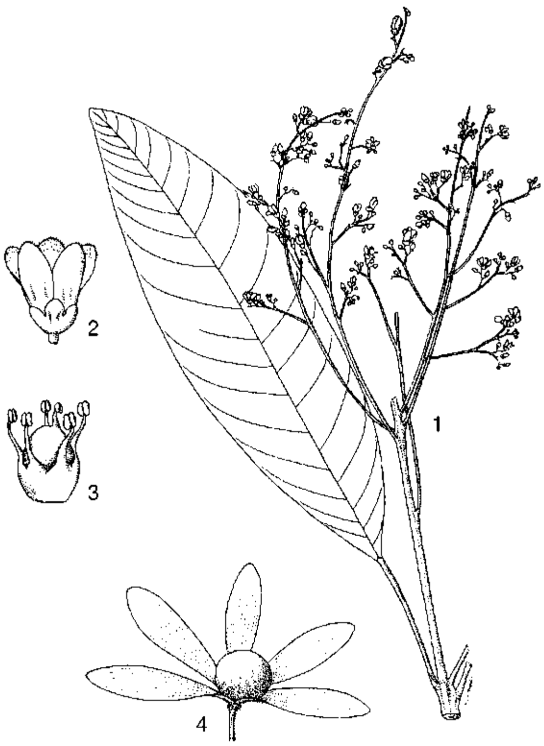
Proc. Linn. Soc., London 1: 283 (1846).

Vernacular names Indonesia: kereta, bagel, mirah, kedondong rabuk (Sumatra). Malaysia: merpauh daun runching (Peninsular).

Distribution Bangladesh, the Andaman Islands, Burma (Myanmar), Thailand, Vietnam, Peninsular Malaysia and Sumatra.

Uses *S. floribunda* is a major source of merpauh; in Bangladesh it is the most commonly used timber for veneer and plywood. It yields good quality pulp.

Observations A medium-sized tree up to 30(–45) tall, bole branchless for up to 20 m, up to 75(–90) cm in diameter, buttresses up to 2.5 m high, often slightly sinuous or angular, bark surface shallowly fissured, dippled or scaly, pale greyish to reddish-brown, inner bark pinkish; leaves elliptical to narrowly elliptical, or obovate-oblong, 5.5–16(–25) cm × 2–5(–6) cm, glabrous, not papillose beneath, petiole semi-terete, sulcate or flat above; calyx divided to one-fourth or one-third of its length, petals 3.5–4 mm long, cuneate at base, often puberulous on both surfaces; drupe globose or subglobose, 12.5–17.5 mm in diameter, enlarged petals 4–9 cm long. *S. floribunda* consists of two varieties: var. *floribunda* (synonyms: *Swintonia griffithii* Kurz, *Swintonia helferi* Hook.f., *Swintonia puberula* Pearson) and var. *penangiana* (King) Kochummen (synonym: *Swintonia penangiana* King), which differ from each other mainly in vegetative characters. It occurs in lowland and hill forest, occasionally on limestone, sometimes in pure stands especially on ridges (e.g. in northern Peninsular Malaysia), up to 1000 m altitude. The density of the wood is about 660 kg/m^3 at 15% moisture content. See also the table on wood properties.



Swintonia floribunda Griffith – 1, flowering twig; 2, flower; 3, stamens and pistil; 4, fruit.

Selected sources 45, 78, 162, 163, 206, 364, 380, 508, 524, 541, 566, 705.

Swintonia foxworthyi Elmer

Leafl. Philipp. Bot. 5: 1751 (1913).

Vernacular names Brunei: rengas bukit. Malaysia: pitoh (Iban, Sabah). Philippines: lomarau (Kuyonon).

Distribution Western Sumatra, Borneo (Sarawak, Brunei, Sabah) and the Philippines.

Uses The wood is reputed to be used as merpauh.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 100 cm in diameter, buttresses up to 3 m high, bark surface smooth or slightly flaky, reddish or dark brown; leaves elliptical or rarely lanceolate, 5–15 cm × 1.5–5.5 cm, glabrous, papillae distinct on the lower surface, petiole 1.5–5.5 cm long, usually flat above; calyx divided almost to the base, petals 2–3 mm long, claw-like contracted at base, sparsely puberulous on both surfaces in the apical part; drupe globose or subglobose, 12.5–17.5 mm in diameter, enlarged petals 5.5–7.5 cm long. The fruits are sometimes galled into globose bodies 2.5 cm in diameter. *S. foxworthyi* grows in primary, mixed dipterocarp and kerangas forest, up to 600 m altitude.

Selected sources 162, 544.

Swintonia glauca Engl.

Bot. Jahrb. Syst. 1: 44 (1880).

Vernacular names Brunei: selan merah. Indonesia: rengas tiong (Sumatra). Malaysia: selan merah, rengas pitoh (Sarawak), telauchap laki (Malay, Sabah).

Distribution Eastern Sumatra and Borneo.

Uses The wood is used as merpauh, e.g. for interior joinery.

Observations A medium-sized tree up to 30 m tall, bole up to 70 cm in diameter, buttresses sometimes present and up to 1.5 m high, bark surface smooth or somewhat flaky, grey to pinkish-brown; leaves lanceolate or rarely elliptical, 6–15 cm × 2.7–6 cm, glabrous, distinctly papillose below, petiole 2.5–4 cm long, semi-terete, grooved or flat above; calyx divided almost to the base, petals 3–3.5 mm long, truncate or obtuse at base, densely puberulous on both surfaces; drupe ellipsoid, 17–25 mm in diameter, enlarged petals about 5.5 cm long. *S. glauca* is locally common on podzols and in shallow peat swamps. The density of the wood is 640–720 kg/m^3 at 15% moisture content.

Selected sources 69, 162.

Swintonia minutalata Ding Hou

Blumea 24: 38 (1978).

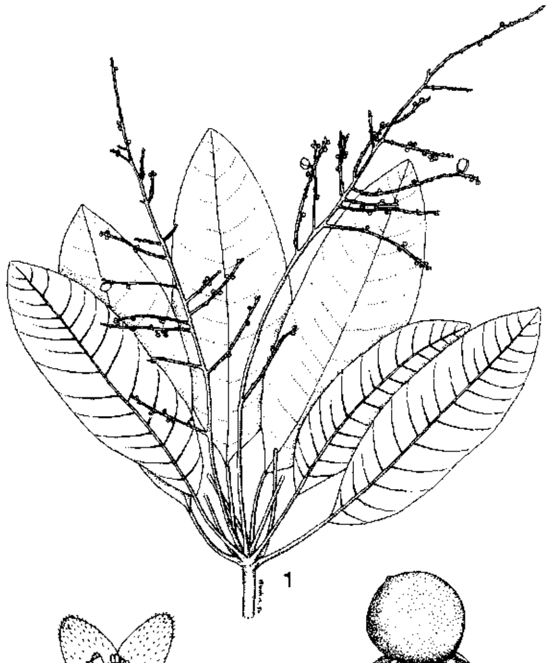
Vernacular names Indonesia: njala (East Kalimantan). Malaysia: petoh, rengas (Iban, Sarawak).

Distribution Borneo (Sarawak, Kalimantan).

Uses The wood is reputed to be used as merpauh.

Observations A small to medium-sized tree up to 25 m tall, bole up to 50 cm in diameter, buttresses up to 1 m high, bark surface smooth, shedding in small flakes, pale red, inner bark pale reddish-brown; leaves elliptical, 11.5–22.5 cm × 3–6.5 cm, glabrous, papillae distinct on the lower surface, petiole 3.5–6.5 cm long, often terete in its basal half and flat above in the upper half; calyx divided almost to the base, petals 1.5–2.5 mm long, sparsely puberulous but glabrescent on both surfaces; drupe globose, about 15 mm in diameter, enlarged petals 7.5–12.5 mm long. *S. minutalata* occurs in primary lowland forest and on ridges, occasionally abundant on deep heavy loams in mixed dipterocarp forest.

Selected sources 162, 576.



Swintonia minutalata Ding Hou – 1, flowering twig; 2, flower; 3, fruit.

Swintonia schwenkii (Teijsm. & Binnend.) Teijsm. & Binnend. ex Hook.f.

Fl. Brit. India 2: 26 (1876).

Synonyms *Anauxanopetalum schwenkii* Teijsm. & Binnend. (1861).

Vernacular names Indonesia: ambago (Batak, Sumatra), galagensa (Malay, Sumatra), rengas (Kalimantan). Malaysia: merpauh periang (Peninsular), baba chit (Iban, Sarawak), pitoh bukit (Malay, Sarawak). Burma (Myanmar): civit, taung-thayet, shitle. Thailand: ka-yu mue-yaeng (Malay, peninsular), khanthong (Krabi, Satun), priang (Pattani).

Distribution Burma (Myanmar), Thailand, Cambodia, Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses *S. schwenkii* is an important source of merpauh.

Observations A large tree up to 45(–53) m tall, bole up to 70(–120) cm in diameter, buttresses up to 3 m high, bark surface smooth or dippled, sometimes deeply fissured, grey-brown to reddish-brown; leaves narrowly elliptical, rarely elliptical, 7–12(–16) cm × 3–4.5(–6) cm, glabrous, without papillae on the lower surface (or very obscure), midrib sharply keeled below, petiole 3.5–6 cm long, terete throughout to only in its basal half, sometimes flat or grooved above in the apical one-third to half; calyx divided to about halfway, petals 2–3 mm long, cuneate at base, densely puberulous on both surfaces; drupe ovoid-oblong or ellipsoid, 17.5–20 mm long, enlarged petals 5.5–7 cm long. *S. schwenkii* grows in primary or rarely secondary lowland and hill forest, usually on leached sandy soils, in mixed dipterocarp or kerangas forest, occasionally on ultrabasic soils or limestone, up to 700 m altitude. The density of the wood is 650–810 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 162, 163, 206, 364, 410, 463, 465, 474, 566, 574, 576, 705.

Swintonia spicifera Hook.f.

Fl. Brit. India 2: 27 (1876).

Vernacular names Indonesia: kerete (Sumatra). Malaysia: merpauh daun tebal, mupus, rengas kilat senja (Peninsular).

Distribution Peninsular Malaysia and Sumatra.

Uses *S. spicifera* is an important source of merpauh.

Observations A medium-sized to fairly large tree up to 36(–54) m tall, bole up to 80(–115) cm in diameter, buttresses rather tall, occasionally reaching to 4 m high, bark surface dippled or fissured, scaly or flaky, dark brown to purplish-brown, inner bark pinkish; leaves elliptical, rarely ovate, or oblanceolate, 5.5–18(–23) cm × 2.5–5(–6) cm, glabrous, without papillae on the lower surface (or very obscure), petiole 1.5–6 cm long, semi-terete, flat or slightly convex above; flowers densely set on unbranched apical parts of panicle branches, calyx divided to one-fifth to one-third of its length; drupe ellipsoid, 20–25 mm long, enlarged petals about 3.5 cm long. *S. spicifera* occurs in lowland and hill forest, sometimes growing gregariously on ridges, up to 500 m altitude. The density of the wood is 640–880 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 77, 78, 162, 206, 364, 463, 465, 566, 705.

D. Hou (general part, selection of species),
P.B. Laming (properties),
R.B. Miller (wood anatomy)

Syzygium Gaertner

Fruct. 1: 166 (1788).

MYRTACEAE

$x = 11$; *S. cumini*: $2n = 22, 44, 55, 66$, *S. grande*: $n = 11$, *S. malaccense*: $2n = 22$, *S. nervosum*: $2n = 22$, *S. oblatum*: $n = 11$, *S. samarangense*: $2n = 33, 44, 66, 88, 110$

Trade groups Kelat: medium-weight to heavy hardwood, e.g. *Syzygium buettnerianum* (K. Schumann) Niedenzu, *S. claviflorum* (Roxb.) A.M. Cowan & J.M. Cowan, *S. fastigiatum* (Blume) Merr. & Perry, *S. grande* (Wight) Walp., *S. longiflorum* K. Presl, *S. nervosum* DC., *S. polyanthum* (Wight) Walp., *S. syzygioides* (Miq.) Merr. & Perry.

Vernacular names Kelat. Indonesia: ki tembaga, jambu laut. Malaysia: jambu (Peninsular), obar (Sabah), obah (Sarawak). Papua New Guinea: water gum. Philippines: makaasim. Burma (Myanmar): thabye-gui. Thailand: wa, daeng.

Origin and geographic distribution *Syzygium* is a very large genus with about 1000 species occurring in the African and Asian tropics. About 70 species are found in Indo-China, 80 in Thailand, 190 in Peninsular Malaysia, 50 in Java, 165 in Borneo, 180 in the Philippines and 140 in New Guinea. The major areas of endemism are the Philippines and New Guinea (with about 80% of the species endemic), and Borneo and Peninsular Malaysia (with about 60% of the species endemic), although the large number of endemic species might partly reflect an insufficient comparison between the species of different areas.

Uses The wood is used for heavy and light construction, house construction (posts and poles), window sills, furniture, flooring, telegraph poles, ships, bridges, railway sleepers, bottom boards of railway carriages, implements, fibreboard, and veneer and plywood. It is also used for charcoal and as fuelwood.

The fruits of some species are edible. Several species are commonly cultivated for their edible fruits, such as *S. aqueum* (Burm.f.) Alston, *S. cumini* (L.) Skeels, *S. jambos* (L.) Alston, *S. malaccense* (L.) Merr. & Perry and *S. samarangense* (Blume) Merr. & Perry. The bark of some species has been used for dyeing materials brown, red or black, or for tanning fishing-nets and leather, and for caulking boats. The bark, roots, young shoots, leaves and fruits are used in local medicine. The aromatic leaves are used as a spice for food; the use of the flower buds of *S. aromaticum* (L.) Merr. & Perry (clove) as spice is well known. The leaves of some species are used as a substitute for tea. Some species are planted as ornamental trees along roadsides and in gardens, and as fire-break.

Production and international trade Peninsular Malaysia exports small amounts of kelat timber. In 1983 the export of sawlogs was 4600 m^3 (51% to Singapore and 49% to Hong Kong) with a value of US$ 180 000. Kelat is occasionally exported from Peninsular Malaysia as 'mixed medium hardwood'. The export of kelat logs from Sabah was 20 000 m^3 in 1987 with a value of US$ 1.3 million. In 1992 Sabah exported 13 000 m^3 of kelat timber (84% as logs, 16% as sawn timber) with a total value of US$ 1.1 million (US$ 75/m^3 for logs, US$ 145/m^3 for sawn timber). In Papua New Guinea, *Syzygium* timber is ranked in MEP (Minimum Export Price) group 4; in 1992 low-quality saw logs fetched a minimum price of US$ 43/m^3, and the best quality logs for peeling US$ 60/m^3.

Japan imports this timber mainly from Papua New Guinea (about 3% of the total import from Papua New Guinea), although small amounts are imported from elsewhere in South-East Asia and from the Solomon Islands.

Properties Kelat is a medium-weight to heavy hardwood. The colour of the heartwood varies between species from greyish-brown, golden brown or pinkish-brown to red-brown or purple-brown. The sapwood is usually slightly paler and indistinctly to moderately sharply defined from the heartwood; it may reach 15-40 mm in width. The density of the wood is (450–)520–925(–1100) kg/m^3 at 15% moisture content. The grain is typically interlocked and often irregular and wavy, texture moderately fine and even. The wood is often figureless and non-lustrous, sometimes streaked with dark brown or blackish bands.

At 15% moisture content, the modulus of rupture is 64–116 N/mm^2, modulus of elasticity 10 900–17 600 N/mm^2, compression parallel to grain 42–59 N/mm^2, compression perpendicular to grain c. 6 N/mm^2, shear 5.5–13 N/mm^2, cleavage c. 33 N/mm radial and 49–56 N/mm^2 tangential, Janka side hardness 4070–6540 N and Janka end hardness 5250–5760 N.

The rates of shrinkage are variable, but in general they are rated as medium to moderately high: from green to 15% moisture content c. 1.9% radial and 3.3% tangential, from green to 12% moisture content 1.7–4.3% radial and 4.1–8.4% tangential, and from green to oven dry 3.1–5.0% radial and 5.1–9.0% tangential. Kelat timber air dries slowly to very slowly. In Malaysia boards 15 mm thick are reported to dry in 5 months and boards 40 mm thick in 10 months. Stock must be dried carefully and it is advised to weigh down the stacks and to apply end-coating; the timber is liable to end-splitting and checking. Kiln drying requires a mild schedule (in Malaysia kiln drying schedule C is recommended). Pre-drying before kilning is advised to prevent serious degrade. Timber of 80 mm × 80–130 mm can be dried in about 60 days in a climate chamber from 62% to 26% moisture content, but there is a tendency to surface checking, twisting and bowing. Boards 25 mm thick take about 9 days to kiln dry. A high-humidity treatment at completion of drying will generally relieve stresses. Form stability is good when dry.

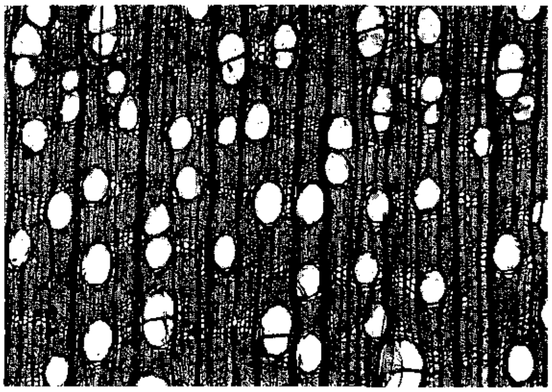
In general, kelat can be converted without difficulty and machines well both green and air-dry. However, the harder and heavier wood of some species cannot be regarded as easy to saw. Air-dried timber is rated as satisfactory to rip-saw and cross-cut when using saws with tungsten carbid tipped teeth and a 20° rake angle; narrow bandsawing may produce smooth surfaces but large amounts of sawdust may remain on saw faces. Saws with excessive hooks tend to chatter, but conversion in a modern mill presents little difficulty. Kelat wood planes easily; a very good surface is obtainable by surface planing with a 35° rake angle, but flat-sawn material from Papua New Guinea shows a tendency to sporadic breakdown, and a reduction of rake angle is recommended. The wood takes a good finish. Kelat is sometimes a good turnery wood, but generally it is unsatisfactory for turning; material from Malaysia usually produces a smooth surface upon turning, but material from Papua New Guinea is reported to have a strong tendency to tearing. Boring is slightly difficult and produces a slightly rough finish. Boring of wood from Papua New Guinea may cause burns at 3000 rounds per minute when using two-wing straight-fluted dowell drills; there is no breaking out at drill exit. Mortising by using the chisel gives good results; satisfactory results are obtainable by using the oscillating cutter and the slot. Moulding with a double-fluted router bit produces satisfactory results. The wood nails and screws reasonably, but preboring is advised to prevent splitting especially close to the ends of boards. Stapling is satisfactory but some raising of face grain and splitting may occur when stapled quite close to the end-grain edge. Generally a good sanded finish can be obtained. The wood polishes well; transparent and stained coatings produce an attractive appearance. The gluing properties are reasonably good. Kelat is easy to cut into smooth, tight rotary-cut veneer of uniform thickness; the veneer dries with slight to moderate buckling and splitting, and the shrinkage is high.

Considerable variation in durability can be expected because of the wide range of densities between the wood of different species. The denser wood is rated as at least moderately durable in contact with the ground. The heartwood of water gum (*S. buettnerianum*) from Papua New Guinea is rated as durable to very durable; stake tests show a service life in contact with the ground of 8–15 years under tropical conditions. The heartwood of Philippine species such as *S. bordenii* and *S. gratum* is also rated as durable in contact with the ground. However, the average service life of test stakes of *S. griffithii* in contact with the ground in Malaysia was only 3.3 years. The wood is often slightly susceptible to powder-post beetle

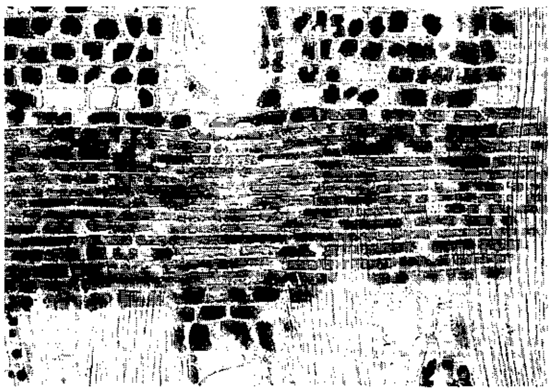
and termite attack and should be treated with preservatives when not used immediately. Attack by pinhole borers is unlikely to be serious. Sapwood and heartwood are susceptible to staining and should be treated with an anti-stain solution as soon as possible. A test in Peninsular Malaysia with untreated wood of *S. chloranthum* showed a service life of about 2 years under marine conditions. The heartwood is difficult to treat with preservatives, but the sapwood is more easily treatable. Wood of *S. chloranthum* showed an average absorption of 123 kg/m^3 when using a standard open tank treatment and an equal mixture of creosote and diesel fuel, but experiments in India showed that the wood of some *Syzygium* species is capable of absorbing only about 15 kg/m^3, even by pressure treatment.
A test on the chemical properties of kelat wood in Malaysia gave the following results: 46% cellulose, 27.5% lignin, 11% pentosan and 0.5% ash; the solubility is 2.9% in alcohol-benzene, 6.6% in hot water and 14.5% in a 1% NaOH solution. The wood of some species is reported to be siliceous. The wood is rich in tannins. The energy value of wood of *S. cumini* is 20 240 kJ/kg.

Description Small to medium-sized, sometimes large trees up to 45(–50) m tall, or rarely shrubs, with bole up to 150(–200) cm in diameter, often fluted at base or with small to moderately large buttresses, stilt roots sometimes present; bark surface highly variable, smooth, cracked, fissured, scaly or flaky, usually greyish-brown to reddish-brown, inner bark usually pink to dark red; twigs with a finely reticulate fibrous surface, usually glabrous. Leaves opposite and simple, glabrous, secondary veins close-set to widely spaced, with a distinct intramarginal vein, dotted with minute oil glands, petiolate but sometimes subsessile, lacking stipules. Inflorescence axillary, terminal, on leafless branches, or on branches or trunk, paniculate, racemose or umbellate, sometimes few-flowered and cymose or flowers fascicled on tubercles, bracts and bracteoles usually inconspicuous and deciduous. Flowers bisexual and regular, (3–)4–5(–10)-merous, clavate to obovoid in bud, often white but sometimes pinkish or reddish; calyx with short to long tube (globose to narrowly elongated-turbinate), the base often contracted into a pseudostalk, and with prominent to minute lobes (sometimes lobes absent and calyx tube truncate at apex), persistent in fruit or deciduous, in some species the calyx limb calyptriform; petals usually free but sometimes connivent or calyptriform, often with oily spots; stamens usually numerous, in several rows on the margin of the disk lining the calyx tube, usually free, anther sacs usually parallel, versatile, opening longitudinally, connective gland usually present; ovary inferior, 2(–4)-locular with few to many ovules in each locule, ovules usually radiating from a centrally located axile placenta, sometimes superimposed along a vertical placenta, style 1, usually filiform, short or long, stigma punctiform or rarely capitate. Fruit a berry with thick and fleshy, spongy, leathery or brittle rind, usually crowned by the remains of the calyx tube and/or lobes, often depressed at apex. Seeds 1–2 per fruit, rarely more; cotyledons thick, usually distinct from each other. Seedling with hypogeal or semi-hypogeal germination; cotyledons usually equal and peltate, petiolate or not; stem 4-angular near top; leaves decussate; tip of seedling often red.

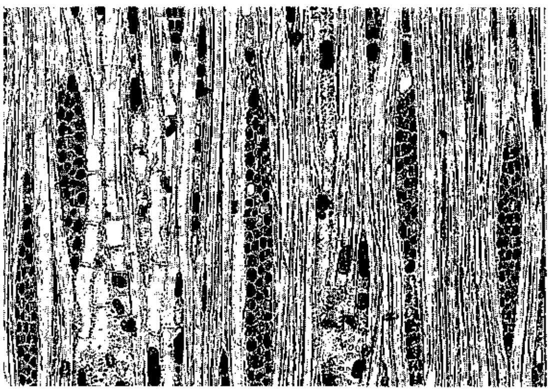
Wood anatomy
– Macroscopic characters:
Heartwood yellowish-grey, brownish-olive, golden brown to reddish-brown or purplish-brown, usually indistinctly demarcated from the paler sapwood, but sometimes fairly sharply defined. Grain usually interlocked and more or less irregular, sometimes wavy. Texture moderately fine to fine and even; the wood is usually dull and without figure on planed surfaces, but sometimes vessel lines show up as white or dark red scratches because of the solid contents of vessels, often feeling rather rough to the touch, generally without characteristic odour or taste. Growth rings absent or inconspicuous, but occasionally concentric, 3–5 mm thick bands with few or no vessels present; vessels variable in size within the species, moderately few to numerous and fairly evenly distributed; parenchyma sparse to abundant, not visible without a lens; rays invisible or barely visible to the naked eye.
– Microscopic characters:
Vessels diffuse, 5–20(–38)/mm^2, solitary and in radial multiples of 2–3(–8), less frequently in clusters, round to oval, 70–200 μm in tangential diameter; perforations simple; intervessel pits alternate, vestured, round to oval, 6–8 μm in diameter; vessel-ray pits with reduced borders to simple, gash-like or round to oval, 15–20 μm in diameter; reddish-brown or sometimes whitish gum-like deposits present; tyloses sparse to abundant, thin-walled. Fibres 900–2600 μm long, non-septate or partly septate, thin-walled to thick-walled (walls c. 4 μm thick), with simple to variably bordered pits. Parenchyma sparse to very abundant, entirely or predominantly paratracheal, aliform, some-



transverse section (×25)



radial section (×75)



tangential section (×75)

Syzygium polyanthum

times limited to the abaxial sides of the vessels, locally confluent or completely confluent (e.g. *S. polyanthum*) into numerous (6–12/mm), wavy, narrow bands; apotracheal parenchyma sparse to fairly abundant, usually consisting of diffuse crystalliferous strands, in up to 8-celled strands. Rays 8–18/mm, of 2 distinct sizes, uniseriate rays sparse to about as numerous as multiseriate rays; uniseriate rays consisting wholly of upright cells, 1–10 cells high; multiseriate rays (up to 10-seriate) up to 0.8 mm high, composed of mixed procumbent and upright to square cells, but in some species wholly or predominantly composed of procumbent cells (Kribs type heterogeneous II to III and homogeneous). Crystals comparatively rare in apotracheal parenchyma, when present solitary or in clusters and in some species in chambered cells; ray and parenchyma cells usually with orange-brown or reddish-brown deposits. Silica usually absent, but some species reported as siliceous. Intercellular canals and ripple marks absent.

Species studied: *S. bordenii, S. cumini, S. fastigiatum, S. malaccense, S. nervosum, S. polyanthum, S. versteegii, S. xanthophyllum.*

Growth and development Most *Syzygium* species are evergreen, shedding their leaves gradually throughout the year, but they develop new leaves and flowers at seasonal intervals. They tend to flower gregariously. *S. polyanthum* can flower already when three years old. Some species flower and produce fruits more or less throughout the year (e.g. *S. polyanthum* and *S. gracile*), but most species in Java flower from July to December and fruits are ripe in September to January. In Malaysia, some species flower once a year, after pronounced dry weather, but most species seem to flower twice a year after each dry spell, whereas a few species flower 3 or more times a year (e.g. *S. grande* usually flowers in Peninsular Malaysia from the middle of March to the middle of April, from the end of July to the middle of August and from the end of December to the middle of January, but sometimes there are additionally shorter periods of flowering). The flowers last for about 4–7 days and are usually pollinated by beetles and butterflies. Pollination of *S. malaccense* by bats (*Chiroptera*, especially *Eonycteris spelaea*) was observed in Peninsular Malaysia where bats feed on the nectar and pollen of several tree species. Other floral visitors are the yellow-bellied sunbird, honey bees and ants.

Fruit setting is during the rainy season and the fruits are ripe before the end of this season. The seeds are dispersed by squirrels, birds and small fruit bats, but seed dispersal of river-bank and seashore species may be by water.

Under favourable conditions in India, 40-year-old *S. cumini* trees attained a mean height of 24.1 m and a diameter at breast height of 31.5 cm.

Other botanical information In the older literature *Syzygium* was regarded as a subgenus of *Eugenia*. In Malaysia, it is still the practice to treat *Eugenia* in its broadest sense (including *Syzygium*). Indeed, there is no single morphological character by which the two genera can be consistently distinguished. Although *Eugenia* sensu stricto and *Syzygium* differ in many characters, all these characters show at least some overlap (e.g. vegetative and/or reproductive parts usually pubescent in *Eugenia* (c. 90% of the species), usually not in *Syzygium* (c. 95%); bracteoles usually persistent and conspicuous in *Eugenia* (c. 80%), mostly fugacious and inconspicuous in *Syzygium* (c. 95%); pseudostalk of flower rarely present in *Eugenia* (c. 1%) and mostly present in *Syzygium* (c. 90%); cotyledons usually fused in *Eugenia*, usually distinct in *Syzygium*; surface of seed-coat smooth in *Eugenia*, rough in *Syzygium*). It is claimed that constant anatomical differences exist, particularly in floral vasculature (in *Eugenia* the vascular supply of the ovules is from the sides, i.e. transeptal, and there is no vascular tissue in the centre of the ovary below the placentae; in *Syzygium* it is through the centre of the gynoecium, i.e. axile, and all transections of the lower part of the ovary reveal vascular tissue in the centre). However, the floral vasculature of only a small fraction of the species has been studied. Evidence from wood anatomy, bark anatomy and pollen morphology also supports the separation of *Eugenia* and *Syzygium*. *Syzygium* is strictly confined to the Old World, *Eugenia* s.s. mainly to the New World, but not exclusively (e.g. *Eugenia aherniana* C.B. Robinson from the Philippines).

In the more recent literature *Jambosa* is considered as a synonym of *Syzygium*; there is no single character or combination of characters by which *Jambosa* can be distinguished.

The genus *Acmena* is distinguished from *Syzygium* and *Eugenia* by the ruminate cotyledons, the apically dehiscent anthers, and the position of the placenta which is at the apex of the axis in each locule with pendulous ovules. The species of *Acmena* are often treated in the literature under *Syzygium* or *Eugenia*. The most important timber-producing species are the widespread *Acmena acuminatissima* (Blume) Merr. & Perry (synonyms: *Eugenia cumingiana* S. Vidal, *Syzygium cumingianum* (S. Vidal) L.S. Gibbs) and *Acmena hemilampra* (F. v. Mueller ex F.M. Bailey) Merr. & Perry from Papua New Guinea and northern Australia. *Acmena* will be treated separately, but not in this volume.

Acmenosperma differs in having 6–8 petals (usually), clavate flower buds (rare in *Syzygium*), pendulous ovules (rare in *Syzygium*) and ruminate cotyledons. The most important timber-producing species is the widespread *Acmenosperma claviflorum* (Roxb.) E. Kausel. Several authors, however, consider the differences as insufficient to separate it at generic level, and here this species is included in *Syzygium* as *S. claviflorum* (Roxb.) A.M. Cowan & J.M. Cowan.

S. nervosum DC. (synonym: *S. operculatum* (Roxb.) Niedenzu) is often considered to belong to the genus *Cleistocalyx* (*Cleistocalyx operculatus* (Roxb.) Merr. & Perry), which differs from *Syzygium* only in the calyptriform calyx. As this feature is not supported by any other character and also rarely occurs in *Syzygium*, *Cleistocalyx* is not kept separate.

In Australia, the timber of several species is used for construction and traded as 'satinash', e.g. *S. canicortex* B. Hyland, *S. crebrinerve* (C.T. White) L. Johnson, *S. corynanthum* (F. v. Mueller) L. Johnson, *S. francisii* (F.M. Bailey) L. Johnson, *S. gustavioides* (F.M. Bailey) B. Hyland, *S. kuranda* (F.M. Bailey) B. Hyland, *S. luehmannii* (F. v. Mueller) L. Johnson, *S. papyraceum* B. Hyland, *S. sayeri* (F. v. Mueller) B. Hyland, *S. trachyphloium* (C.T. White) B. Hyland and *S. wesa* B. Hyland.

Ecology *Syzygium* can be found from sea-level to high in the mountains and is common over large areas, especially as understorey tree, in primary as well as secondary forest. Some species may dominate the vegetation, e.g. *S. grande* and *S. syzygioides* in forest bordering the rocky and sandy bays in Peninsular Malaysia. Very few species have been recorded from limestone. Most species are trees of the second and third storey of the forest. In montane heath forest *Syzygium* species are common understorey trees.

Propagation and planting *Syzygium* is propagated by seed and sometimes by wildlings collected under adult trees. Species well known for their edible fruits are commonly propagated by cuttings, air layering, grafting, and budding. Tissue culture is still in an experimental stage.

The number of seeds per kg ranges from 3000–8500. Seed loses its viability very rapidly; after 4–6 weeks it hardly germinates anymore.

Therefore, seed should be sown directly from the fruit on top of loose soil and under shade. It should not be buried, as this seriously reduces the germination percentage; for *S. polyanthum* it falls from 84% to 9% in Java. Germination is rapid, starting after 1–3 weeks and is complete after 5–12 weeks; 35–100% of the seed sown germinates.

Natural regeneration is generally profuse and seedlings can survive under shade for several years. Attempts to plant bare rooted seedlings of *S. cumini* have not been successful. Wildlings should be hardened off in the nursery before being planted; planting out wildlings immediately, with a ball of soil, was not successful because of the sudden change to the high light intensity at the planting site. Spacing *S. polyanthum* at 2 m × 3 m was considered to be too wide, as it gave rise to a unfavourable stem form and undesired branching. Small *Syzygium* trees may be underplanted in forest plantations to reduce excessive development of weeds. Examples are *S. pycnanthum* Merr. & Perry, *S. litorale* (Blume) Amshoff and *S. splendens*, but they seldom yield timber-sized trees. *S. polyanthum* is also often used for underplanting. The leaves of these species decay relatively slowly and yield large quantities of mulch. Underplanting of kelat has been reported for teak (*Tectona grandis* L.f.), pine (*Pinus* spp.), kauri (*Agathis* spp.) and *Albizia procera* (Roxb.) Benth. plantations.

Silviculture and management Kelat can tolerate shade very well, and light shade promotes the formation of a desirable stem form and branching pattern. Natural pruning is good as soon as the canopy closes. Whenever pruning is necessary, wounds heal very fast. Some species coppice readily. Kelat needs a rather fertile soil. *S. cumini* may be considered for planting on swampy grounds because of its high resistance to oxygen deficiency.

Diseases and pests On average kelat is not prone to fungal attacks of its roots. No major diseases have been recorded, but since the *Syzygium* species producing edible fruit are liable to several fungal diseases (e.g. leaf-spot, anthracnose, thread blight, root rot) it is likely that these diseases also occur to some extent in other species. *Cryptosporella eugeniae* is a virulent wound pathogen in clove (*S. aromaticum*), producing conspicuous red-brown staining of the wood; it can also attack the main stem of young trees and causes them to die when girdling is complete.

The following noxious insect species have been observed on *Syzygium* in Indonesia: *Argyroploce mormopa* (a tip-boring caterpillar on *S. polyanthum*), *Coccus viridus* (feeding on the sap), *Acarina* (mites) and *Alcides patruelis* (larvae living in the shoots and beetles gnawing holes in the tender parts of the shoots). Termites can be a serious pest of young seedlings, and other pests include the red tree ant *Oecophylla smaragdina* and the coccid *Saissetia eugeniae*.

Yield In pure plantations of *S. polyanthum* on fertile soil in Java the mean annual increment at 7 years was 21.5 m^3 of wood per ha, at 8 years in another plantation (spacing 2 m × 3 m) 9.1 m^3 of timber (clear bole wood volume) per ha, and at 17.5 years (spacing 1 m × 2.5 m) 7.4 m^3 of timber per ha. In natural forest in Riau, the same species showed a mean annual increment of 10.5 m^3 of wood per ha.

Genetic resources In general, kelat is common throughout South-East Asia and many species are also common in secondary forest. However, such an immense genus undoubtedly contains numerous species which are rare or local endemics.

Ex-situ germplasm collection has been carried out in Malaysia for some species such as *S. grande* and *S. polyanthum* and several species producing edible fruits.

Prospects In many parts of South-East Asia, most of the kelat timber today appears to be taken out in firewood fellings, and the genus is certainly of secondary importance as a source of timber. Further studies of kelat are desirable, since experience in Borneo, Papua New Guinea and northern Australia suggests that the timber of several species has potential for special purposes.

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Selection of species

All the species treated below probably belong to the genus *Syzygium* according to the concept defined under 'other botanical information'. However, for some species, especially from Malaysia, there is no name in *Syzygium* available and consequently these are treated under a *Eugenia* name. All names are arranged alphabetically according to epithet.

Syzygium acutangulum K. Schumann

K. Schumann & Hollrung, Fl. Kais. Wilh. Land: 89 (1889).

Synonyms *Syzygium papuasicum* Merr. & Perry (1942).

Distribution The Aru Islands, New Guinea, New Britain and the Solomon Islands.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 30 m tall, bark surface smooth, rust-red, branchlets 4-angled, compressed or terete; leaves oblong-elliptical, 12–25 cm × 6–12 cm, with c. 15 pairs of secondary veins, petiole 5–16 mm long; flowers in panicles up to 20 cm long on leafless twigs, calyx c. 3 mm long, minutely lobed; fruit subglobose, up to 25 mm in diameter, black and juicy when ripe. *S. acutangulum* occurs in rain forest, often on wet land, up to 1000 m altitude.

Selected sources 221, 430, 489.

Syzygium acutatum (Miq.) Amshoff

Blumea 5: 497 (1945).

Synonyms *Jambosa acutata* Miq. (1855), *Eugenia argutata* Koord. & Valeton (1900).

Vernacular names Indonesia: ki hanjere, ki tanduk (Sundanese, Java).

Distribution Western Java.

Uses The timber is probably used for house building.

Observations A medium-sized to fairly large tree up to 35 m tall, bole columnar, up to 100 cm in diameter; leaves elliptical, 7–10 cm × 3.5–5 cm, secondary veins thin and closely spaced, petiole 5–10 mm long; flowers in axillary and terminal panicles, calyx c. 5 mm long, 5-lobed; fruit unknown. *S. acutatum* occurs scattered in humid forest up to 1200 m altitude. It is insufficiently known.

Selected sources 36, 234.

Syzygium adelphicum Diels

Nova Guinea 14: 93 (1924).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 23 m tall, bole up to 37 cm in diameter, bark surface brown and flaky; leaves broadly obovate to obovate-cordate, small, 0.5–1.5 cm × 0.4–1.5 cm, with 8–10 pairs of prominent secondary veins, petiole up to 2 mm long; flowers in subsessile, terminal inflorescences, whitish, calyx c. 3 mm long, 4-lobed; fruit small, green. Var. *adenanthum* Merr. & Perry has comparatively small leaves. *S. adelphicum* occurs locally abundantly in montane rain forest and cloud forest at 2000–2700 m altitude. The wood is pale and hard.

Selected sources 221, 430.

Syzygium alvarezii (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 375 (1951).

Synonyms *Eugenia alvarezii* C.B. Robinson (1909).

Vernacular names Philippines: Alvarez malaruhat (general), balteak (Igorot), lobloban (Bontok).

Distribution The Philippines (Luzon, Mindoro).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 20 m tall, bole up to 40 cm in diameter, bark surface cinnamon-coloured; leaves elliptical, oblong or elliptical-lanceolate, 4.5–6 cm × 2–3 cm, with 10–15 pairs of distinct secondary veins, petiole up to 6 mm long; flowers sessile in axillary and terminal panicles, white, calyx c. 4 mm long, with inconspicuous lobes; fruit subglobose, c. 10 mm in diameter, reddish. *S. alvarezii* occurs chiefly in mossy forest on ridges and peaks at 1000–2400 m altitude.

Selected sources 426, 533.

Eugenia anisosepala Duthie
Hook.f., Fl. Brit. India 2: 481 (1878).
Distribution Peninsular Malaysia.
Uses The timber is reputed to be used as kelat.
Observations A medium-sized tree up to 20 m tall, bole up to 80 cm in diameter, slightly fluted at base, bark surface fawn-coloured and flaky, inner bark orange-brown and fibrous; leaves elliptical to oblong-lanceolate, up to 11 cm × 5.5 cm, with up to 14 pairs of prominent secondary veins having intermediate veins in between, petiole up to 6 mm long; flowers in terminal panicles, white, calyx c. 8 mm long with 4 unequal lobes; fruit unknown. *E. anisosepala* occurs scattered. The wood is greyish purple-brown and has a density of about 880 kg/m^3 at 15% moisture content.
Selected sources 140, 529, 705.

Syzygium antisepticum (Blume) Merr. & Perry
Mem. Amer. Acad. Arts & Sci. 18: 159 (1939).
Synonyms *Eugenia cuprea* Koord. & Valeton (1900), *Eugenia spicata* Koord. & Valeton (1900) non Lamk.
Vernacular names Indonesia: gelam buut, ki tambaga, pancal kidang (Java).
Distribution Sumatra, Java and Borneo.
Uses The timber is occasionally used for building houses. The bark has been used for dyeing black.
Observations A medium-sized to fairly large tree up to 40 m tall, bole columnar, up to 100 cm in diameter, bark surface copper-red and flaky; leaves ovate-lanceolate, 3–8 cm × 1–4 cm, with rather closely spaced (2–4 mm) secondary veins, petiole 3–4 mm long; flowers in axillary or terminal inflorescences, whitish, calyx c. 6 mm long with tube prolonged beyond ovary and 5(–6) subequal lobes; fruit globose, c. 10 mm in diameter, whitish. *S. antisepticum* occurs in rain forest up to 1700 m altitude. The wood is hard, durable and pinkish-brown to reddish-brown. The density is 860–940 kg/m^3 at 15% moisture content.
Selected sources 36, 234, 303, 429, 474.

Eugenia arcuatinervia Merr.
Philipp. Journ. Sci., Bot., 1, Suppl.: 104 (1906).
Synonyms *Cleistocalyx arcuatinervius* (Merr.) Merr. & Perry (1937).
Vernacular names Philippines: birakbak (Negrito), malabayabas (Tagalog), malagsam-bakolod (Bagobo).
Distribution The Philippines.
Uses The timber is reputed to be used as kelat.
Observations A medium-sized tree up to 20 m tall, bark surface pale greyish or brownish; leaves ovate-lanceolate, 12–14 cm × 4.5–5.5 cm, with c. 10 pairs of secondary veins prominent below, petiole c. 15 mm long; flowers in axillary and terminal panicles, white, calyx obscurely 4-lobed; fruit unknown. *E. arcuatinervia* occurs in primary forest at low and medium altitudes.
Selected sources 417, 426.

Syzygium benjaminum Diels
Bot. Jahrb. Syst. 57: 411 (1922).
Synonyms *Syzygium micropetalum* Merr. & Perry (1942).
Distribution New Guinea.
Uses The timber is reputed to be used as kelat.
Observations A small to medium-sized tree up to 21 m tall, bole up to 35 cm in diameter, bark surface brown; leaves oblong to obovate or elliptical, 1.5–5 cm × 1–2.5 cm, with up to 17 pairs of secondary veins prominent below, petiole 1–4 mm long; flowers in axillary (sometimes terminal), simple or few-branched inflorescences, white, calyx up to 3 mm long with 4 minute lobes; fruit subglobose, c. 5 mm in diameter, violet when ripe. *S. benjaminum* occurs in primary montane forest and cloud forest at 1350–2700 m altitude.
Selected sources 221, 430.

Syzygium bicolor Merr. & Perry
Journ. Arn. Arb. 23: 286 (1942).
Distribution New Guinea.
Uses The timber is reputed to be used as kelat.
Observations A small to medium-sized tree, bark surface flaky and reddish-brown; leaves elliptical, 3–5 cm × 1–3 cm, with 4–6 pairs of rather indistinct secondary veins, petiole c. 4 mm long; flowers in axillary and terminal inflorescences, white, calyx up to 10 mm long with 5 subequal lobes; fruit unknown. *S. bicolor* is locally frequent in foothill and montane rain forest at 1200–1800 m altitude.
Selected sources 221, 430.

Syzygium blancoi (Merr.) Merr.
Philipp. Journ. Sci., Bot. 79: 378 (1951).
Synonyms *Eugenia blancoi* Merr. (1915).
Vernacular names Philippines: malambis (Samar-Leyte Bisaya).
Distribution The Philippines (Luzon, Samar).
Uses The timber is reputed to be used as kelat.
Observations A medium-sized tree; leaves oblong-elliptical, 8–13 cm × 3–5.5 cm, with c. 8 pairs of indistinct secondary veins, petiole c. 4 mm long;

flowers sessile in terminal paniculate inflorescences, white, calyx c. 5 mm long, truncate and lacking lobes; fruit unknown. *S. blancoi* occurs in primary forest at low altitudes.

Selected sources 420, 426.

Syzygium bordenii (Merr.) Merr.

Philipp. Journ. Sci., Bot. 79: 378 (1951).

Synonyms *Eugenia bordenii* Merr. (1906).

Vernacular names Philippines: malaruhat-puti (general), apalang (Tagalog), panglumbuyan (Iloko).

Distribution The Philippines.

Uses The wood is used for construction of houses, ships and bridges, and for flooring, furniture and implements.

Observations A small to medium-sized tree up to 25 m tall, bole straight, branchless for up to 12 m and up to 65 cm in diameter, often fluted, bark surface pale grey; leaves elliptical-oblong to oblanceolate or oblong or obovate, 8–13 cm × 3–6 cm, with 10–12 pairs of secondary veins, petiole up to 5 mm long; flowers sessile in axillary or terminal, branched and densely flowered inflorescences, comparatively large, white, calyx c. 10 mm long, lobes distinct and persistent; fruit globose, c. 15 mm in diameter. *S. bordenii* is locally common, but not abundant in primary forest at low altitudes. The wood is reddish-brown, heavy (795-910 kg/m^3 at 15% moisture content), hard and durable; it is available in small quantities.

Selected sources 414, 426, 527.

Syzygium bracteosum Merr. & Perry

Journ. Arn. Arb. 23: 250 (1942).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 29 m tall, bole up to 105 cm in diameter, bark surface scaly, whitish to dark brown; leaves elliptical to obovate-elliptical, 4–10 cm × 2.5–5.5 cm, with c. 10 pairs of secondary veins distinct below, petiole 6–9 mm long; flowers in terminal panicles, rose to red, calyx c. 7 mm long, distinctly lobed; fruit unknown. *S. bracteosum* is rather rare in montane rain forest at 1800–2300 m altitude.

Selected sources 221, 430.

Syzygium buettnerianum (K. Schumann) Niedenzu

Engl. & Prantl, Nat. Pflanzenfam. 3, 7: 85 (1893).

Synonyms *Eugenia buettneriana* K. Schumann (1889).

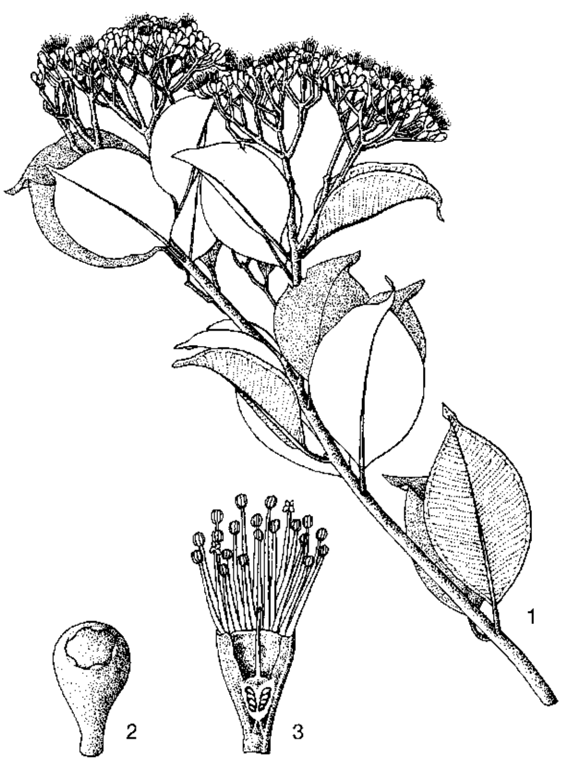
Vernacular names Water gum (En).

Distribution New Guinea, the Solomon Islands and northern Australia.

Uses The timber is used for construction (both light and heavy), ship building, flooring, window sills, furniture, implements, piles and steps.

Observations A medium-sized to fairly large tree up to 35 m tall, bole massive, up to 200 cm in diameter usually having thick buttresses, bark surface greyish to brown, peeling off in flakes; leaves elliptical, 6–8.5 cm × 3–4.5 cm, with c. 10–20 pairs of secondary veins, petiole 10–12 mm long; flowers in the axils of uppermost leaves and terminal, red, calyx c. 5 mm long; fruit subglobose or ellipsoid, up to 25 mm long, purplish when ripe. *S. buettnerianum* is common in rain forest up to 2500 m altitude. The wood is brown to red-brown, moderately strong and moderately durable; the density is about 700 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 12, 60, 72, 145, 164, 221, 249, 289, 347, 483, 543, 728.



Syzygium buettnerianum (K. Schumann) Niedenzu – 1, flowering twig; 2, flower bud; 3, sectioned flower.

Syzygium calubcob (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 380 (1951).

Synonyms *Eugenia calubcob* C.B. Robinson (1909).

Vernacular names Philippines: kalubkob (Tagalog), balanga (Bisaya), barakbak (Ilokano).

Distribution The Philippines; rarely cultivated for the fruits.

Uses The timber is used for temporary construction work. The fruits are edible.

Observations A small to medium-sized tree up to 30 m tall, bole up to 55(–90) cm in diameter, bark surface greyish to dark red; leaves elliptical-oblong to lanceolate, 7.5–23 cm × 2–10 cm, with 10–15 pairs of distinct secondary veins, petiole up to 6 mm long; flowers subsessile or shortly pedicelled, in inflorescences from below the leaves or terminal, white, calyx c. 15 mm long, with 4 large subpersistent lobes; fruit subglobose, up to 5 cm in diameter, yellow-green. *S. calubcob* is widely distributed and common in thickets and forest at low and medium altitudes.

Selected sources 68, 125, 426, 533, 673.

Syzygium carrii Hartley & Perry

Journ. Arn. Arb. 54: 209 (1973).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 30 m tall; leaves elliptical to lanceolate-elliptical, 1.5–3 cm × 1–1.5 cm, with closely spaced (1–2 mm), rather distinct secondary veins, petiole c. 2 mm long; flowers in axillary and terminal inflorescences, calyx c. 10 mm long; fruit unknown. *S. carrii* occurs in montane forest at 1500–2100 m altitude.

Selected sources 221.

Eugenia cerina M.R. Henderson

Gard. Bull. Sing. 11: 322, fig. 12 (1947).

Synonyms *Eugenia punctulata* King (1901) non F.M. Bailey.

Vernacular names Malaysia: kelat gelam (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo.

Uses The timber is reputed to be used as kelat. The fruit is edible.

Observations A small to medium-sized tree up to 27 m tall, bole up to 40 cm in diameter, with steep buttresses up to 1.5 m high, sometimes fluted or having stilt roots, bark surface papery flaky, reddish-brown; leaves obovate, oblanceolate or oblong, 2.5–11 cm × 1.5–5 cm, with c. 16 pairs of indistinct secondary veins, petiole 5–10 mm long; flowers in axillary and terminal panicles, white, calyx c. 2.5 mm long, obscurely 4-toothed; fruit oblong to obovoid, up to 14 mm long, whitish. *E. cerina* is often common in swampy forest on coastal white sands, near rivers and in peat swamp. The wood is greyish-brown with an olive tinge; it is heavy (about 950 kg/m^3 at 15% moisture content) and hard.

Selected sources 77, 78, 104, 140, 529, 705.

Syzygium chloranthum (Duthie) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 173 (1939).

Synonyms *Eugenia chlorantha* Duthie (1878).

Vernacular names Malaysia: kelat merah, kelat jambu merah, kelat lapis (Peninsular).

Distribution Peninsular Malaysia, Singapore, Sumatra and Borneo (Sarawak, perhaps also Sabah).

Uses The timber is reputed to be used as kelat. The roots are thought to be used in local medicine.

Observations A small to medium-sized tree up to 25 m tall, bark surface smooth, greyish-brown to dark reddish-brown; leaves elliptical, ovate-elliptical to lanceolate, 6.5–19.5 cm × 2.5–8.5 cm, with c. 30 pairs of close-set secondary veins distinct below, petiole up to 10 mm long; flowers in axillary and terminal panicles, greenish-white with rose-red stamens, calyx c. 6 mm long, with 4 thick and persistent lobes; fruit subglobose, up to 20 mm in diameter, green flushed rose-purple. *S. chloranthum* is locally common in lowland and hill forest.

Selected sources 78, 104, 429, 529, 705.

Syzygium cinereum (Kurz) P. Chantaranothai & J. Parnell

Kew Bull. 48: 596 (1993).

Synonyms *Eugenia cinerea* Kurz (1875), *Eugenia pseudosubtilis* King (1901).

Vernacular names Malaysia: keriang, keriang batu (Peninsular). Thailand: wa-na (Phangnga), samet-daeng (Chumphon).

Distribution India, Burma (Myanmar), Thailand, Peninsular Malaysia, Singapore and Sumatra; possibly also Indo-China and Borneo.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 30 m tall, bole up to 70 cm in diameter, slightly fluted at base and with buttresses up to 2 m high, bark surface smooth, cracked or fissured and scaly, greyish-brown to reddish-brown, twigs whitish;

leaves elliptical, oblong-elliptical or obovate, (5–)7–11(–16) cm × (2.5–)4–5(–7) cm, with 6–10 pairs of secondary veins fairly distinct below, petiole up to 15 mm long; flowers sessile in axillary and terminal panicles, rarely on twigs below leaves, yellowish-green to reddish, calyx up to 2 mm long, with 4 shallow lobes; fruit depressed globose, up to 15 mm in diameter, pink to almost black when ripe. *S. cinereum* is common in lowland forest and also occurs in freshwater swamp forest and occasionally in montane forest.

Selected sources 90, 104, 529, 705.

Syzygium clavellatum (Merr.) Merr.

Philipp. Journ. Sci., Bot. 79: 382 (1951).

Synonyms *Eugenia clavellata* Merr. (1906).

Vernacular names Philippines: kutangol (Subanun).

Distribution The Philippines (Luzon, Samar, Mindanao).

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 20 m tall, bark surface greyish or pale brown; leaves elliptical-ovate, 4–8 cm × 2–4.5 cm, with numerous indistinct secondary veins, petiole c. 4 mm long; flowers sessile in axillary and terminal panicles, calyx c. 2 mm long, truncate or very obscurely 4-lobed; fruit unknown. *S. clavellatum* occurs in primary forest at medium altitudes.

Selected sources 417, 426.

Syzygium claviflorum (Roxb.) A.M. Cowan & J.M. Cowan

Trees of North Bengal: 67 (1929).

Synonyms *Eugenia claviflora* Roxb. (1832), *Syzygium leptanthum* (Wight) Niedenzu (1893), *Acmenosperma claviflorum* (Roxb.) E. Kausel (1957).

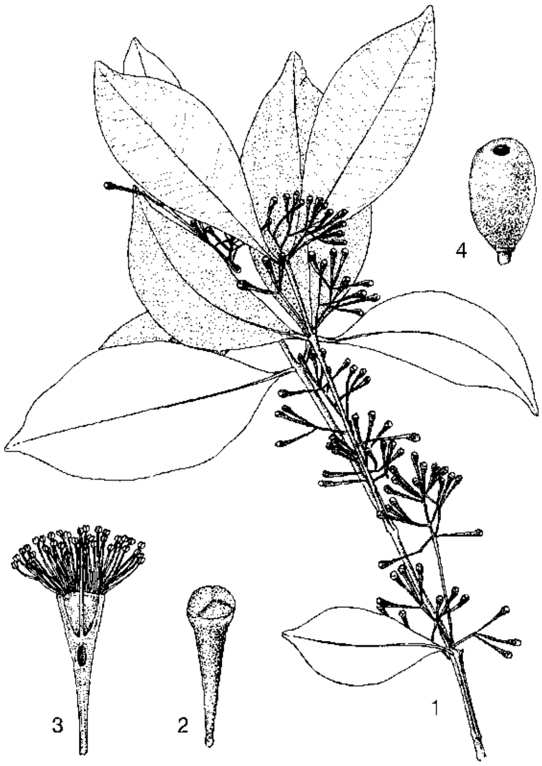
Vernacular names Grey satinash (En). Malaysia: jambu arang, kelat merah, bangkoh (Peninsular). Philippines: kurasam (Ibanag). Burma (Myanmar): thabey-kywe-gaung. Thailand: wa hin (peninsular), lueat (Surat Thani).

Distribution India, Bangladesh, Burma (Myanmar), Indo-China, southern China, Thailand, and throughout Malesia, to northern Australia.

Uses The timber is used throughout the area of distribution, e.g. for construction. In Malaysia the ripe fruits are preserved as pickle.

Observations A medium-sized tree up to 25(–35) m tall, bole up to 60 cm in diameter, with short buttresses, bark surface smooth to flaky, greyish or brown; leaves lanceolate to elliptical-oblong, 5.5–18(–20) cm × 2–7.5 cm, with up to 26(–37) pairs of secondary veins fairly distinct below, petiole 2–7(–8.5) mm long; flowers sessile in axillary and terminal cymose inflorescences, flower buds clavate, calyx gradually narrowed to base without well-defined pseudostalk, 4-lobed, petals (5–)6–8(–10); fruit variable in shape, cylindrical to ovoid, globose or pear-shaped, up to 2 cm long, red to purplish-red when ripe; cotyledons ruminate. *S. claviflorum* is very variable and occurs in lowland rain forest on various soils, up to 1200 m altitude. The density of the wood is 720–880 kg/m^3 at 15% moisture content.

Selected sources 90, 104, 221, 249, 429, 454, 705.



Syzygium claviflorum (Roxb.) A.M. Cowan & J.M. Cowan – 1, twig with flower buds; 2, flower bud; 3, sectioned flower; 4, fruit.

Eugenia conglomerata Duthie

Hook.f., Fl. Brit. India 2: 497 (1878).

Vernacular names Malaysia: selembat (Peninsular).

Distribution Peninsular Malaysia and Singapore.

Uses The timber is suitable for house building.

Observations A medium-sized tree up to 27 m

tall, bole up to 60 cm in diameter, with buttresses up to 2 m high, bark surface scaly, reddish-brown; leaves oblanceolate to narrowly obovate, 5–10 cm × 2–5.5 cm, with 8–12 pairs of indistinct secondary veins, petiole up to 10 mm long; flowers in fascicled spikes from small tubercles on older twigs below the leaves, reddish, calyx c. 1.5 mm long, 4-lobed; fruit depressed globose, up to 12 mm in diameter, dark purplish-red when ripe. *E. conglomerata* is uncommon. The wood is brown and very durable.

Selected sources 78, 529, 705.

Syzygium corymbosum (Blume) DC.

Prodr. 3: 261 (1828).

Synonyms *Eugenia corymbifera* Koord. & Valeton (1900).

Vernacular names Indonesia: ki sireum (Sundanese, Java), salam wana (Javanese, Java).

Distribution Java.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter; leaves oblong-elliptical, 8–15 cm × 3–5 cm, with 8–10 pairs of secondary veins prominent below, petiole 10–20 mm long; flowers in terminal, strongly branched and many-flowered inflorescences, white, calyx up to 6 mm long, obscurely lobed; fruit globose, c. 25 mm in diameter, greenish. *S. corymbosum* occurs scattered in primary rain forest up to 1000 m altitude.

Selected sources 36, 303.

Syzygium costulatum (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 385 (1951).

Synonyms *Eugenia costulata* C.B. Robinson (1909).

Vernacular names Philippines: paitan (general), malakna (Tagalog), bayakbak (Pangasinan).

Distribution The Philippines (Pangasinan, Bataan, Rizal, Tayabas, Camarines).

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 22 m tall, bole up to 75 cm in diameter; leaves elliptical to elliptical-lanceolate, 5–14.5 cm × 3–5.5 cm, with 8–12 pairs of distinct secondary veins, petiole up to 6 mm long; flowers sessile in axillary or terminal inflorescences, white, calyx c. 5 mm long, with 4 inconspicuous lobes; fruit ellipsoid, up to 20 mm long, brown. *S. costulatum* occurs in primary forest at medium altitude.

Selected sources 426, 533.

Syzygium curranii (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 386 (1951).

Synonyms *Eugenia curranii* C.B. Robinson (1909).

Vernacular names Philippines: Curran lipote (general).

Distribution The Philippines (Luzon, Samar).

Uses The wood is used for boards. The fruits are edible and used for wine and jelly.

Observations A small to medium-sized tree up to 15 m tall, bole up to 30 cm in diameter, bark surface scaly, pinkish-brown; leaves oblong, 15–29 cm × 4.5–8 cm, with 16–22 pairs of secondary veins, petiole 5–8 mm long; flowers in panicles on short tubercles on stems and branches, white, pedicel up to 9 mm long, calyx c. 10 mm long, with 4 large, unequal lobes; fruit ellipsoid, up to 25 mm in diameter, dark red to black. *S. curranii* is quite rare and occurs in primary forest at low altitudes.

Selected sources 68, 125, 399, 426, 673.

Syzygium decipiens (Koord. & Valeton) Merr. & Perry

Journ. Arn. Arb. 23: 281 (1942).

Synonyms *Eugenia decipiens* Koord. & Valeton (1900), *Syzygium megalanthelium* Diels (1924), *Syzygium rectangulare* Merr. & Perry (1942).

Vernacular names Indonesia: ki tambaga (Sundanese, Java). Philippines: malaruhat-pula (Tagalog).

Distribution Western Java, the Philippines (Luzon), the Aru Islands, New Guinea and the Solomon Islands.

Uses The timber is used for house construction, furniture and implements.

Observations A medium-sized tree up to 25 m tall, bole up to 50 cm in diameter, sometimes with small buttresses, bark surface somewhat flaky, reddish-brown or greyish-brown; leaves elliptical to lanceolate, 7–14 cm × 3–5.5 cm, with numerous, closely spaced, indistinct secondary veins, petiole 5–10 mm long; flowers in large, profusely branched panicles on branches, pinkish, calyx up to 5 mm long, shortly or obscurely 4-toothed; fruit depressed globose, up to 15 mm in diameter, dark purple when ripe. *S. decipiens* occurs in humid primary forest in the lowlands, in New Guinea especially on the fringes of flooded forest of river plains, in Java up to 1300 m altitude. The wood is pale to dark reddish-brown, heavy and hard.

Selected sources 36, 221, 303, 414, 426, 430.

Syzygium densinervium (Merr.) Merr.

Philipp. Journ. Sci., Bot. 79: 387 (1951).

Synonyms *Eugenia densinervia* Merr. (1906).

Vernacular names Philippines: salakadan, katong-matsing, malaruhat (Tagalog).

Distribution The Philippines.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized, slender tree up to 25 m tall, bark surface pale brown or greyish; leaves obovate to elliptical, 11–18 cm × 5–8 cm, with numerous, close-set, indistinct secondary veins, petiole up to 20 mm long; flowers in terminal corymbose panicles, whitish often tinged with red, calyx c. 6 mm long, obscurely 4-lobed; fruit shortly ellipsoid to subglobose, c. 15 mm long, purplish-red when ripe. *S. densinervium* occurs in primary forest up to 600 m altitude. It may possibly be closely allied to *S. fastigiatum*.

Selected sources 125, 426.

Syzygium duthieanum (King) Masam.

Enum. Phan. Born.: 527 (1942).

Synonyms *Eugenia duthieana* King (1901).

Vernacular names Malaysia: biareh rimba, kelat balak, kelat puteh (Peninsular).

Distribution Peninsular Malaysia and Singapore.

Uses The timber is used in house building.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 60 cm in diameter, with short buttresses up to 1 m high, bark surface smooth, scaly or dippled, red-brown; leaves elliptical to elliptical-lanceolate or elliptical-ovate, 5–15 cm × 3–6.5 cm, with up to 8 pairs of indistinct secondary veins, petiole 5–7 mm long; flowers in axillary or terminal racemes, white, calyx c. 5 mm long, with 4 small lobes; fruit globular to slightly pear-shaped, knobby, c. 2 cm long, greenish. *S. duthieanum* occurs in lowland and hill forest up to 800 m altitude. The wood is dark red to purplish-brown; the density is about 850 kg/m^3 at 15% moisture content.

Selected sources 78, 90, 140, 529, 705.

Syzygium dyerianum (King) P. Chantaranothai & J. Parnell

Kew Bull. 48: 596 (1993).

Synonyms *Eugenia dyeriana* King (1901), *Eugenia corrugata* King (1922), *Eugenia atronervia* M.R. Henderson (1949).

Distribution Thailand and Peninsular Malaysia.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 24 m tall, bole up to 50 cm in diameter, with short buttresses up to 1 m high, bark surface smooth to distantly scaly, red-brown; leaves elliptical or oblong, 8–28 cm × 4–12 cm, with 8–20 pairs of widely spaced, prominent secondary veins, petiole up to 15 mm long; flowers often clustered in axillary or terminal panicles, white, calyx with 4 unequal lobes; fruit globular or depressed globular, up to 6 cm in diameter. *S. dyerianum* is common in rain forest up to 1300 m altitude. The wood is brown with a purplish-grey tinge; the density is about 800 kg/m^3 at 15% moisture content.

Selected sources 90, 140, 378, 529, 705.

Syzygium effusum (A. Gray) Müll. Stuttg.

Walp., Ann. bot. syst. 4: 383 (1857).

Synonyms *Eugenia effusa* A. Gray (1854), *Syzygium leucoderme* Diels (1922), *Syzygium niviferum* (Greves) Merr. & Perry (1942), *Syzygium obtusum* Merr. & Perry (1942), *Syzygium sylvanum* (Ridley) Merr. & Perry (1942).

Distribution Throughout New Guinea, east to Fiji.

Uses The timber is reputed to be used as kelat. The fruits are edible.

Observations A medium-sized tree up to 33 m tall, bole up to 50 cm in diameter, bark surface scaly, greyish-brown or dark brown; leaves obovate, spatulate or elliptical, 2–8 cm × 1.5–5 cm, with 10–15 pairs of inconspicuous secondary veins, petiole c. 5 mm long; flowers in terminal inflorescences, reddish in bud, whitish when open, calyx up to 5 mm long, with 4 obsolete to distinct lobes; fruit globose, whitish. *S. effusum* occurs in primary rain forest up to 2800 m altitude and is locally common. The density of the wood is about 880 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 141, 221, 430.

Syzygium elliptilimbum (Merr.) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 187 (1939).

Synonyms *Eugenia elliptilimba* Merr. (1917).

Distribution Borneo (Sarawak, Kalimantan) and the Philippines (Mindanao).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree, bark surface pale brown; leaves elliptical to broadly oblong-elliptical, 12–18 cm × 5.5–8 cm, with c. 20 pairs of distinct secondary veins, petiole up to 8 mm long; flowers in terminal corymbose panicles, calyx truncate at apex, without distinct lobes;

fruit unknown. *S. elliptilimbum* occurs in primary forest at low and medium altitudes; in Sarawak it grows locally on friable sandy-clay soils in mixed dipterocarp forest.

Selected sources 576.

Syzygium fastigiatum (Blume) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 152 (1939).

Synonyms *Eugenia bracteolata* Wight (1850), *Eugenia fastigiata* (Blume) Koord. & Valeton (1900), *Syzygium bibracteatum* (Greves) Merr. & Perry (1942).

Vernacular names Indonesia: gelam, ki jangkar, salam gede (Sundanese, Java). Malaysia: kelat puteh (Peninsular). Philippines: hahanum (Negrito). Thailand: kongkang-bok (Ranong).

Distribution Burma (Myanmar), Thailand, Peninsular Malaysia, Sumatra, western Java, Borneo, the Philippines and New Guinea.

Uses The timber is used for house building and general light construction.

Observations A medium-sized tree up to 25(–28) m tall, bole straight, cylindrical, up to 75 cm in diameter, bark surface smooth to papery scaly, greyish-brown; leaves obovate-oblong or oblanceolate, 4–16 cm × 2–6 cm, with closely set (up to 36 pairs), faintly visible secondary veins, petiole up to 20 mm long; flowers in terminal or occasionally axillary, corymbose panicles with persistent bracts and bracteoles, whitish, calyx 5–7 mm long, with 4 short lobes; fruit ellipsoid, c. 10 mm long, with enlarged and incurved calyx lobes at apex. *S. fastigiatum* occurs in rain forest, in Java up to 1200 m altitude.

Selected sources 36, 77, 90, 221, 234, 336, 529, 705.

Syzygium filiforme (Wallich ex Duthie) P. Chantaranothai & J. Parnell

Kew Bull. 48: 598 (1993).

Synonyms *Eugenia filiformis* Wallich ex Duthie (1878).

Vernacular names Malaysia: kelat api, kelat merah, kelat manek (Peninsular).

Distribution South-western Thailand, Peninsular Malaysia and Singapore.

Uses The timber is used for house building.

Observations A small to large tree up to 42 m tall, bole up to 85 cm in diameter, slightly fluted and with short buttresses, bark surface smooth to finely cracked, reddish-brown or dark brown; leaves lanceolate to ovate-lanceolate or oblong-elliptical, 5–11 cm × 2–5 cm, with up to 16 pairs of inconspicuous secondary veins, petiole up to 7 mm long; flowers in axillary or terminal racemes, sometimes solitary, white, with filiform pedicel, calyx up to 10 mm long, with 4 short and equal lobes; fruit globose or depressed globose, up to 15 mm in diameter, greenish. *S. filiforme* is common in lowland rain forest up to 700(–900) m altitude. The wood is fawn-coloured to olive brown; the density is about 820 kg/m^3 at 15% moisture content.

Selected sources 78, 90, 104, 140, 529, 705.

Syzygium flavescens (Ridley) Merr. & Perry

Journ. Arn. Arb. 23: 278 (1942).

Synonyms *Eugenia flavescens* Ridley (1916).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 25 m tall, bole narrowly flanged or fluted at base, bark surface flaky, greyish-brown; leaves elliptical to elliptical-lanceolate, c. 13 cm × 4 cm, with rather inconspicuous secondary veins 5–10 mm apart, petiole c. 5 mm long; flowers in lateral inflorescences, pinkish or whitish, calyx up to 4 mm long; fruit c. 5 mm long, purplish-black when mature. *S. flavescens* occurs in lowland rain forest up to 1000 m altitude.

Selected sources 221, 430.

Eugenia flosculifera M.R. Henderson

Gard. Bull. Sing. 11: 329 (1947).

Distribution Peninsular Malaysia and Singapore.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to large tree up to 45 m tall, bole up to 70 cm in diameter, with buttresses up to 2 m high, bark surface dippled to papery scaly, rarely fissured, greyish-brown, twigs whitish or yellowish; leaves elliptical to obovate-elliptical, 4–8 cm × 2–3.5 cm, with up to 8 pairs of inconspicuous secondary veins, petiole up to 10 mm long; flowers in axillary or terminal panicles, calyx c. 2.5 mm long, with 4 lobes; fruit broadly oblong to oblong-obovoid, c. 15 mm long, pale shiny green when ripe. *E. flosculifera* occurs widely in lowland rain forest.

Selected sources 705.

Syzygium forte (F. v. Mueller) B. Hyland

Austr. Journ. Bot., Suppl. Ser. 9: 88 (1983).

Synonyms *Eugenia fortis* F. v. Mueller (1865), *Syzygium rubiginosum* Merr. & Perry (1942).

Vernacular names White apple, flaky-barked satinash (En).

Distribution Papua New Guinea and northern Australia.

Uses The timber is occasionally used and marketed. The fruits are sometimes eaten.

Observations A medium-sized tree up to 30 m tall, bole cylindrical or slightly fissured, up to 100 cm in diameter, occasionally buttressed, bark surface papery flaky, reddish-brown; leaves orbicular or obovate to narrowly ovate, elliptical or lanceolate, 7–14.5 cm × 2.5–10.5 cm, with 8–15 pairs of distinct secondary veins, petiole up to 16 mm long; flowers in terminal paniculate inflorescences (or in upper leaf axils), white, calyx up to 10 mm long, with 4 subequal lobes; fruit depressed globular to ovoid, up to 40 mm in diameter, whitish. *S. forte* is locally common in lowland rain forest, especially near rivers. The density of the wood is 690–960 kg/m³ at 15% moisture content.

Selected sources 221, 249, 430.

Syzygium furfuraceum Merr. & Perry

Journ. Arn. Arb. 23: 276 (1942).

Synonyms *Syzygium folidorhachis* Merr. & Perry (1942).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 22 m tall, bole up to 55 cm in diameter, bark surface scaly, dark brown, flaking off in minute particles in inflorescences; leaves elliptical, 9–18 cm × 6.5–11 cm, with numerous distinct or indistinct secondary veins, petiole up to 15 mm long; flowers in lateral inflorescences on trunk and large branches, greenish-white in bud, calyx up to 7 mm long, with 4 distinct lobes; fruit slightly cup-shaped or pitcher-like, c. 7 mm long, borne on the trunk, brownish-green. *S. furfuraceum* occurs scattered in primary rain forest up to 2300 m altitude.

Selected sources 221, 430.

Syzygium garciniifolium (King) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 167 (1939; 'garcinifolium').

Synonyms *Eugenia garciniifolia* King (1901; 'garcinifolia').

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to fairly large tree up to 39 m tall, bole up to 95 cm in diameter, with buttresses up to 2(–4.5) m high, bark surface smooth, fissured or scaly, greyish to reddish; leaves elliptical or elliptical-oblong, 13–20 cm × 5–10 cm, with up to 15 pairs of prominent secondary veins, petiole up to 25 mm long; flowers in terminal panicles, white, calyx c. 10 mm long, with 4 unequal lobes; fruit subglobose, c. 10 mm in diameter. *S. garciniifolium* is uncommon.

Selected sources 529, 705.

Syzygium gigantifolium (Merr. ex C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 391 (1951).

Synonyms *Eugenia gigantifolia* Merr. ex C.B. Robinson (1909).

Vernacular names Philippines: malatalisai (general), bagotalisi (Panay Bisaya).

Distribution The Philippines (Mindoro, Culion, Mindanao, Basilan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 20 m tall, bole up to 40 cm in diameter, bark surface yellowish-brown or reddish-brown; leaves elliptical to oblanceolate, very large, 34–66 cm × 9–21 cm, with 16–23 pairs of distinct secondary veins, petiole up to 2 mm long (leaves subsessile) but stout; flowers in cymes on small tubercles on older branches, with up to 13 mm long pedicel with articulation below the calyx, calyx up to 25 mm long, with 4 large, unequal, subpersistent lobes; fruit pitcher-like, c. 13 mm long. *S. gigantifolium* occurs in open forest at low altitude.

Selected sources 426, 533.

Syzygium glaucum (King) P. Chantaranothai & J. Parnell

Kew Bull. 48: 598 (1993).

Synonyms *Eugenia glauca* King (1901).

Vernacular names Thailand: daeng (Trang).

Distribution Burma (Myanmar), Thailand, Peninsular Malaysia and Singapore.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to large tree up to 45 m tall, bole up to 80 cm in diameter, with buttresses up to 3 m high, bark surface fissured and scaly, red to reddish-grey; leaves obovate to elliptical-lanceolate, 3.5–11 cm × 2–6 cm, with c. 15 pairs of distinct secondary veins, petiole up to 10 mm long; flowers in few-flowered axillary or terminal racemes or panicles, whitish, calyx c. 4 mm long, with 4 minute and deciduous lobes; fruit globose to slightly pear-shaped, up to 28 mm in diameter. *S. glaucum* occurs in lowland forest, in Thailand up to 1600 m altitude. The wood is purplish grey-brown.

Selected sources 90, 140, 529, 705.

Syzygium gonatanthum (Diels) Merr. & Perry

Journ. Arn. Arb. 23: 256 (1942).

Synonyms *Jambosa gonatantha* Diels (1922), *Eugenia forbesii* Greves (1923), *Syzygium forbesii* (Greves) Merr. & Perry (1942).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 21 m tall, bole up to 45 cm in diameter, bark surface scaly, dark brown; leaves ovate-oblong to elliptical, 6.5–20 cm × 2–7 cm, with 6–8 pairs of prominent secondary veins, petiole up to 15 mm long; flowers in axillary or lateral inflorescences, solitary or 2–3 on a very short peduncle, white, creamy or yellow, calyx up to 20 mm long, with conspicuous lobes; fruit unknown. *S. gonatanthum* occurs in lowland and foothill rain forest up to 1400 m altitude.

Selected sources 141, 221, 430.

Syzygium gracile (Korth.) Amshoff

Blumea 5: 500 (1945).

Synonyms *Jambosa gracilis* Korth. (1847), *Eugenia clavimyrtus* Koord. & Valeton (1900), *Eugenia virens* (Blume) Koord. & Valeton (1900), *Eugenia leptogyna* C.B. Robinson (1909), *Syzygium fusiforme* (Duthie) Merr. & Perry (1939).

Vernacular names Indonesia: ki petag, ki sireum (Sundanese, Java). Philippines: balibadan (Manobo).

Distribution Peninsular Malaysia, Singapore, western and central Java, Borneo (Sarawak, Sabah) and the Philippines.

Uses The timber is occasionally used for house building. The bark was formerly used to prepare a black dye.

Observations A small to medium-sized tree up to 30 m tall, bole up to 70 cm in diameter, slightly fluted and with buttresses up to 2 m high; leaves elliptical-oblong to lanceolate, 5.5–19 cm × 2–8 cm, with 8–18 pairs of thin secondary veins distinct below, petiole up to 20 mm long; flowers solitary in leaf-axils or 3–5 together at stem-apices on up to 60 mm long pedicels, white or greenish-white, calyx up to 30 mm long, with 4 broad, unequal and persistent lobes; fruit globose, ellipsoid or ovoid, up to 20 mm long, dark green. *S. gracile* occurs in forest up to 1500 m altitude, and is not common. The density of the wood is 810–900 kg/m³ at 15% moisture content.

Selected sources 36, 63, 218, 234, 303, 426, 429, 474, 529, 533, 705.

Syzygium grande (Wight) Walp.

Repert. bot. syst. 2: 180 (1843).

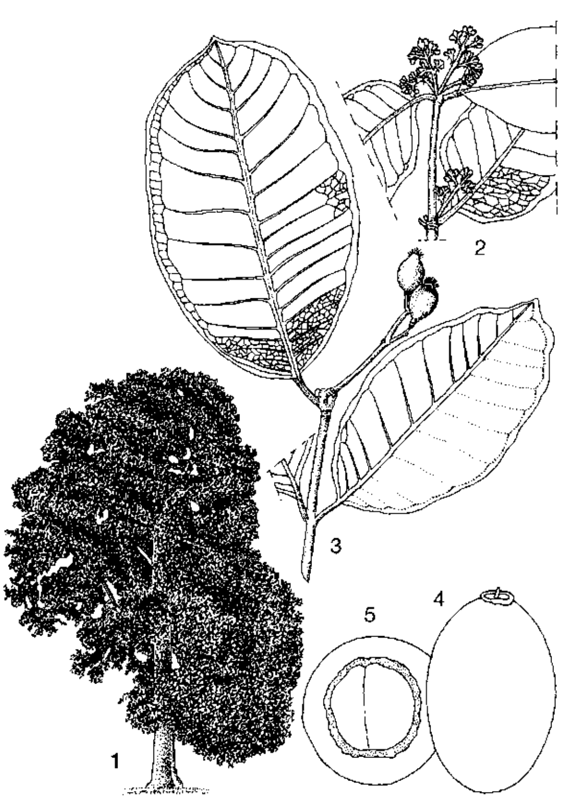
Synonyms *Eugenia grandis* Wight (1841).

Vernacular names Sea apple (En). Malaysia: kelat jambu, jambu air laut, jambu jembah (Peninsular). Burma (Myanmar): toung-thabyay, thabyay-kyee. Thailand: mao (peninsular), yamuyimma (Malay, Narathiwat), wa-dong (Kanchanaburi).

Distribution India, Sri Lanka, Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia and Borneo.

Uses The timber is used for house and ship building. The trees are planted along roadsides and have been used as fire-breaks.

Observations A medium-sized tree up to 30 m tall, bole up to 80 cm in diameter, fluted at base, bark surface shallowly fissured and somewhat flaky, greyish-buff or pinkish; leaves elliptical or broadly elliptical, 10–25 cm x 6–12 cm, with up to 14(–20) pairs of well-spaced, distinct secondary veins, petiole up to 20 mm long; flowers clustered



Syzygium grande (Wight) Walp. – 1, tree habit; 2, flowering twig; 3, fruiting twig; 4, fruit; 5, cross section of fruit.

in axillary and terminal panicles, white, calyx c. 7 mm long, with 4 very unequal lobes; fruit subglobose to ellipsoid, up to 40 mm long, green when ripe. *S. grande* is a common tree on sandy and rocky coasts of Peninsular Malaysia. It occurs also in bamboo forest, savanna and edges of forest near the sea-shore, up to 1200 m altitude. The wood is brown with a purple-grey tinge; the density is 705–875 kg/m^3 at 15% moisture content.

Selected sources 78, 90, 104, 140, 234, 336, 429, 454, 474, 529, 705.

Syzygium gratum (Wight) S.N. Mitra

Indian Forester 99: 100 (1973).

Synonyms *Eugenia grata* Wight (1841), *Eugenia glaucicalyx* Merr. (1906), *Syzygium glaucicalyx* (Merr.) Merr. (1951).

Vernacular names Philippines: mariig (Tagalog), kalaum (Culion), malaruhat (Laguna). Thailand: khraimet (Chiang Mai), sametchun (central), metchun (peninsular).

Distribution India, Burma (Myanmar), Thailand and the Philippines.

Uses The timber is used for construction of houses, ships and bridges, and for furniture and implements. Young shoots are eaten locally as a vegetable.

Observations A medium-sized tree up to 20 m tall, bole branchless for up to 10 m and up to 80 cm in diameter; leaves variable in shape and size, ovate to lanceolate or narrowly elliptical, 5–11.5 cm × 1.5–5 cm, with 10–15 pairs of secondary veins, petiole up to 10.5 mm long; flowers in axillary or terminal panicles, white, calyx 4–9.5 mm long, with 5 minute lobes; fruit globose, white. *S. gratum* is a highly variable species and possibly closely allied to *S. zeylanicum*. It occurs in the Philippines in primary forest up to 600 m altitude, in Thailand in dry evergreen and mixed deciduous forest up to 1400 m altitude. The supply of the timber in the Philippines is very limited. The wood is dark reddish-brown, heavy (c. 960 kg/m^3 at 15% moisture content), hard and durable.

Selected sources 90, 414, 426, 527.

Syzygium griffithii (Duthie) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 174 (1939).

Synonyms *Eugenia griffithii* Duthie (1878).

Vernacular names Malaysia: kelat lapis, kelat bising (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo.

Uses The timber is reputed to be used as kelat. The bark has been used to dye clothes reddish or, after stamping in mud, black.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 70 cm in diameter, buttresses up to 5 m high, bark surface dippled, scaly and flaky, reddish-brown; leaves narrowly elliptical to oblong-elliptical, 8–20 cm × 4–9 cm, with c. 15 pairs of secondary veins indistinct above, petiole up to 10 mm long; flowers sessile in axillary and terminal racemes or panicles, calyx c. 5 mm long, with 4 unequal and deciduous lobes; fruit subglobose, c. 20 mm in diameter, greenish. *S. griffithii* closely resembles *S. subrufum* (King) Masam., but it has shorter inflorescences, smaller leaves and larger flowers. It is widely distributed in lowland and hill forest. The wood is purplish grey-brown; the density is 670–735 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 78, 140, 206, 364, 378, 529, 705.

Syzygium hackenbergii Diels

Bot. Jahrb. Syst. 60: 312 (1926).

Vernacular names Indonesia: gelam tikus (Kalimantan).

Distribution Borneo (southern Kalimantan).

Uses The rather slender boles are used as poles in house building.

Observations A small to medium-sized tree up to 15 m tall, bole up to 30 cm in diameter, with small buttresses; leaves obovate or broadly obovate, 3–6 cm × 2–4 cm, with numerous close-set secondary veins, petiole up to 7 mm long; flowers sessile in terminal panicles with stout branches, calyx c. 3.5 mm long, with 4 short lobes; fruit unknown. The wood is reddish, hard and fairly durable.

Selected sources 429.

Syzygium helferi (Duthie) P. Chantaranothai & J. Parnell

Kew Bull. 48: 599 (1993).

Synonyms *Eugenia helferi* Duthie (1878).

Vernacular names Malaysia: beti paya (Peninsular). Thailand: daeng-hin (Surat Thani).

Distribution Burma (Myanmar), Thailand and northern Peninsular Malaysia.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 18 m tall, bole up to 60 cm in diameter, fluted at base, bark surface smooth to scaly, pinkish or greyish-brown; leaves elliptical-oblong to ovate-lanceolate, 6–13 cm × 1.5–5.5 cm, with up to 15 pairs of indistinct secondary veins, petiole up to 15 mm long; flowers in axillary and terminal panicles, creamy white, calyx c. 5 mm long, with 4 unequal and persistent lobes; fruit oblong to oblong-globose, up to 20 mm long, pale greenish-white. *S. helferi* occurs on sandy soils near the sea and in rocky forest in the lowland, up to 700 m altitude. The wood is brown with a grey-pink tinge; the density is about 845 kg/m^3 at 15% moisture content.

Selected sources 78, 90, 140, 529, 705.

Syzygium homichlophilum Diels

Bot. Jahrb. Syst. 57: 409 (1922).

Synonyms *Syzygium retivenium* Merr. & Perry (1942).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 31 m tall, bole up to 50 cm in diameter, bark surface scaly, brown; leaves oblong to oblong-obovate, 2–6.5 cm × 0.7–3.5 cm, with up to 15 pairs of rather distinct secondary veins, petiole up to 10 mm long; flowers in leafy terminal inflorescences, calyx with 4 small lobes; fruit unknown. *S. homichlophilum* occurs in primary montane rain forest and cloud forest at 1500–2700 m altitude, and is locally common.

Selected sources 141, 221, 430.

Syzygium hoseanum (King) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 150 (1939).

Synonyms *Eugenia hoseana* King (1901).

Distribution Peninsular Malaysia and Borneo (Sarawak, Sabah).

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 15 m tall, bole up to 20 cm in diameter, but in Sarawak reportedly much larger, bark surface smooth to minutely fissured, yellowish-brown; leaves elliptical, elliptical-oblong to obovate, up to 15 cm × 7 cm, with 10–20 pairs of distinct secondary veins, petiole c. 10 mm long; flowers sessile in axillary or terminal short and compact racemose inflorescences, sometimes solitary or clustered, surrounded by persistent bracts, white, calyx with 5 persistent lobes; fruit oblong-globose, c. 10 mm in diameter, faintly ridged. *S. hoseanum* is uncommon in Peninsular Malaysia but locally abundant in Sarawak in mixed dipterocarp forest on leached yellow sandy soils.

Selected sources 576, 705.

Syzygium inophyllum DC.

Prodr. 3: 260 (1828).

Synonyms *Eugenia inophylla* (DC.) Roxb. (1832).

Vernacular names Malaysia: kelat puteh, samak paya, gelam tikus (Peninsular).

Distribution Burma (Myanmar), Peninsular Malaysia, Borneo and the Moluccas.

Uses The timber is used in house building.

Observations A medium-sized tree up to 24 m tall, bole straight, up to 40 cm in diameter, fluted at base or with short buttresses, bark surface scaly, reddish-brown; leaves elliptical to elliptical-lanceolate, 7–14 cm × 3.5–8 cm, with numerous, close-set and indistinct secondary veins, petiole up to 13 mm long; flowers sessile in axillary and terminal panicles, creamy, calyx with (4–)5 obscure lobes; fruit globose or depressed globose, c. 25 mm in diameter. *S. inophyllum* occurs in lowland and lower montane rain forest. The wood is pinkish-brown; the density is about 770 kg/m^3 at 15% moisture content.

Selected sources 78, 140, 529, 705.

Syzygium intumescens (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 396 (1951).

Synonyms *Eugenia intumescens* C.B. Robinson (1909).

Vernacular names Philippines: hagoho (Panay Bisaya), malaruhat (Tagalog), tual (Igorot).

Distribution The Philippines (Luzon, Masbate, Leyte, Camiguin de Misamis).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree; leaves elliptical, oblanceolate or obovate, 10–23 cm × 5–11 cm, with 12–18 pairs of secondary veins, leaves sessile or with petiole up to 5 mm long; flowers sessile in axillary or terminal paniculate inflorescences, calyx c. 5 mm long, with 4 fairly large, rounded lobes; fruit unknown. *S. intumescens* occurs in primary forest at medium altitude.

Selected sources 426, 533.

Eugenia kiahii M.R. Henderson

Gard. Bull. Sing. 11: 307 (1947).

Distribution Peninsular Malaysia.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 27 m tall, bole up to 60 cm in diameter, with sharp buttresses up to 3 m high and stilt roots in swampy habitat, bark surface papery scaly, reddish-brown; leaves rounded to elliptical-oblong, 8–14 cm × 5–9 cm, with 7–10 pairs of indistinct secondary veins, petiole c. 10 mm long; flowers in short dense terminal inflorescences, calyx with 5 distinct lobes; fruit unknown. *E. kiahii* is widely distributed in lowland forest including swamps.

Selected sources 705.

Syzygium kihamense Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 150 (1939).

Distribution Borneo (Sabah, Kalimantan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 25 m tall, bole up to 50 cm in diameter; leaves obovate-oblong, 12–22 cm × 3.5–8 cm, with 8–12 pairs of rather distinct secondary veins, petiole up to 9 mm long; flowers in axillary and terminal inflorescences; fruit pitcher-like, c. 7 mm long.

Selected sources 77, 429.

Eugenia koordersiana King

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 70: 128 (1901).

Distribution Peninsular Malaysia.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to fairly large tree up to 39 m tall, bole up to 115 cm in diameter, with steep buttresses up to 4 m tall and occasionally stilt-rooted, bark surface dippled or scaly (rarely smooth), reddish-brown; leaves ovate-elliptical to narrowly elliptical or oblanceolate, 5–11 cm × 2.5–5 cm, with 8–14 pairs of distinct secondary veins, petiole up to 10 mm long; flowers sessile in axillary and terminal panicles, white, calyx c. 5 mm long, with 4 distinct lobes; fruit unknown. The wood is purplish grey-brown; the density is about 805 kg/m^3 at 15% moisture content.

Selected sources 140, 529, 705.

Syzygium kunstleri (King) K.N. Bahadur & R.C. Gaur

Indian Journ. Forest. 1(4): 349 (1978).

Synonyms *Eugenia kunstleri* King (1901).

Distribution Peninsular Malaysia, Singapore and Borneo.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 30 m tall, bole up to 40 cm in diameter, slightly fluted at base, bark surface papery flaky, orange-brown; leaves oblong-lanceolate to elliptical-lanceolate, 6.5–19 cm × 3–6 cm, with 8–12 pairs of distinct secondary veins, petiole up to 15 mm long; flowers sessile in axillary or terminal panicles, greenish-yellow, calyx c. 3 mm long, with 4 obscure lobes; fruit ovoid or obovoid, c. 15 mm long, green with a reddish tinge. *S. kunstleri* occurs in lowland forest up to 250 m altitude. The wood is yellowish-brown; the density is about 845 kg/m^3 at 15% moisture content.

Selected sources 140, 529, 705.

Syzygium lagerstroemioides Merr. & Perry

Journ. Arn. Arb. 23: 262 (1942).

Distribution Papua New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree, bark surface papery, bright pale brown; leaves narrowly obovate or elliptical, 13–17 cm × 5–6 cm, with 18–20 pairs of distinct secondary veins, petiole up to 4 mm long; flowers in axillary or terminal inflorescences, calyx with 4 large and persistent lobes; fruit globose, rugose and prominently ribbed, c. 20 mm in diameter, green. *S. lagerstroemioides* occurs generally along streams in rain forest up to 1600 m altitude.

Selected sources 221, 430.

Syzygium laqueatum Merr. & Perry

Journ. Arn. Arb. 23: 257 (1942).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to fairly large tree up to 37 m tall, bole up to 85 cm in diameter, bark surface scaly, brown; leaves elliptical, 10–18 cm × 5–10 cm, with 6–9 pairs of fairly distinct secondary veins, petiole c. 15 mm long; flowers in lateral inflorescences, white, calyx up to 20 mm long, with 4 large and unequal lobes; fruit pear-shaped, up to 5 cm long, dark red. *S. laqueatum* occurs in primary foothill and montane rain forest at 700–2350 m altitude; it is not common.

Selected sources 221, 430.

Syzygium leytense (Elmer) Merr.

Philipp. Journ. Sci., Bot. 79: 398 (1951).

Synonyms *Eugenia leytensis* Elmer (1908), *Eugenia samarensis* Merr. (1915), *Eugenia sarcocarpa* Merr. (1921).

Vernacular names Philippines: bagotambis (Bisaya, Manobo), bugnoran, tutambis (Samar-Leyte Bisaya).

Distribution The Philippines (Samar, Leyte).

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree; leaves oblong-elliptical to narrowly obovate-elliptical, 16–35 cm × 7–14 cm, with 18–25 pairs of distinct secondary veins, petiole up to 2 mm long, stout; flowers fascicled on branches below the leaves, with pedicels up to 8 mm long, white, calyx tube 5–6 mm long, with 4 orbicular, persistent lobes; fruit ovoid, c. 25 mm long. *S. leytense* occurs in primary forest up to 500 m altitude.

Selected sources 420, 426.

Syzygium longiflorum K. Presl

Abh. k. Böhm. Ges. Wiss. ser. 5.3: 500 (1845).

Synonyms *Myrtus lineata* Blume (1826) non Swartz, *Jambosa lineata* (Blume) DC. (1828), *Eugenia lineata* (Blume) Duthie (1878), *Eugenia longiflora* (K. Presl) Fern.-Vill. (1880), *Eugenia teysmannii* (Miq.) Koord. & Valeton (1900), *Syzygium lineatum* (Blume) Merr. & Perry (1938).

Vernacular names Indonesia: kayu udang (Sumatra), ki sireum (Sundanese, Java), nagasari rangkang (Javanese, Java). Malaysia: kelat lapis, kelat puteh, kelat merah (Peninsular). Philippines: lagi-lagi (Bisaya). Thailand: khwat (Sukothai, Surat Thani), phung kha (Narathiwat), daeng song plueak (Trang).

Distribution Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, western Java, Borneo and the Philippines.

Uses The timber is used for house building and implements. The bark is used for tanning fishing-nets. The roots and young shoots are used in local medicine.

Observations A small to medium-sized tree up to 22(–28) m tall, bole up to 40(–60) cm in diameter, occasionally stilt-rooted, bark surface smooth, cracking and scaly, reddish-brown; leaves elliptical to elliptical-lanceolate or ovate-lanceolate, 5–12 cm × 2–5 cm, with numerous and close-set secondary veins fairly distinct below, petiole up to 12 mm long; flowers in axillary and terminal panicles, calyx c. 6 mm long, with 4 conspicuous and persistent lobes; fruit oblong-ovoid or ellipsoid, up to 13 mm long. *S. longiflorum* is common in primary and sometimes secondary lowland forest, in Java up to 1600 m altitude. The colour of the wood is reported as yellowish-white to purplish-brown; the density is 730–915 kg/m^3 at 15% moisture content.

Selected sources 36, 63, 77, 78, 90, 140, 234, 426, 429, 529, 674, 705.

Syzygium luzonense (Merr.) Merr.

Philipp. Journ. Sci., Bot. 79: 401 (1951).

Synonyms *Jambosa luzonensis* Merr. (1904), *Eugenia luzonensis* (Merr.) Merr. (1906).

Vernacular names Philippines: duktulan (Tagalog).

Distribution The Philippines.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree, bark surface yellowish-red; leaves lanceolate, 9–14 cm × 3.5–5 cm, with up to 16 pairs of secondary veins, petiole thickened, c. 10 mm long; flowers subsessile or pedicelled, in axillary or terminal widely branching and few-flowered to many-flowered panicles, white, calyx c. 10 mm long, with 4 distinct unequal lobes; fruit unknown. *S. luzonense* is locally common in primary forest at low and medium altitudes. The wood is greyish-brown, heavy and hard.

Selected sources 414, 426.

Syzygium maingayi P. Chantaranothai & J. Parnell

Kew Bull. 48: 605 (1993).

Synonyms *Eugenia oblongifolia* Duthie (1878).

Distribution Peninsular Thailand, Peninsular Malaysia and Singapore.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 55 cm in diameter, with short buttresses and rarely stilt-rooted, bark surface smooth, greyish-brown; leaves elliptical to oblong-elliptical or oblanceolate, 6–15 cm × 2.5–6 cm, with 10–14 pairs of distant and distinct secondary veins, petiole up to 7 mm long; flowers sessile in axillary and terminal corymbose panicles, whitish, calyx c. 5 mm long, with 5 obscure lobes; fruit depressed globose, c. 17 mm in diameter, pale green when ripe. *S. maingayi* occurs in lowland and hill forest up to 900 m altitude.

Selected sources 90, 529, 705.

Syzygium mananquil (Blanco) Merr.

Philipp. Journ. Sci., Bot. 79: 402 (1951).

Synonyms *Eugenia mananquil* Blanco (1845).

Vernacular names Philippines: manangkil (Tagalog), panglongbuyen-kopakopa (Iloko), kagoko (Samar-Leyte Bisaya, Lanao).

Distribution The Philippines (Luzon, Mindoro, Leyte, Mindanao).

Uses The timber is used in the construction of houses, especially for posts. The fruit is edible.

Observations A small to medium-sized tree up to 30 m tall, bole sometimes reaching 120 cm in diameter; leaves elliptical, 7–15 cm × 2.5–5.5 cm, with 8–13 pairs of secondary veins, petiole up to 7 mm long; flowers in cymes on tubercles on trunk, pinkish-white or yellowish-white, pedicels with an articulation under the pseudostalk at the base of the calyx, calyx with 4 persistent lobes; fruit ovoid, c. 4 cm long, red when ripe. *S. mananquil* is common in primary forest at low and medium altitude.

Selected sources 68, 426, 533.

Syzygium melliodorum (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 402 (1951).

Synonyms *Eugenia melliodora* C.B. Robinson (1909).

Vernacular names Philippines: midbit (Tagalog).

Distribution The Philippines (Luzon, Mindoro, Leyte).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree, bole up to 60 cm in diameter, bark surface grey; leaves obovate or elliptical, 12–17 cm × 6.5–9 cm, with 12–15 pairs of secondary veins, petiole up to 13 mm long; flowers sessile in axillary inflorescences, calyx c. 5 mm long, with 4 rounded lobes; fruit unknown. *S. melliodorum* occurs in primary forest at low altitude.

Selected sources 426, 533.

Syzygium merrittianum (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 403 (1951).

Synonyms *Eugenia merrittiana* C.B. Robinson (1909).

Vernacular names Philippines: tumolad (Tagalog), bago-tambis (Panay Bisaya), makaasim (Bikol).

Distribution The Philippines (Luzon, Mindoro, Sibuyan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 20 m tall, bole up to 70 cm in diameter; leaves oblong or elliptical, 6–15 cm × 2.5–5.5 cm, with 18–25 pairs of rather indistinct secondary veins, petiole up to 6 mm long or leaves subsessile; flowers in terminal corymbose inflorescences, calyx c. 15 mm long, with 4 large unequal and deciduous lobes; fruit unknown. *S. merrittianum* grows in forest on slopes and along streams at low and medium altitudes.

Selected sources 426, 533.

Syzygium microcymum (Koord. & Valeton) Amshoff

Blumea 5: 497 (1945).

Synonyms *Eugenia microcyma* Koord. & Valeton (1900).

Vernacular names Indonesia: gelam, ki tambaga (Sundanese, Java).

Distribution Java.

Uses The timber is used for building houses.

Observations A medium-sized to fairly large tree up to 35 m tall, bole columnar, slightly fluted, up to 60 cm in diameter, with very small buttresses, bark surface papery flaky, copper-red; leaves elliptical-oblong, 6.5–13 cm × 2.5–5 cm, with numerous close-set thin, more or less distinct secondary veins, petiole up to 10 mm long; flowers in axillary and terminal inflorescences, calyx c. 4 mm long, with 4 small lobes; fruit unknown. *S. microcymum* occurs very locally in forest up to 1200 m altitude.

Selected sources 36, 234, 303.

Syzygium muelleri (Miq.) Miq.

Fl. Ned. Ind. 1(1): 453 (1855).

Synonyms *Eugenia muelleri* Miq. (1850), *Eugenia venulosa* Wallich ex Duthie (1878).

Vernacular names Malaysia: kelat puteh, kelat putera, kelat paya (Peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore and Borneo (Sabah, Kalimantan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 22 m tall, bole slightly fluted at base, stilt-rooted, bark surface smooth or slightly fissured and scaly, greyish-brown; leaves elliptical to obovate, 5–11.5 cm × 3–5.5 cm, with 5–14 pairs of rather distinct secondary veins, petiole up to 5 mm long; flowers in terminal corymbose panicles, white, calyx 3.5–5 mm long, with 5 obscure lobes; fruit globose, c. 13 mm in diameter, green suffused purple. *S. muelleri* often occurs along streams and in swamp forest, locally frequently. The wood is purplish grey-brown or dull red; the density is about 1000 kg/m^3 at 15% moisture content.

Selected sources 78, 90, 104, 140, 429, 529, 705.

Syzygium multiglandulosum Merr. & Perry

Journ. Arn. Arb. 23: 269 (1942).

Distribution Irian Jaya.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 30 m tall, bole up to 65 cm in diameter, bark surface scaly, red-brown; leaves oblong-elliptical or elliptical, 7–12 cm × 3.5–5.5 cm, with c. 12 pairs of fairly distinct secondary veins, petiole up to 15 mm long; flowers comparatively large, calyx with 4 large lobes; fruit subglobose, c. 4 cm in diameter, with thick and hard pericarp, dark red when ripe. *S.*

multiglandulosum occurs in primary foothill rain forest at 650–1150 m altitude.

Selected sources 221, 430.

Syzygium napiforme (Koord. & Valeton) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 183 (1939).

Synonyms *Eugenia napiformis* Koord. & Valeton (1900).

Vernacular names Indonesia: ki tanduk, ki pancar (Sundanese, Java).

Distribution Peninsular Malaysia, western Java and Borneo (Sabah, East Kalimantan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to fairly large tree up to 36 m tall, bole straight, up to 100 cm in diameter, with up to 2 m high buttresses, bark surface scaly or flaky, reddish-brown; leaves elliptical to oblong, 4.5–16 cm × 1.5–7 cm, with numerous close-set, faintly visible secondary veins, petiole up to 10 mm long; flowers sessile in axillary and terminal subumbelliform, usually few-flowered panicles, calyx up to 13 mm long, coarsely wrinkled to tuberculate, with 4–5 small, persistent lobes; fruit cone-shaped, obconical or obovoid, up to 25 mm long. *S. napiforme* occurs in lowland peat-swamp and hill forest up to 1800 m altitude.

Selected sources 36, 77, 303, 429, 705.

Syzygium nervosum DC.

Prodr. 3: 260 (1828).

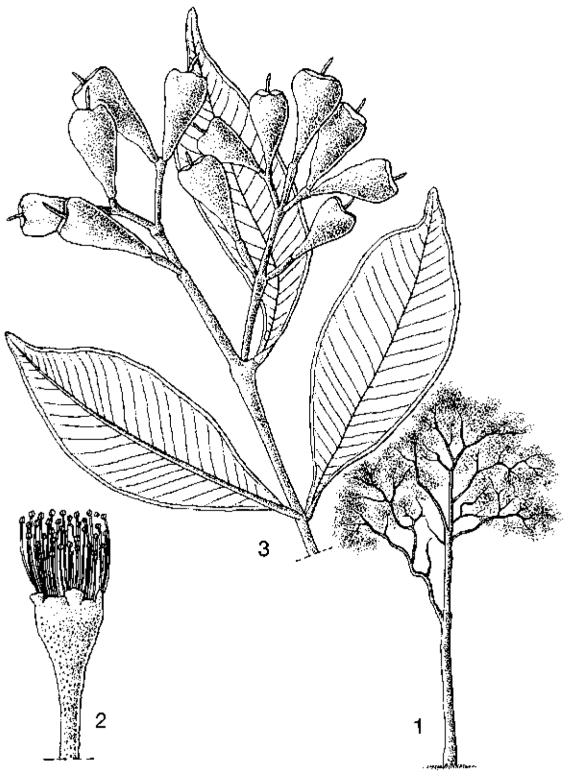
Synonyms *Eugenia operculata* Roxb. (1832), *Syzygium operculatum* (Roxb.) Niedenzu (1893), *Cleistocalyx operculatus* (Roxb.) Merr. & Perry (1937).

Vernacular names Indonesia: salam banen (Sundanese), banje, jambon (Javanese, Java). Philippines: malaruhat (general). Burma (Myanmar): tea-thaby-ay. Thailand: wa-khao (Surat Thani), wa-nam (Phangnga).

Distribution India, Burma (Myanmar), Indo-China, southern China, Thailand, throughout Malesia, to northern Australia (Northern Territory).

Uses The timber is used locally for house building and implements. The fruit is edible. In Indo-China a substitute for tea is made from the leaves.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 80 cm in diameter,



Syzygium napiforme (Koord. & Valeton) Merr. & Perry – 1, tree habit; 2, flower; 3, fruiting twig.

Syzygium nervosum DC. – 1, twig with old flowers; 2, opening bud; 3, flower; 4, infructescence.

with sharp buttresses up to 2.5 m high, bark surface smooth to scaly or flaky, greyish-brown; leaves elliptical-oblong to elliptical-lanceolate, (6–)8–22 cm × 3–7 cm, with 7–15 pairs of secondary veins distinct below, petiole up to 15 mm long; flowers in lateral many-flowered, paniculate inflorescence on twigs below the leaves, calyx calyptriform, the upper part falling as a lid; fruit ellipsoid to globose, c. 1 cm long, red, purplish or black when ripe. *S. nervosum* occurs in forest up to 1500 m altitude, usually at the margins of freshwater swamps and near streams. The wood is greyish-yellow; the density is 680–850 kg/m^3 at 15% moisture content.

Selected sources 36, 78, 90, 120, 218, 234, 249, 474, 480, 529, 705.

Syzygium nigricans (King) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 194 (1939).

Synonyms *Eugenia nigricans* King (1901).

Distribution Peninsular Malaysia and Borneo (Kalimantan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to fairly large tree up to 39 m tall, bole up to 100 cm in diameter, with buttresses up to 2 m high, rarely stilt-rooted or slightly fluted at base, bark surface scaly or flaky, greyish-brown; leaves elliptical to oblong, 4.5–15 cm × 2–7 cm, with numerous close-set secondary veins more distinct above than below, petiole up to 10 mm long; flowers in axillary and terminal panicles, white, calyx c. 4 mm long, with 5 obscure and deciduous lobes; fruit globose, c. 22 mm in diameter. *S. nigricans* occurs in lowland rain forest.

Selected sources 429, 529, 705.

Syzygium nitidum Benth.

Hook., Lond. Journ. Bot. 2: 221 (1843).

Synonyms *Eugenia benthamii* A. Gray (1854).

Vernacular names Philippines: makaasim (general).

Distribution The Philippines, Tobi Island (Caroline Islands, USA).

Uses The timber is used for general construction, ship building, furniture, telegraph poles and implements.

Observations A medium-sized tree up to 25 m tall, bole up to 60 cm in diameter, bark surface slightly flaky, brown; leaves elliptical-oblong to broadly oblanceolate, 8–14 cm × 3–6 cm, with 8–12 pairs of indistinct secondary veins, petiole fairly long; flowers subsessile in terminal, sometimes lateral, paniculate, densely flowered inflorescences, white, calyx c. 10 mm long, with 4 broad and persistent lobes; fruit globose, c. 15 mm in diameter, greenish. *S. nitidum* occurs in well-drained rain forest at low and medium altitudes. The reddish-brown wood is available in very limited quantities.

Selected sources 125, 414, 426, 527.

Syzygium oblatum (Roxb.) A.M. Cowan & J.M. Cowan

Trees of North Bengal: 68 (1929).

Synonyms *Eugenia oblata* Roxb. (1832).

Vernacular names Malaysia: jambu hutan, kelat beti, samak naching (Peninsular). Burma (Myanmar): thabyay-nee. Thailand: maha (Lamphun), ka-pe-tro (Khmer, Trat), wa-nam (Trang).

Distribution Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia and Borneo.

Uses The timber is used in house building.

Observations A small to medium-sized tree up to 24 m tall (but usually much less), bole up to 55 cm in diameter, with short buttresses, bark surface smooth to scaly, greyish-brown; leaves broadly lanceolate to oblong-elliptical, 7.5–16.5 cm × 3–6.5 cm, with up to 25 pairs of fairly close-set secondary veins distinct below, petiole up to 10 mm long; flowers sessile in axillary and terminal corymbose panicles, white, calyx c. 7 mm long, with 4–5 distinct and subpersistent lobes; fruit depressed globose to oblong-globose, c. 2 cm in diameter, purplish-black when ripe. *S. oblatum* is widely distributed and particularly common along tidal rivers and near the sea. The wood is dark brown, hard, strong and durable.

Selected sources 78, 90, 336, 399, 429, 529, 705.

Syzygium ochneocarpum (Merr.) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 184 (1939).

Synonyms *Eugenia ochneocarpa* Merr. (1929).

Distribution Borneo (Sarawak, Sabah).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree, bole often crooked, up to 60 cm in diameter, bark surface flaky; leaves elliptical to oblong-elliptical, 8–12 cm × 4–6 cm, with numerous close-set and indistinct secondary veins, petiole c. 10 mm long; flowers in axillary and terminal inflorescences; fruit pear-shaped, c. 15 mm long, whitish-green. *S. ochneocarpum* often occurs in comparatively dry forest.

Selected sources 77, 427, 429.

Syzygium palembanicum Miq.

Fl. Ned. Ind. Suppl.: 313 (1861).

Synonyms *Eugenia grandis* Wight var. *lepidocarpa* Kurz (1877), *Eugenia lepidocarpa* Wallich ex Kurz (1877), *Eugenia palembanica* (Miq.) Merr. (1917).

Vernacular names Malaysia: kelat seluang, samak teberau, samak ubar (Peninsular).

Distribution Burma (Myanmar), Peninsular Malaysia, Singapore, Sumatra, Borneo (Sarawak, Kalimantan).

Uses The timber is used for construction. The bark is used for tanning fishing-nets and baskets and for caulking boats.

Observations A small to medium-sized tree up to 24 m tall, bole slightly fluted, up to 50 cm in diameter, with short buttresses up to 1 m high, bark surface smooth to flaky or finely fissured, brown; leaves ovate-oblong to elliptical-oblong (rarely lanceolate), 7–17 cm × 3–11 cm, with 10–17 pairs of fairly distinct secondary veins, petiole up to 15 mm long; flowers in axillary or terminal panicles, white, calyx c. 5 mm long, with 4 unequal and deciduous lobes; fruit subglobose, c. 2 cm in diameter, ribbed. *S. palembanicum* is common in lowland rain forest up to 700 m altitude. The wood is dark brown, fairly heavy and hard, but rather brittle.

Selected sources 78, 104, 234, 336, 429, 529, 705.

Syzygium papillosum (Duthie) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 157 (1939).

Synonyms *Eugenia papillosa* Duthie (1878).

Vernacular names Malaysia: kelat paya, kelat jangkang, samak bukit (Peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Borneo (Kalimantan).

Uses The timber is used for house building.

Observations A medium-sized tree up to 30 m tall, bole up to 40 cm in diameter, with strong, arched stilt roots, bark surface thickly papery flaky, bright orange-rufous; leaves ovate-oblong or elliptical-oblong to oblong-lanceolate, 20–35 cm × 7.5–15 cm, with up to 20 pairs of secondary veins distinct below, petiole short (up to 5 mm long) and thick; flowers sessile in axillary or terminal panicles, yellowish-green to white, subtended by 2 subpersistent bracts, calyx c. 10 mm long, with 4 unequal lobes; fruit globose, c. 2.5 cm in diameter, pale green. *S. papillosum* occurs in lowland rain forest, often in freshwater swamps and along streams up to 500 m altitude.

Selected sources 78, 90, 104, 429, 705.

Syzygium petakense Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 150 (1939).

Distribution Borneo (East Kalimantan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 25 m tall; leaves narrowly elliptical to oblanceolate-elliptical, 8–14 cm × 3–7 cm, with 9–14 pairs of distinct secondary veins, petiole up to 7 mm long; flowers sessile in lateral or terminal inflorescences on last year's branchlets, calyx c. 2 mm long, with small lobes; fruit cup-shaped. *S. petakense* occurs in lowland rain forest, up to 450 m altitude.

Selected sources 429.

Syzygium phaeostictum Merr. & Perry

Journ. Arn. Arb. 23: 270 (1942).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to large tree up to 41 m tall, bark surface scaly, grey; leaves oblong-elliptical, 7–12 cm × 3–4.5 cm, with 7–10 pairs of fairly distinct secondary veins, petiole up to 15 mm long; flowers on lateral inflorescences, shortly pedicelled, white to reddish, calyx c. 8 mm long, with 4 subequal lobes; fruit unknown. *S. phaeostictum* occurs in foothill and lower montane rain forest at 1150–1650 m altitude, and is locally common.

Selected sources 221, 430.

Syzygium philippinense (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 409 (1951).

Synonyms *Eugenia philippinensis* C.B. Robinson (1909).

Vernacular names Philippines: bagohian (Tagalog), bagotambis, bohokan (Samar-Leyte Bisaya).

Distribution The Philippines (Luzon, Samar, Leyte).

Uses The timber is used for house-posts and in ship-building.

Observations A medium-sized tree up to 20 m tall, bole up to 50 cm in diameter; leaves elliptical, oblong, ovate or obovate, 6–13 cm × 3.5–6 cm, with 9–14 pairs of secondary veins, petiole up to 12 mm long; flowers sessile in axillary or terminal inflorescences, calyx c. 7 mm long, with 4 fairly large, unequal lobes; fruit unknown. *S. philippinense* occurs in forest at low and medium altitudes.

Selected sources 426, 533.

Syzygium plumeum (Ridley) Merr. & Perry

Journ. Arn. Arb. 23: 296 (1942).

Synonyms *Eugenia plumea* Ridley (1916), *Syzygium leptanthelium* Diels (1922).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 25 m tall, bark surface cinnamon-brown; leaves oblong-obovate to oblong-oblanceolate, 4–7 cm × 1.5–3.5 cm, with numerous secondary veins, petiole up to 10 mm long; flowers in axillary and terminal panicles, white, calyx c. 3 mm long, with 4 small lobes; fruit unknown. *S. plumeum* occurs in foothill and montane rain forest up to 2300 m altitude.

Selected sources 141, 221.

Syzygium pluviatile Hartley & Perry

Journ. Arn. Arb. 54: 199 (1973).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized or large tree; leaves elliptical, 8.5–11 cm × 5.5–7.5 cm, with secondary veins spaced at 6–7 mm, petiole up to 15 mm long; flowers in terminal paniculate inflorescences, purplish, having an extension of the disk free for about 1 mm, calyx c. 14 mm long, with 4 distinct unequal lobes; fruit unknown. *S. pluviatile* occurs in lowland rain forest up to 100 m altitude.

Selected sources 221.

Eugenia polita King

Journ. As. Soc. Beng. pt. 2, Nat. Hist. 70: 110 (1901).

Vernacular names Malaysia: kelat nasi nasi, kelat nenasi (Peninsular).

Distribution Peninsular Malaysia.

Uses The timber is reputed to be used as kelat.

Observations A shrub to medium-sized tree up to 25 m tall, bark surface thinly flaky, rufous-orange; leaves lanceolate to ovate-lanceolate, 4.5–9 cm × 2–3.5 cm, with up to 14 pairs of secondary veins indistinct above and distinct or indistinct below, leaves subsessile; flowers sessile in axillary and terminal panicles, white, calyx with 5 conspicuous and persistent lobes; fruit globose or ovoid-globose, c. 6 mm in diameter, greenish-white. *E. polita* is locally common on rocky locations in hilly and mountainous habitats up to 1700 m altitude. The wood is purplish-brown; the density is about 840 kg/m^3 at 15% moisture content.

Selected sources 104, 140, 529, 705.

Syzygium polyanthum (Wight) Walp.

Repert. bot. syst. 2: 180 (1843).

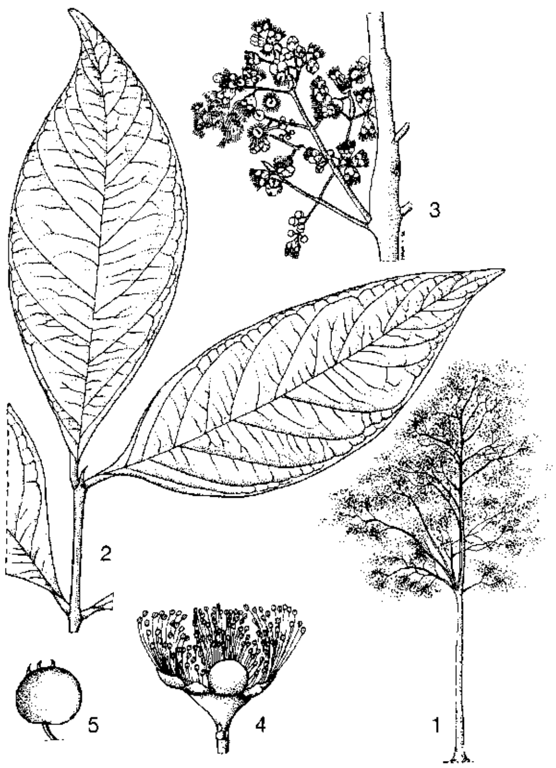
Synonyms *Eugenia polyantha* Wight (1841).

Vernacular names Indonesia: salam, manting (Java), ubar serai (Sumatra). Malaysia: samak, kelat samak, serah (Peninsular). Thailand: dok-maeo (peninsular), daeng-kluai (central), mak (Chumphon, Ranong).

Distribution Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, Java and Borneo.

Uses The timber is used for house building. The bark is used for tanning fishing-nets and for dyeing mattings. An extract of the bark is used against diarrhoea; bark, roots and leaves are used for poulticing against itch. The aromatic leaves are used as spice with food, the fruits are edible.

Observations A medium-sized tree up to 30 m tall, bole up to 60 cm in diameter, bark surface fissured and scaly, grey; leaves oblong-elliptical, narrowly elliptical or lanceolate, 5–16 cm × 2.5–7 cm, with 6–11 pairs of secondary veins distinct below, petiole up to 12 mm long; flowers sessile in



Syzygium polyanthum (Wight) Walp. – 1, tree habit; 2, twig with leaves; 3, branchlet with inflorescence; 4, flower; 5, fruit.

panicles from twigs below leaves, sometimes panicles axillary, white, calyx c. 3 mm long, with 4 broad persistent lobes; fruit depressed globose or globose, up to 12 mm in diameter, dark red to purplish-black when ripe. *S. polyanthum* is widely distributed and locally common in lowland primary and secondary forest, also in thickets and bamboo forest, in Java up to 1000 m, in Sabah up to 1200 m, in Thailand up to 1300 m altitude. The wood is pale brown to pinkish-brown with a purplish tinge; the density is 540–790 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 36, 63, 77, 78, 90, 104, 134, 140, 218, 234, 261, 281, 331, 378, 399, 429, 454, 474, 526, 529, 585, 658, 705.

Syzygium polycephaloides (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 410 (1951).

Synonyms *Eugenia polycephaloides* C.B. Robinson (1909).

Vernacular names Philippines: lipote (Tagalog, Bukidnon), maigang (Bisaya), baligang (Bikol).

Distribution The Philippines (Luzon, Mindoro, Samar, Leyte); locally cultivated for the fruits.

Uses The timber is reputed to be used as kelat. The fruits are edible and can be made into an excellent jelly.

Observations A small to medium-sized tree up to 25 m tall, bole up to 75(–90) cm in diameter, bark surface purplish-grey; leaves elliptical, oblong to oblanceolate, 6–20 cm × 4–7.5 cm, with 14–18 pairs of distinct secondary veins, petiole up to 5 mm long or leaves subsessile; flowers sessile in inflorescences from branches below the leaves, white, calyx c. 5 mm long, with 4 broad lobes; fruit subglobose, c. 1 cm in diameter, red to purple when ripe. *S. polycephaloides* occurs in primary forest at low and medium altitudes and is rather rare.

Selected sources 68, 125, 426, 533, 673.

Syzygium prainianum (King) P. Chantaranothai & J. Parnell

Kew Bull. 48: 608 (1993).

Synonyms *Eugenia prainiana* King (1901).

Distribution Peninsular Thailand and Peninsular Malaysia.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to large tree up to 48 m tall, bole up to 70 cm in diameter, with short buttresses up to 2 m high, bark surface flaky, reddish-brown; leaves elliptical-oblong to lanceolate, 9–18 cm × 3–7.5 cm, with c. 25 pairs of indistinct secondary veins, petiole up to 15 mm long; flowers sessile in axillary or terminal corymbose inflorescences, white, calyx 5–10 mm long, with 5 persistent lobes; fruit oblong-ovoid to globose, up to 2.5 cm long. The specimens from Thailand are distinguished as subsp. *minor* P. Chantaranothai & J. Parnell; they have shorter calyces, stamens and styles. *S. prainianum* occurs locally in lowland forest up to 900 m altitude. The wood is reportedly brown with a pink tinge; the density is about 700 kg/m^3 at 15% moisture content.

Selected sources 90, 140, 529, 705.

Eugenia pseudocrenulata M.R. Henderson

Gard. Bull. Sing. 12: 216 (1949).

Synonyms *Eugenia crenulata* Duthie (1878) non Willd.

Distribution Peninsular Malaysia and Singapore.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 24 m tall, bole up to 50 cm in diameter, with stilt roots and short buttresses up to 1 m high, bark surface smooth to cracking or fissured and with horizontal rings, greyish-brown or reddish-brown; leaves rounded-elliptical to narrowly oblong-elliptical, 10–20 cm × 5–10 cm, with crenate margin and c. 30 pairs of distinct secondary veins, petiole up to 20 mm long; flowers sessile in terminal corymbose panicles, calyx c. 5 mm long, with 4 large, deciduous lobes; fruit depressed globose, up to 18 mm in diameter. *E. pseudocrenulata* occurs in lowland forest and is not common.

Selected sources 529, 705.

Syzygium pustulatum (Duthie) Merr.

Philipp. Journ. Sci., Bot. 79: 421 (1951).

Synonyms *Eugenia pustulata* Duthie (1878).

Vernacular names Malaysia: kelat jambu ayer, jambu penawar bukit, gelam tikus (Peninsular).

Distribution Peninsular Malaysia, Singapore and Borneo.

Uses The timber is reputed to be used as kelat. An infusion of the leaves in cold water is given against syncope.

Observations A small to medium-sized tree up to 24 m tall, bole up to 60 cm in diameter, but usually less, bark surface smooth to cracking or scaly, pinkish-brown; leaves oblong or oblong-lanceolate, 8–22 cm × 3–6.5 cm, with 10–15 pairs of secondary veins distinct below, petiole up to 10 mm long;

flowers in axillary and terminal panicles, greenish-yellow, calyx c. 5 mm long, with 4 small and subpersistent lobes; fruit oblong-globose, c. 13 mm long, greenish-white. *S. pustulatum* occurs scattered, especially in rocky locations in forest near the coast.

Selected sources 78, 529, 705.

Syzygium pyrifolium (Blume) DC.

Prodr. 3: 261 (1828).

Synonyms *Calyptranthus pyrifolia* Blume (1826), *Eugenia pyrifolia* (Blume) Duthie (1878) non Desv., *Eugenia tumida* Duthie (1878), *Eugenia javensis* Koord. & Valeton (1900), *Eugenia salaccensis* Koord. & Valeton (1900), *Eugenia striata* Koord. & Valeton (1900).

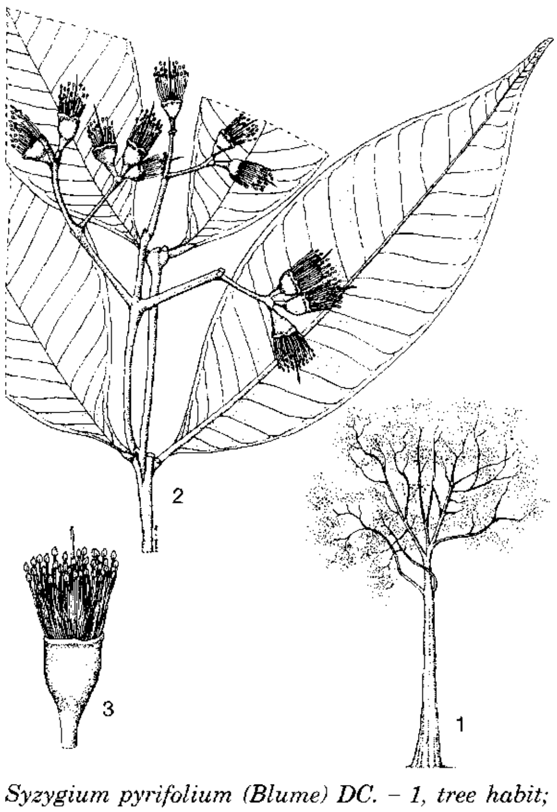
Vernacular names Indonesia: ki tambaga (Sundanese, Java). Malaysia: kelat puteh, kelat lapis, samak darat (Peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Singapore, Java and Borneo (Sarawak).

Uses The timber is used for house building.

Observations A small to medium-sized tree up to 22 m tall, bole up to 45 cm in diameter, bark surface smooth to cracking, greyish-brown; leaves elliptical-oblong to ovate-lanceolate, 4–11 cm × 1.5–6 cm, with numerous close-set secondary veins more or less distinct below, petiole up to 10 mm long; flowers in axillary and terminal corymbose panicles, white, calyx up to 7 mm long, with 4 small and deciduous lobes; fruit depressed globose, up to 25 mm in diameter, greenish. *S. pyrifolium* is common in Peninsular Malaysia in primary and secondary lowland rain forest, in Java it occurs at 1000–1500 m altitude. The wood is reported as pale, hard and durable.

Selected sources 36, 78, 90, 104, 303, 529, 705.



Syzygium pyrifolium (Blume) DC. – 1, tree habit; 2, flowering twig; 3, flower.

Syzygium racemosum (Blume) DC.

Prodr. 3: 261 (1828).

Synonyms *Eugenia jamboloides* Koord. & Valeton (1900).

Vernacular names Indonesia: kopo mangud, resep (Java), klampok bato (Madura).

Distribution Java and Borneo (Kalimantan).

Uses The timber is occasionally used for house building. The bark is used to prepare a black dye.

Observations A small to medium-sized tree up to 22 m tall, bole up to 65 cm in diameter, often bent and short, branches usually grey or yellowish-brown; leaves elliptical-oblong to lanceolate, 8–15 cm × 3.5–5 cm, secondary veins up to 25 pairs, usually less than 5 mm from each other, faintly visible below, petiole up to 15 mm long; flowers in axillary or terminal many-flowered panicles, white, calyx c. 5 mm long, lobes nearly absent; fruit globose, up to 20 mm in diameter. *Syzygium javanicum* Miq. from Sumatra and Java and *Syzygium cerasiforme* (Blume) Merr. & Perry (synonym: *Eugenia cerasiformis* (Blume) DC.) from Thailand, Peninsular Malaysia, Sumatra, Java and Borneo are possibly conspecific. *S. racemosum* occurs in Java in teak forest and mixed forest up to 1200 m altitude. The density of the wood is 850–960 kg/m^3 at 15% moisture content.

Selected sources 36, 63, 218, 234, 303, 429, 474.

Syzygium remotifolium (Ridley) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 188 (1939).

Synonyms *Eugenia remotifolia* Ridley (1930).

Distribution Borneo (Sarawak, Sabah, Kalimantan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 25 m tall; leaves elliptical, c. 12 cm × 5 cm, with up to 12 pairs of distinct secondary veins, petiole c. 5

mm long; flowers sessile in terminal many-flowered inflorescences, white, calyx without distinct lobes; fruit unknown.

Selected sources 77, 429, 530.

Syzygium richardsonianum Merr. & Perry

Journ. Arn. Arb. 23: 274 (1942).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 25 m tall, bole up to 30 cm in diameter, bark surface smooth, whitish; leaves elliptical, 7.5–12 cm × 4–8 cm, with c. 13 pairs of inconspicuous secondary veins, petiole c. 15 mm long; flowers sessile in terminal paniculate inflorescences, cream-coloured, calyx with 4 unequal, comparatively large, deciduous lobes; fruit depressed globose, c. 45 mm in diameter, yellowish-white. *S. richardsonianum* occurs in primary and secondary foothill and montane rain forest at 1000–2800 m altitude.

Selected sources 221, 430.

Syzygium ridleyi (King) P. Chantaranothai & J. Parnell

Kew Bull. 48: 608 (1993).

Synonyms *Eugenia ridleyi* King (1901).

Vernacular names Malaysia: kelat jambu ayer, kelat merah (Peninsular). Thailand: mak (Phangnga).

Distribution Peninsular Thailand, Peninsular Malaysia and Singapore.

Uses The timber is used locally as kelat.

Observations A medium-sized tree up to 30 m tall, bole up to 65 cm in diameter, with tall buttresses up to 3 m high, bark surface fissured and scaly or flaky, greyish-brown to reddish; leaves ovate-lanceolate or oblong-lanceolate, 8–18 cm × 3–6 cm, with 6–12 pairs of secondary veins distinct below, deep blue when young, petiole c. 10 mm long; flowers in axillary and terminal panicles, bright green, calyx 3–5 mm long, with 4 short but broad persistent lobes; fruit globose with 2 distinct ridges, c. 30 mm in diameter, greenish. *S. ridleyi* occurs scattered in lowland rain forest. The wood is grey-brown with a purple tinge; the density is about 670 kg/m^3 at 15% moisture content.

Selected sources 78, 90, 104, 140, 529, 705.

Syzygium rosaceum Diels

Bot. Jahrb. Syst. 57: 406 (1922).

Distribution Papua New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 20 m tall, bark surface flaky; leaves oblong to oblong-oblanceolate or oblong-obovate, 4–6.5 cm × 1.5–2.5 cm, secondary veins fairly prominent below, petiole up to 5 mm long; flowers in terminal subcorymbose panicles, pinkish, calyx c. 6 mm long with a c. 5 mm long pseudostalk and 5 short lobes; fruit unknown. *S. rosaceum* occurs in lowland and foothill rain forest up to 1000 m altitude.

Selected sources 141, 221.

Syzygium rostratum (Blume) DC.

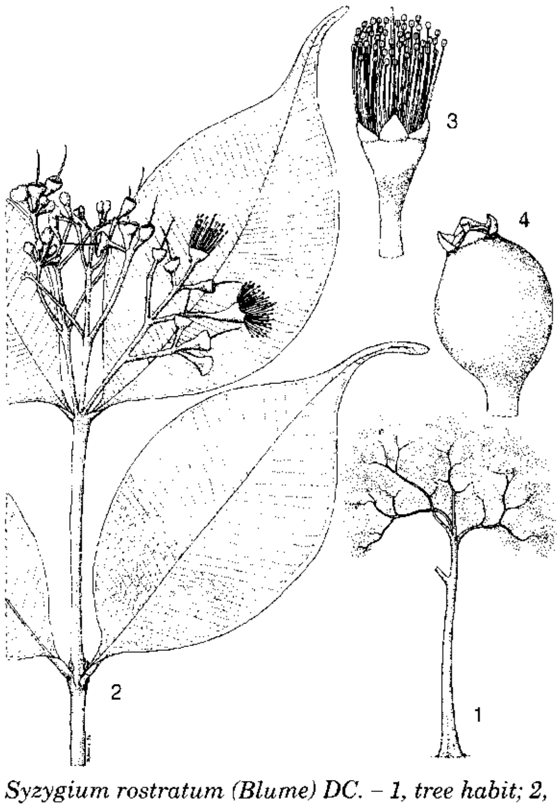
Prodr. 3: 261 (1828).

Synonyms *Eugenia tenuicuspis* (Miq.) Koord. & Valeton (1900).

Distribution Sumatra, Java, Borneo (Sabah) and Irian Jaya.

Uses The timber is occasionally used for house building.

Observations A medium-sized tree up to 20 m tall, bole up to 50 cm in diameter, bark surface smooth to finely fissured, greyish; leaves ovate to lanceolate, 7–9 cm × 3–7 cm, with linear, rounded acumen and numerous close-set secondary veins, petiole c. 10 mm long; flowers mostly in axillary,



Syzygium rostratum (Blume) DC. – 1, tree habit; 2, flowering twig; 3, flower; 4, fruit.

short panicles, white, calyx c. 6 mm long, with 4 small lobes; fruit ellipsoid, c. 15 mm long, pinkish-white. *S. rostratum* is closely related to *S. syzygioides*. It occurs in Java in humid forest at 1300–1700 m altitude, in Sabah up to 2400 m altitude. The density of the wood is about 930 kg/m^3 at 15% moisture content.

Selected sources 36, 221, 303, 429, 474.

Syzygium rosulentum (Ridley) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 150 (1939).

Synonyms *Eugenia rosulenta* Ridley (1930).

Vernacular names Malaysia: ubah samak (Sarawak).

Distribution Borneo.

Uses The timber is reputed to be used as kelat. The bark is used for tanning nets.

Observations A medium-sized tree, bole with tall, stout buttresses, bark surface flaky, red-brown; leaves elliptical, c. 20 cm × 9.5 cm, with c. 18 pairs of secondary veins distinct below, petiole c. 15 mm long; flowers sessile in compact, stout terminal cymes, pink, with persistent bracts, small, calyx c. 3 mm long with 4 lobes of c. 1 mm long; fruit unknown. In Sarawak, *S. rosulentum* occurs in small groups on friable clay-rich soils on ridges in mixed dipterocarp forest, often with *Shorea pauciflora* King.

Selected sources 576.

Syzygium rugosum Korth.

Nederl. Kruidk. Arch. 1: 204 (1847).

Synonyms *Eugenia rugosa* (Korth.) Merr. (1917).

Distribution Peninsular Malaysia and Borneo (Kalimantan); possibly also Sumatra.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to fairly large tree up to 38 m tall, bole up to 120 cm in diameter, with buttresses up to 2 m high, bark surface scaly or flaky, occasionally fissured, red or reddish-brown; leaves very variable in shape, from ovate to narrowly oblong-lanceolate, 6–16 cm × 2–7 cm, with 10–30 pairs of fairly close-set, fine, indistinct secondary veins, petiole up to 10 mm long; flowers in axillary and terminal, fairly compact inflorescences, calyx up to 10 mm long, with 4–5 persistent lobes; fruit broadly obconical to slightly cone-shaped, c. 1 cm long. *S. rugosum* is widely distributed.

Selected sources 429, 705.

Syzygium sayeri (F. v. Mueller) B. Hyland

Austr. Journ. Bot., Suppl. Ser. 9: 119 (1983).

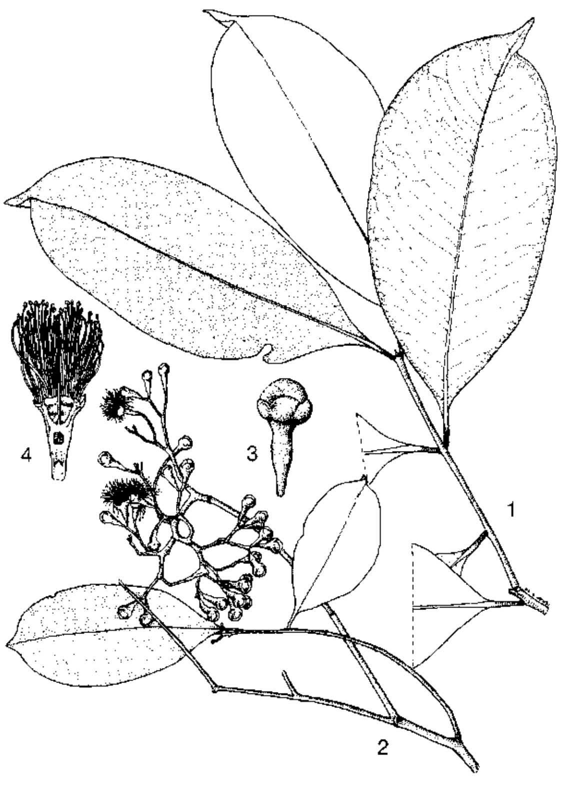
Synonyms *Eugenia sayeri* F. v. Mueller (1892), *Syzygium dictyophlebium* Merr. & Perry (1942).

Vernacular names Pink satinash (En, Australia).

Distribution Papua New Guinea and northern Australia (northern Queensland).

Uses The timber is occasionally used and marketed. The fruits are edible but not particularly palatable.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 150 cm in diameter, with buttresses, bark surface flaky or scaly, sometimes slightly fissured, pale brown to reddish; leaves elliptical to obovate or lanceolate, 7.5–16 cm × 2.5–7.5 cm, with 12–17 pairs of fairly distinct secondary veins and large oil dots, petiole up to 13 mm long; flowers in terminal paniculate inflorescences on lateral branches below the leaves, calyx up to 16 mm long, with 4 unequal, large and persistent lobes; fruit globose or depressed globose,



Syzygium sayeri (F. v. Mueller) B. Hyland – 1, twig with leaves; 2, flowering twig; 3, flower bud; 4, sectioned flower.

up to 4 cm in diameter, white when ripe. *S. sayeri* occurs in rain forest up to 1250 m altitude, often near gullies or watercourses. The density of the wood is about 780 kg/m^3 at 15% moisture content.

Selected sources 221, 249, 430.

Syzygium schumannianum (Niedenzu) Diels

Bot. Jahrb. Syst. 57: 402 (1922).

Synonyms *Eugenia schumanniana* (Niedenzu) Greves (1923).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 20 m tall; leaves elliptical to oblong-elliptical, 9–18 cm × 3.5–8 cm, with up to 17 pairs of distinct secondary veins; flower buds c. 20 mm long, obviously striate; fruit flask-shaped, c. 4 cm long, prominently ribbed and white. *S. schumannianum* occurs in rain forest up to 850 m altitude.

Selected sources 221, 430.

Syzygium simile (Merr.) Merr.

Philipp. Journ. Sci., Bot. 79: 414 (1951).

Synonyms *Eugenia similis* Merr. (1906).

Vernacular names Philippines: panglongboien (Iloko), malaruhat (Tagalog), arang (Mangyan).

Distribution The Philippines.

Uses The timber is used for house and ship building and for implements. The fruits are edible.

Observations A small tree up to 15 m tall; leaves elliptical-ovate to oblong-ovate, 9–11 cm × 4–6 cm, with c. 14 pairs of fairly indistinct secondary veins, petiole slender, up to 25 mm long; flowers in panicles from branches below the leaves, calyx c. 3 mm long, with 4 distinct and persistent lobes; fruit subglobose, purplish to black when ripe. *S. simile* occurs in forest at low and medium altitudes throughout the Philippines, but the supply of timber is limited. The wood is greyish-brown.

Selected sources 414, 426, 527, 673.

Syzygium splendens (Blume) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 180 (1939).

Synonyms *Eugenia opaca* auct. non Poir.

Vernacular names Indonesia: gelam, ki sireum, ki tambaga (Sundanese, Java).

Distribution Java and Borneo (Sarawak, Kalimantan).

Uses The timber is used locally for house building.

Observations A medium-sized tree up to 20 m tall, bole straight, slightly fluted, up to 30 cm in diameter, with buttresses, bark surface greyish-brown to coppery reddish-brown; leaves oblong-elliptical, 9–20 cm × 3.5–8 cm, with 10–14 pairs of secondary veins distinct below, petiole c. 10 mm long; flowers sessile in axillary or terminal panicles, calyx c. 5 mm long, with 4 unequal lobes, inner lobes with a petal-like apex; fruit globose, up to 2 cm in diameter. *S. splendens* occurs scattered in rain forest up to 1300 m altitude. The wood is pale brown or pinkish-brown, heavy and fairly hard.

Selected sources 36, 234, 303, 429.

Syzygium subcorymbosum Merr. & Perry

Journ. Arn. Arb. 23: 297 (1942).

Distribution New Guinea, New Britain and the Solomon Islands.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 25 m tall, bole slender, bark surface slightly scaly, greyish; leaves elliptical, 5.5–7 cm × 3–4 cm, with numerous indistinct secondary veins, petiole up to 5 mm long; flowers sessile in terminal subcorymbose inflorescences, white, calyx up to 9 mm long, with 5 lobes; fruit barrel-shaped, up to 3.5 cm long. *S. subcorymbosum* is often confused with *S. buettnerianum* but differs in the colour of the flowers and the shape and size of the fruits. It occurs in lowland rain forest up to 300 m altitude.

Selected sources 221, 430.

Eugenia subdecussata Wallich ex Duthie

Hook.f., Fl. Brit. India 2: 491 (1878).

Vernacular names Malaysia: kelat belian, kelat asam, samak pulut (Peninsular).

Distribution Peninsular Malaysia, Singapore and Sumatra.

Uses The timber is used for house building.

Observations A medium-sized tree up to 30 m tall, bole up to 55 cm in diameter, with short buttresses up to 1.5 m high, bark surface smooth to fissured or dippled and scaly, greyish-brown to pale pinkish-brown; leaves elliptical or oblong-elliptical, 5–15 cm × 2–7 cm, with up to 15 pairs of indistinct secondary veins, often subsessile or with petiole up to 2.5(–5) mm long; flowers in axillary or terminal panicles, greenish-yellow, calyx with 5 obscure lobes; fruit globose to pear-shaped, up to 2.5 cm long, greenish. *E. subdecussata* is common in lowland forest; it is dwarfed to a shrub on mountain ridges. The wood is brown with a purple-red tinge and durable; the density is about 915 kg/m^3 at 15% moisture content.

Selected sources 78, 104, 140, 529, 705.

Syzygium subglobosum Merr. & Perry

Journ. Arn. Arb. 23: 290 (1942).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 28 m tall, bole up to 65 cm in diameter, bark surface smooth or scaly, reddish-brown; leaves elliptical, 13–14 cm × 7–8 cm, with c. 15 pairs of secondary veins distinct above but not below, petiole c. 15 mm long; flowers in terminal subcorymbose inflorescences, calyx lobes 4, subpersistent; fruit subglobose, c. 2 cm in diameter, greenish-brown. *S. subglobosum* occurs in foothill and montane rain forest at 800–1850 m altitude.

Selected sources 221, 430.

Syzygium subrotundifolium (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 416 (1951).

Synonyms *Eugenia subrotundifolia* C.B. Robinson (1909).

Vernacular names Philippines: kalogkog-dagat (Tagalog).

Distribution The Philippines (Batan Islands, Luzon, Polillo Islands).

Uses The timber is reputed to be used as kelat.

Observations A small tree up to 15 m tall, bole up to 50 cm in diameter, bark surface greyish-brown; leaves almost round to ovate or broadly obovate, 8–15 cm × 6–11.5 cm, with 7–10 pairs of secondary veins, petiole c. 3 mm long, stout; flowers in terminal paniculate inflorescences, large, calyx with 4 large, unequal lobes; fruit unknown. *S. subrotundifolium* occurs in thickets and secondary forest, especially along the sea-shore.

Selected sources 426, 533.

Syzygium suringarianum (Koord. & Valeton) Amshoff

Blumea 5: 500 (1945).

Synonyms *Eugenia suringariana* Koord. & Valeton (1900).

Vernacular names Indonesia: kopo lalay (Sundanese, Java).

Distribution Western Java.

Uses The timber is occasionally used for house building.

Observations A small to medium-sized tree up to 20 m tall, bole straight, up to 50 cm in diameter, bark surface greyish; leaves elliptical-oblong-obovate, 8–20 cm × 4–10.5 cm, with up to 20 pairs of thin secondary veins, petiole up to 18 mm long; flowers sessile in terminal, very short and congested, few-flowered inflorescences, calyx c. 12 mm long, with 4 subequal comparatively large, persistent lobes; fruit ovoid-globose, constricted at apex, striate. *S. suringarianum* occurs scattered in forest at 900–1200 m altitude. The wood is brown and moderately heavy; the density is 790–880 kg/m^3 at 15% moisture content.

Selected sources 36, 234, 303, 474.

Syzygium syzygioides (Miq.) Merr. & Perry

Journ. Arn. Arb. 19: 109 (1938).

Synonyms *Eugenia syzygioides* (Miq.) M.R. Henderson (1949), *Eugenia cymosa* auct. non Lamk.

Vernacular names Indonesia: ki sireum (Sundanese), manting (Javanese), mengkelingan (Belitung). Malaysia: kelat hitam, kelat penaga, kelat jantan (Peninsular). Thailand: daeng-khinok (Prachuap Khiri Khan), daeng-khlong (Chumphon), metchun (Nakhon Si Thammarat).

Distribution Eastern India, Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, Bangka, Belitung, Java and Borneo (Sarawak, Kalimantan).

Uses The timber is used for house building. The bark is used to prepare a brown or black dye and for tanning fishing-nets.

Observations A small to medium-sized tree up to 30 m tall, bole up to 85 cm in diameter, slightly fluted at base or with short buttresses up to 1.5 m high, bark surface smooth to fissured and flaky, reddish-brown or greyish-brown; leaves elliptical or elliptical-oblong to oblong-lanceolate, 4–10 cm × 1.5–5.5 cm, with numerous close-set secondary veins, petiole up to 10 mm long; flowers in axillary and terminal, lax panicles, white with reddish calyx, calyx c. 4 mm long, with 4(–5) minute subpersistent lobes; fruit globose or depressed globose, up to 12 mm in diameter, dark red to purplish-black when ripe. *S. syzygioides* occurs in lowland forest, but it is found up to 1200 m altitude; it is locally common, especially near sandy coasts in Peninsular Malaysia. The wood is purplish red-brown; the density is 815–885 kg/m^3 at 15% moisture content.

Selected sources 36, 78, 90, 104, 140, 234, 336, 429, 529, 705.

Syzygium tawahense (Korth.) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 174 (1939).

Synonyms *Eugenia tawahensis* Korth. (1847).

Distribution Borneo (Sarawak, Sabah and Kalimantan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree, bole up to 50 cm in diameter; leaves oblong-lanceolate, 15–28 cm × 5–8 cm, shortly petiolate; flowers in axillary and terminal inflorescences, sometimes densely clustered at the apices of short branches, calyx c. 10 mm long, with fine ridges and definite lobes; fruit subglobose, up to 3.5 cm in diameter, strongly corrugated. *S. tawahense* is locally very common, for instance on leached sandstone ridges near the coast in Sabah. The density of the wood is 845–875 kg/m^3 at 15% moisture content.

Selected sources 77, 429, 433.

Syzygium tierneyanum (F. v. Mueller) Hartley & Perry

Journ. Arn. Arb. 54: 200 (1973).

Synonyms *Eugenia tierneyana* F. v. Mueller (1865), *Syzygium floribundum* Lauterb. & K. Schumann (1901) non F. v. Mueller, *Syzygium lauterbachianum* Merr. & Perry (1942).

Vernacular names Bamaga satinash (En, Australia).

Distribution New Guinea, the Solomon Islands and northern Australia (northern Queensland).

Uses The timber is occasionally used and marketed. The fruits are edible but have a sharp taste.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 100(–180) cm in diameter, often short and gnarled, buttressed, bark surface papery flaky, brown or reddish-brown; leaves elliptical to lanceolate, 9–20 cm × 3–7.5 cm, with 7–16 pairs of fairly distinct secondary veins, petiole up to 12 mm long; flowers in lateral paniculate inflorescences on branches below the leaves, white, calyx up to 10 mm long, with 4 comparatively large, persistent unequal lobes; fruit globose, c. 2 cm in diameter, pink to red, occasionally white when ripe. *S. tierneyanum* occurs in rain forest up to 1350 m altitude. The density of the wood is 690–740 kg/m^3 at 15% moisture content.

Selected sources 164, 221, 249, 430.

Syzygium triphlebium Diels

Bot. Jahrb. Syst. 57: 400 (1922).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 20 m tall; leaves lanceolate, 10–15 cm × 2.5–5 cm, with fairly widely spaced secondary veins distinct below, petiole up to 14 mm long; flowers in axillary and terminal corymbose panicles, small, calyx c. 3 mm long; fruit unknown. *S. triphlebium* occurs in primary and secondary lowland rain forest and in foothill rain forest up to 1500 m altitude.

Selected sources 141, 221.

Syzygium tripinnatum (Blanco) Merr.

Philipp. Journ. Sci., Bot. 79: 419 (1951).

Synonyms *Eugenia tripinnata* (Blanco) C.B. Robinson (1909).

Vernacular names Philippines: hagis (Bikol), kamandak (Tagalog), baugit (Negrito).

Distribution The Philippines.

Uses The timber is used for general construction.

Observations A small to medium-sized tree up to 20 m tall, bole up to 25 cm in diameter; leaves elliptical to oblong-obovate or oblanceolate, 8–13 cm × 3–5 cm, with 8–13 pairs of rather indistinct secondary veins, petiole c. 5 mm long; flowers in lateral or terminal cymes, pedicels up to 30 mm long, white, calyx up to 10 mm long, with 4 large, slightly unequal, persistent lobes; fruit depressed globose, up to 1.5 cm in diameter, white to reddish. *S. tripinnatum* occurs in primary forest at low and medium altitudes.

Selected sources 125, 426, 533.

Syzygium tympananthum (Diels) Merr. & Perry

Journ. Arn. Arb. 23: 255 (1942).

Synonyms *Jambosa tympanantha* Diels (1922).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 26 m tall, bole up to 45 cm in diameter, bark surface grey to red-brown; leaves oblong-ovate or oblong-obovate, 10–12 cm × 4.5–5.5 cm, with 5–7 pairs of secondary veins, petiole c. 7 mm long; flowers solitary, comparatively large, calyx tube truncate at base and slightly concave or flat, with 4 large lobes; fruit red when ripe. *S. tympananthum* occurs in primary and secondary lowland rain forest and in foothill rain forest up to 1500 m altitude.

Selected sources 141, 221, 430.

Syzygium valdevenosum (Duthie) Merr. & Perry

Mem. Amer. Acad. Arts & Sci. 18: 182 (1939).

Synonyms *Eugenia valdevenosa* Duthie (1878).

Vernacular names Malaysia: kelat jambu, kelat bunga (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Borneo (Sabah, East Kalimantan).

Uses The timber is used for house building. The fruits are edible.

Observations A small to medium-sized tree up to 20 m tall, bark surface smooth, pale greyish; leaves elliptical, oblong-elliptical or obovate, 11–28 cm × 5–11 cm, with 10–24(–30) pairs of secondary veins distinct below, petiole up to 15 mm long; flowers sessile in axillary and terminal panicles, white, calyx c. 7.5 mm long, lacking lobes; fruit depressed globose to oblong-globose, c. 18 mm in diameter, greenish-white. *S. valdevenosum* is locally common (e.g. in Peninsular Malaysia) in lowland and hill forest, often along streams, up to 1300 m altitude. The wood is reportedly pale and not durable when used under outside conditions.

Selected sources 77, 78, 104, 429, 529, 705.

Syzygium vernicosum Merr. & Perry

Journ. Arn. Arb. 23: 260 (1942).

Distribution Papua New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree, bole spur-buttressed, bark surface shedding in soft scales, pale brown; leaves elliptical or oblong, 15–20 cm × 5–8.5 cm, with 8–12 pairs of distinct secondary veins, petiole c. 20 mm long; flowers in axillary or lateral, short inflorescences, very numerous on the smaller branches, pink, large, calyx c. 13 mm long, with c. 5 mm long pseudostalk and 4 large (up to 10 mm) unequal lobes; fruit unknown. *S. vernicosum* occurs very locally in lowland and foothill rain forest.

Selected sources 221, 430.

Syzygium versteegii (Lauterb.) Merr. & Perry

Journ. Arn. Arb. 23: 256 (1942).

Synonyms *Jambosa versteegii* Lauterb. (1910).

Distribution New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A small to medium-sized tree up to 20 m tall, bole up to 40 cm in diameter, bark surface scaly, grey; leaves usually oblanceolate, 16–50 cm × 6–18 cm, with c. 15 pairs of secondary veins, petiole up to 10 mm long; flowers clustered on very short stalks or subsessile in axils of leaves or on older branches, pinkish to reddish, large, calyx c. 30 mm long, with 4 lobes of c. 5 mm long; fruit oblong, c. 9 cm long, red when ripe. *S. versteegii* occurs in rain forest up to 1200 m altitude, often along rivers, sometimes on floodplains and ridges.

Selected sources 221, 430.

Syzygium viburnoides Diels

Bot. Jahrb. Syst. 57: 405 (1922).

Distribution Papua New Guinea.

Uses The timber is reputed to be used as kelat.

Observations A medium-sized tree up to 25 m tall; leaves broadly elliptical, 10–15 cm × 5–9 cm, with numerous, distinct secondary veins, petiole up to 25 mm long; flowers generally single at apices of branchlets of axillary and terminal inflorescences, calyx c. 3.5 mm long, with 4 small lobes; fruit unknown. *S. viburnoides* occurs in lowland and foothill rain forest.

Selected sources 141, 221.

Syzygium xanthophyllum (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 424 (1951).

Synonyms *Eugenia xanthophylla* C.B. Robinson (1909).

Vernacular names Philippines: malatampui (general).

Distribution The Philippines.

Uses The timber is reputed to be used as kelat. The fruits are edible.

Observations A medium-sized tree up to 20 m tall, bole up to 50 cm in diameter, bark surface smooth, greyish; leaves narrowly elliptical or narrowly oblong to almost linear, 7–15 cm long, with c. 18 pairs of secondary veins, petiole fairly short; flowers in short, lateral or terminal cymose clusters, white, calyx lobes persistent; fruit subglobose, up to 3 cm in diameter, reddish when ripe. *S. xanthophyllum* occurs in forest at low altitudes and is not common.

Selected sources 68, 125, 426, 673.

Syzygium zamboangense (C.B. Robinson) Merr.

Philipp. Journ. Sci., Bot. 79: 424 (1951).

Synonyms *Eugenia zamboangensis* C.B. Robinson (1909).

Vernacular names Philippines: malasugi (Lanao).

Distribution The Philippines (Mindanao, Basilan).

Uses The timber is reputed to be used as kelat.

Observations A medium-sized to fairly large tree up to 35 m tall, bole up to 40 cm in diameter; leaves elliptical, 5–12 cm × 2–5 cm, with 12–15 pairs of secondary veins, petiole up to 9 mm long; flowers sessile in axillary, sparingly branched and few-flowered inflorescences, calyx c. 5 mm long, with 4 broad lobes; fruit unknown. *S. zamboangense* occurs in primary forest at low altitude.

Selected sources 426, 533.

Syzygium zeylanicum (L.) DC.

Prodr. 3: 260 (1828).

Synonyms *Myrtus zeylanica* L. (1753), *Eugenia spicata* Lamk (1789), *Eugenia zeylanica* (L.) Wight (1850) non Willd.

Vernacular names Indonesia: gelam buut, ki sireum (Sundanese), pancal kidang (Javanese). Malaysia: gelam tikus laut, kelat nasi nasi, gelam paya (Peninsular). Burma (Myanmar): thabyay-pouk. Thailand: wa-ling (Songkhla).

Distribution India, Sri Lanka, Burma (Myanmar), Indo-China, southern China, Thailand, Peninsular Malaysia, Singapore, Sumatra and Borneo (Sarawak, Sabah and Kalimantan); perhaps also Java and Sulawesi.

Uses The timber is sometimes used for house and ship building, but it is usually not available in larger dimensions; it is also used for implements. The bark has been used to prepare a black dye.

Observations A small to medium-sized tree up to 20 m tall, bole up to 40 cm in diameter, bark surface smooth to irregularly cracked and papery flaky, greyish-brown, greenish-brown or orange-brown; leaves lanceolate or ovate-lanceolate, 2.5–11 cm × (0.5–)1–5.5 cm, with 10–14 pairs of indistinct secondary veins, petiole up to 7 mm long; flowers subsessile in axillary and terminal panicles, white, calyx 5–7 mm long, with often pustulate or wrinkled, glaucous tube and 4–5 short, persistent lobes; fruit broadly ellipsoid to subglobose, up to 8 mm long, white when ripe. *S. zeylanicum* is locally common along sea shores and rivers, and occurs occasionally on ridges and in montane forest.

Selected sources 36, 77, 78, 90, 104, 120, 234, 336, 429, 529.

Noorma Wati Haron (general part),
P.B. Laming (properties),
J.M. Fundter (wood anatomy),
R.H.M.J. Lemmens (selection of species)

Terminalia L.

Syst. nat. ed. 12, 2: 674 (1767); Mant. pl.: 21, 128 (1767).

COMBRETACEAE

$x = 12$; *T. arjuna*: $n = 12 + 0\text{–}2B$, $2n = 24, 26$, *T. bellirica*: $2n = 24, 26, 48$, *T. catappa*: $2n = 24$, *T. chebula*: $2n = 14, 24, 26, 36, 48, 72$, *T. ivorensis*: $2n = 24$, *T. myriocarpa*: $n = 12$

Trade groups Terminalia: lightweight to medium-weight hardwood, e.g. *Terminalia citrina* (Gaertner) Roxb. ex Fleming, *T. copelandii* Elmer, *T. microcarpa* Decne.

In Papua New Guinea, terminalia timber is divided into several distinct trade groups, mainly according to the colour of the wood.

Vernacular names Terminalia. Indonesia: ketapang, jaha, kelumpit. Malaysia: jelawai (Peninsular), ketapang (Peninsular, Sarawak), talisai (Sabah). Papua New Guinea: talis, gahwah, gaurah. Philippines: binggas, kalumpit, lanipau. Burma (Myanmar): taukyan. Thailand: haen. Vietnam: chi[ee]u li[ee]u, c[aa]y b[aw]ng.

Origin and geographic distribution *Terminalia* is a pantropical genus of about 200 species. It occurs throughout the Malesian area towards Polynesia and northern Australia. Few species have been introduced within Malesia, and about 50 species are found naturally. The latter are distributed as follows: Peninsular Malaysia 8 species, Sumatra 11, Java 6, Borneo 8, Sulawesi 10, the Lesser Sunda Islands 10, the Moluccas 7, the Philippines 12 and New Guinea 36.

Uses The wood of *Terminalia* is used for light construction, door and window frames, coffin boards, mouldings, beams, rafters, joists, flooring, furniture, carts, agricultural implements, tool handles, spindles, shuttles, picker sticks, boat building including dug-out canoes made from large stems, masts, mine props, foundation piles, veneer and plywood.

Some species are important tannin-producing trees, the tannin usually being extracted from the fruits and bark. A dye extracted from the fruits and bark is used for dyeing cloth, matting, and rattan black or as a yellow, brown or red dye. The kernel of some species is edible and considered one of the best flavoured tropical nuts. An edible oil can be extracted from the seed. Fruits have medicinal properties; when unripe they purge, and when ripe they have astringent properties. Furthermore, the flowers, bark, leaves and stem (or their extracts) are used in traditional medicine.

Production and international trade In Papua New Guinea, *Terminalia* is one of the major export timbers and is classified in MEP (Minimum Export Price) group 2; in 1992 saw logs fetched a minimum price of US$ 60/m^3. Export of *Terminalia* timber from Sabah in 1992 was only 2620 m^3 (95% as logs and 5% as sawn timber) with a total value of US$ 195 000 (US$ 70/m^3 for logs and US$ 185/m^3 for sawn timber). The import in Japan in 1987 amounted to 2.2% of the total timber import from Papua New Guinea; only very small amounts were imported from Sabah and Sarawak. Very small amounts of 'taukyan' (*T. alata* and *T. crenulata* Roth) from India and Burma (Myanmar) have been imported in Japan.

Properties *Terminalia* yields a lightweight to medium-weight hardwood. The colour of the heartwood is variable. The colour groupings are brown, pale brown, red-brown, pale yellow and yellow-brown. The sapwood is normally slightly paler, but it is sometimes not well demarcated from the heartwood. The density is (210–)280–905(–1040) kg/m^3 at 12% moisture content. The grain is straight or interlocked, the texture moderately fine to moderately coarse.

At 12% moisture content the modulus of rupture is 68–111.5 N/mm^2, modulus of elasticity 9935–15 080 N/mm^2, compression parallel to grain 37–61 N/mm^2, compression perpendicular to grain 5–13 N/mm^2, shear 8–13.5 N/mm^2, cleavage 42.5–46 N/mm radial and 48–65 N/mm tangential, Janka side hardness 2650–8660 N and Janka end hardness 4985–10 495 N.

The rates of shrinkage are moderately small to moderately high: 1.0–4.0% radial and 2.3–6.5% tangential from green to 12% moisture content. Seasoning is generally easy and rapid with little degrade, although stacks may have to be weighted to prevent bowing and twisting. Kiln drying is fairly rapid under moderate schedules. Moisture movement of the wood in service is low.

Terminalia wood is easy to work with machine and hand tools. When present, interlocked grain tends to pick up in planing and gives a woolly finish. In this case a 20° cutting angle is recommended. The wood finishes and polishes well, with a slight satiny lustre, but it may be necessary to use a filler. It glues, sands, screws and nails well, although pre-boring is often necessary to prevent splitting. The steam-bending properties of *T. catappa* are poor. Peeling properties are fair to good. Quarter-cut veneers of *T. brassii* show attractive striped faces. *T. brassii* yields good-quality pulp. The dust of some species may cause dermatitis.

The wood is rated as non-durable in contact with the ground or when exposed. It is easily attacked by termites, pinhole borers, marine borers and blue stain, and the sapwood is also susceptible to *Lyctus* borer attack. Sapwood is generally easily treated with preservatives, but sometimes it is moderately resistant, whereas heartwood is moderately resistant to very resistant and penetration may be erratic; dip-diffusion of green wood of the yellow-brown terminalia group proved effective, but preservatives are leachable and timber treated in this way should not come in contact with the ground. Absorption of creosote by *T. bellirica* wood is 130 kg/m^3, by *T. myriocarpa* wood 190 kg/m^3, and by the wood of other species probably under 80 kg/m^3.

Wood of *T. subspathulata* contains 67% holocellulose, 43% α-cellulose, 25% lignin, 14% pentosan and 0.4% ash. The solubility is 3.3% in alcohol-benzene, 5.2% in hot water and 16% in a 1% NaOH solution.

The fruits and bark are often rich in tannins, up to 23% in the bark (e.g. *T. catappa*), and as much as 40% in fruits (e.g. *T. chebula*). The tannins are classified as ellagitannins (esters of ellagic acid) and are quite complex in nature.

Description Medium-sized but more frequently large evergreen or semi-deciduous trees up to 50(–60) m tall; bole long and straight, cylindrical, up to 150(–300) cm in diameter, usually with large plank buttresses or stilt roots; bark surface longitudinally fissured or shallowly cracked and flaky, yellow-brown to greyish-brown, inner bark fibrous, tawny brown to yellowish or red; branching often sympodial, crown with branches in false whorls from the main stem and commonly pagoda-like in young trees. Leaves usually arranged spirally, often crowded at the end of the branchlets, simple and entire, pinnately veined, often minutely verrucose and pellucid-punctate due to aggregations of calcium oxalate crystals, frequently with 2 or more glands near the base of the blade or on the petiole; stipules absent. Flowers in an axillary spike or less often in a terminal panicle, in both cases with stalked male flowers towards the apex and sessile bisexual ones towards the base, actinomorphic, (4–)5-merous; calyx hairy or glabrous, united into a tube below (the receptacle), more or less constricted above the tube and apically expanding into a shallow cup terminated by calyx lobes; petals absent; stamens usually 10, exserted, anthers dorsifixed; ovary inferior, unilocular, with 2(–4) pendulous ovules, style simple, free and exserted; disk intrastaminal, usually hairy. Fruit a pseudocarp (true fruit enclosed in the receptacle), indehiscent, very variable, often fleshy and drupe-like, sometimes dry and leathery or corky, often 2–5-winged, sometimes not winged, with sclerenchymatous endocarp, 1-seeded. Seedling of *T. bellirica* with hypogeal germination, other *Terminalia* species with epigeal germination.

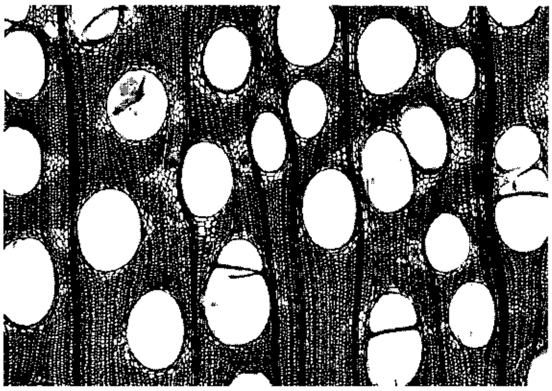
Wood anatomy

– Macroscopic characters:

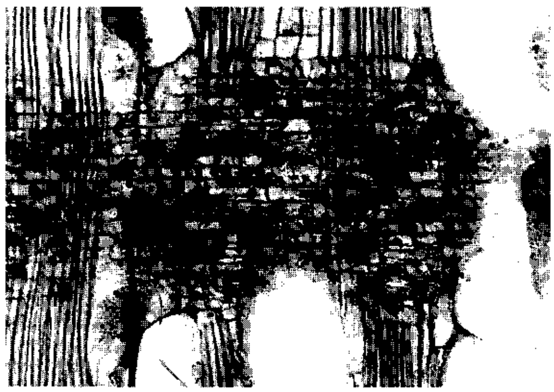
Heartwood pale brown, reddish-brown, or yellowish-brown to brown, often with yellowish or pinkish patches or streaks (e.g. *T. archipelagi*, *T. canaliculata*, *T. catappa*, *T. copelandii*, *T. kaernbachii*, *T. microcarpa*, *T. oreadum*, *T. sepicana*, *T. solomonensis*), sometimes with more or less regular black streaks (e.g. *T. alata*), distinctly or sometimes fairly indistinctly demarcated from the sapwood (pale yellowish-brown to pale brown with irregular patches or streaks with a yellowish tinge). Grain straight to interlocked. Texture moderately fine to moderately coarse. Growth rings generally not distinct, sometimes fairly distinct to distinct (usually in species with long concentric parenchyma bands); parenchyma visible to the naked eye or with a hand lens. Dark-coloured tangential zones of axial traumatic canals present, generally in short arcs.

– Microscopic characters:

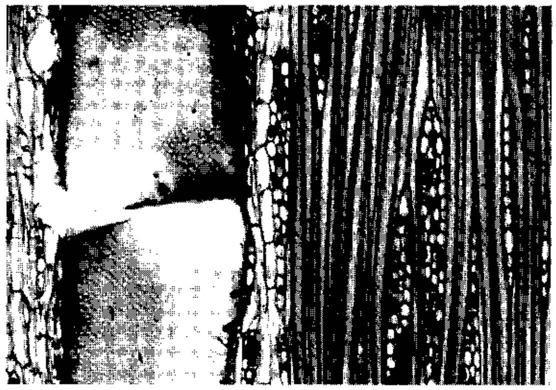
Growth rings, if distinct, marked by periodic variation of parenchyma bands and slight decrease in diameter of vessels from earlywood to latewood. Vessels diffuse, 2–5/mm^2 (*T. brassii*) to 13–23/mm^2 (*T. steenisiana*), solitary and in radial multiples of 2–4, the percentage of solitary vessels usually over 50%, tangential diameter usually 150–300 µm, in some species vessels smaller or larger; perforations simple; intervessel pits alternate, vestured, round, 5–8 µm in diameter; vessel-ray and vessel-parenchyma pits very similar to intervessel pits; amorphous to granular contents or thin-walled tyloses occasionally present. Fibres 1.2–1.4 mm long, non-septate or sometimes with septa (e.g. in *T. alata*, *T. calamansanai*, *T. microcarpa*), thin-walled to thick-walled (walls usually 3.5–4.0 µm thick), with sparse, small and indistinct pits. Parenchyma vasicentric to wing-like, short-confluent, occasionally tending to longer confluent bands, especially near the growth ring boundaries, usually in 5–7-celled strands. Rays 5–8 (–9)/mm (*T. complanata*) to 9–15/mm (*T. calamansanai*), predominantly uniseriate and homocellular (e.g. *T. alata*, *T. bialata* Steud., *T. brassii*, *T. calamansanai*, *T. megalocarpa*) or uniseriate and multiseriate (up to 4(–5)-seriate) and homo-



transverse section (×25)



radial section (×75)



tangential section (×75)

Terminalia kaernbachii

cellular or occasionally with a row of square marginal cells (Kribs type heterogenous III; other species studied), 0.1–1.0(–1.5) mm high. Crystals absent (e.g. *T. brassii*) or present, and, if present, usually frequent as druses, round or elongated, large (often over 100 μm in diameter) and in idioblasts, smaller crystals or styloids in ordinary cells, often over 100 μm long (e.g. *T. calamansanai*, *T. megalocarpa*), or druses, styloids and prismatic crystals in axial parenchyma (e.g. *T. oreadum*). Silica inclusions absent. Occasionally, axial traumatic canals with dark contents present in short or relatively long arcs (e.g. *T. archipelagi*, *T. complanata* and *T. oreadum*).

Species studied: *T. alata*, *T. archboldiana*, *T. archipelagi*, *T. bialata*, *T. brassii*, *T. calamansanai*, *T. canaliculata*, *T. catappa*, *T. complanata*, *T. copelandii*, *T. kaernbachii*, *T. longespicata*, *T. megalocarpa*, *T. microcarpa*, *T. oreadum*, *T. sepicana*, *T. solomonensis*, *T. steenisiana*.

Growth and development Trees of *T. bellirica* planted at 1 m × 6 m in Java have a mean annual increment in height of 1.6 m and in diameter of 2.1 cm at the age of 15 years; when sown directly at 1 m × 3 m the annual height and diameter increment are 1.2 m and 1.3 cm, respectively, after 6 years. The mean annual increment for *T. kaernbachii* is 2.6 m in height and 2.8 cm in diameter at the age of 8.5 years. Height increment of planted *T. alata* was only 5 m in 10 years. The mean annual diameter increment of *T. ivorensis* and *T. superba* on the Solomon Islands is 1.4–3.6 cm and 1.8–3.1 cm, respectively, at 9–16 years.

The development of the trees is according to Aubréville's architectural model, so called 'pagoda trees' or 'Terminalia branching': growth is determined by a monopodial trunk with rhythmic growth, bearing whorled branch tiers, and branches plagiotropic by apposition. *T. catappa* has a leaf-exchanging habit: the old leaves senesce at the same time that the new ones flush.

Terminalia has an effective system of self-incompatibility. The flowers are pollinated by various insects (*Coleoptera*, *Diptera*, *Hemiptera*, *Hymenoptera* and *Lepidoptera*). The flowering-to-fruiting period of *T. subspathulata* is 4 months in natural forest in Peninsular Malaysia. Several species have corky fruits or fruits containing air chambers and are thus adapted to dispersal by water.

Other botanical information Flowering or sterile material is often difficult to identify to the species level with certainty. Fruit characters in combination with characters of the leaves are generally quite specific. Species with winged fruits look similar to *Combretum* trees, although the latter genus generally comprises lianas. *Terminalia* fruits differ from those of *Combretum* in having an at least partially sclerenchymatous endocarp.

Ecology The Malesian species of *Terminalia* generally occur as elements of the canopy layer, sometimes of the subcanopy layer, in evergreen, semi-deciduous or sometimes deciduous, primary and secondary forest. Most species prefer moist locations like swamp forest or periodically flooded riverine forest, but are also found in hill forest, teak forest, and even in dry mixed dipterocarp forest; some species are littoral. *Terminalia* is mostly found at low altitudes but few individual species may ascend up to 2000 m altitude. The climate ranges from everwet to seasonal.

Propagation and planting *Terminalia* can be propagated by seed including direct sowing, by cuttings, grafting, and wildlings. Seed is readily and severely attacked by insects and other animals, even before fruit fall. Nevertheless, it should be collected from the ground, as seed still on the tree may not be fully mature. The number of fruits and seeds per kg of different species is very variable: for *T. alata* 330–550 fruits, for *T. bellirica* about 520 seeds, for *T. catappa* about 500 seeds, for *T. ivorensis* 5500–7300 seeds, for *T. myriocarpa* 8800–9900 seeds, for *T. superba* 8000–10 000 fruits, for *T. calamansanai* about 14 000 dewinged seeds, and for *T. brassii* about 70 000 seeds. In general, seed viability diminishes rapidly, with the exception of *T. superba*, the seed of which can be stored in sealed containers at 2–4°C for 1 year, and some Indian species (e.g. seed of *T. alata* can be stored under ambient conditions for 2 years, and seed of *T. arjuna* for as long as 3 years). *T. catappa* seed remains viable for a long time and its fruits may be transported over long distances by sea water. Dried seed of *T. brassii* with a moisture content of 5% can be stored for a prolonged period at temperatures under −20°C.

There are considerable differences in seed viability between species: for *T. alata* the germination rate is 5–50%, for *T. arjuna* 60–80%, for *T. bellirica* 4–100%, for *T. calamansanai* 55–80%, for *T. catappa* 25–70%, for *T. chebula* up to 50%, for *T. ivorensis* 10–50% but up to 93% under experimental temperature fluctuations, for *T. myriocarpa* about 65%, for *T. phellocarpa* about 95%, for *T. subspathulata* about 75%, and for *T. superba* 60–80%. Seed of some species is pretreated by soaking in water for 24–48 hours, by manual scar-

ification, or, in the case of *T. ivorensis*, by alternate days of soaking and drying for one week. *T. catappa* seed has been found not to benefit from various pretreatments.
Covering of seeds or fruits in the seed-bed is important for increasing the germination percentage. Light shade is generally applied during germination, but it should be removed after 1–2 months. Adequate moisture during germination is a prerequisite. Germination generally starts within 2 weeks after sowing and lasts for another 2–5 weeks; seed of *T. phellocarpa* started germinating only after 3.5 months and the last seed germinated 7 months after sowing.
Pricking out should be carried out early enough to avoid disturbing the rapidly developing taproot. For *T. superba* pricking out is recommended 6 weeks after sowing when 2 leaves have developed, whereas for *T. ivorensis* it should be as soon as the 2 cotyledons unfold. Seedlings of *Terminalia* are ready for planting when they are 20–30 cm tall. Stumps of *T. ivorensis* should have a diameter of at least 1.3 cm, striplings should be 120–180 cm tall. Large diameter stumps (3–4 cm) are recommended for *T. alata*. The use of stumps and striplings of *T. brassii* and *T. calamansanai* in plantations in the Solomon Islands was not satisfactory; only pot plants of these species should be used. Wildlings have been successfully used for *T. superba*. Cuttings of *T. superba* and *T. ivorensis* rooted in 2 weeks, with a rooting percentage of 11–100% for *T. superba* depending on the degree of rejuvenation.
Direct sowing of *T. bellirica* in Java was successful. *T. brassii* is planted in Papua New Guinea at 2.7 m × 2.7 m, in the Solomon Islands at 3.0–4.5 m × 3.0–4.5 m. *T. superba* is planted in Africa at 6–14 m × 6–14 m, *T. bellirica* in Java at 1 m × 3 m. *T. superba* can be planted on a wide variety of sites, whereas *T. ivorensis* does not tolerate waterlogging, shallow soils over hardpans or dry sands. *T. brassii* tolerates anaerobic soil conditions and *T. alata* requires moist soil conditions and deep, heavy, clayey soils.

Silviculture and management Considerable experience is available in the silviculture of a number of *Terminalia* species, notably *T. brassii*, *T. calamansanai* and *T. catappa*, especially in the Solomon Islands. *T. superba* and *T. ivorensis* are very well-known plantation species in tropical Africa and have been planted in the Solomon Islands as well. During the first 1–2 years *Terminalia* trees can tolerate light to moderate shade rather well. Thereafter they should receive full overhead light for optimal growth; they are considered as pioneer trees.
Weeding is necessary during the first 3–4 years after planting. Under the rather dense crowns of direct sown *T. bellirica* in Java (spacing 1 m × 3 m) no weeds could develop. Most species, with the apparent exception of *T. catappa*, have good to extremely good self-pruning capacity; for *T. superba* the tree is branchless for 70–80%, occasionally up to 90% of the total tree height. Because of the wide spreading branches, the trees need much space; final stocking for *T. calamansanai* in the Solomon Islands is 60 trees/ha and for *T. superba* in Congo and Ivory Coast (Africa) 70 trees/ha corresponding to a spacing of 12 m × 12 m. For this reason, *T. ivorensis* is more suitable for line planting than for planting in pure plantations. Coppicing ability is good for a number of *Terminalia* species planted in Africa and India. *T. chebula* is known to withstand fire well, but *T. superba* and *T. ivorensis* are very vulnerable in this respect.
The rotation applied for pulpwood production of *T. brassii* and *T. calamansanai* in the Solomon Islands is 10–11 years and for sawlog production it is estimated at 20 years. The rotation for *T. ivorensis* and *T. superba* as applied in Africa is 40 years in favourable locations.

Diseases and pests In the Solomon Islands, *T. calamansanai* and *T. brassii* are attacked by the larva of a cerambycid borer, *Oxymagis hormi*, but they protect themselves to some extent by gum exudates. Seventeen species of defoliating caterpillars have been observed on *T. calamansanai*, but none of them constitutes a major pest. *Roeselia lignifera* is considered as potentially dangerous in the Solomon Islands for *T. brassii* plantations; the caterpillar of this moth has completely defoliated 3–4-year-old stands in Papua New Guinea.

Harvesting It is difficult to extract *T. brassii* from natural forest because of the usually wet soil conditions.

Yield The mean annual volume increment of a trial plantation of *T. bellirica* in Java planted at 1 m × 6 m was 6 m^3/ha at the age of 15 years. The mean annual increment of *T. brassii* on fertile riverine sites in Papua New Guinea was 25–35 m^3/ha, and in the Solomon Islands it was 16 m^3/ha and 20 m^3/ha, respectively in plantations of 12 years at spacings of 3 m × 3 m and 4.5 m × 4.5 m. Increment and yield figures for *T. calamansanai* in the Solomon Islands are considered to be very similar to those of *T. brassii*. Yields of *T. ivorensis* in plantations in Africa range from 8–20 m^3/ha annually and for *T. superba* 9–25 m^3/ha, and 45

m^3/ha for plantations at 6 m × 6 m up to the age of 10 years.

Handling after harvest Freshly felled logs are easily attacked by blue stain and pinhole borers and logs should be converted as soon as possible. Logs of old *T. brassii* trees tend to sink.

Genetic resources Plantations of some *Terminalia* species have been established from different seed sources. However, many species have a small area of distribution, and conservation of genetic resources depends on habitat conservation.

Breeding *Terminalia* is self-incompatible. Selection and breeding of *T. superba* and *T. ivorensis* started in the 1960s in Africa. Since then, plus trees with superior growth rate and stem form have been selected and clone banks have been established. It is known that there are significant clonal differences in *T. superba* in wood formation e.g. regarding rate of growth and radial dimensions of vessels, fibres and parenchyma.

Prospects *T. brassii* has good potential for reafforestation of swampy lowland tropical areas because of its natural tolerance for swampy conditions. Many other *Terminalia* species are promising plantation species as growth is fast and silvicultural characteristics are rather well known.

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Selection of species

Terminalia alata Heyne ex Roth

Nov. pl. sp.: 379 (1821).

Synonyms *Terminalia coriacea* (Roxb.) Wight & Arn. (1834), *Terminalia tomentosa* (Roxb.) Wight & Arn. (1834), *Terminalia macrocarpa* Steud. (1841).

Vernacular names Indian laurel (En). Burma (Myanmar): taukyan. Cambodia: chhlik bay, chhlik snaêng, neang phaëk. Laos: suak 'mon, suak dam, suak kieng. Thailand: rok fa, hok fa, chueak (central, northern). Vietnam: b[aw]ng l[aw]ng kh[eef], c[af] lich, c[aar]m li[ee]n.

Distribution India, Burma (Myanmar), Indo-China and Thailand.

Uses *T. alata* is a valuable and commercial source of timber and may have potential in other South-East Asian countries. The wood is used as terminalia e.g. for house building, furniture, tool handles, and for underwater purposes. When quarter-sawn, the wood yields attractive veneer. The bark is used medicinally against diarrhoea. Oxalic acid can be extracted from it. The bark and especially the fruit yield pyrogallol and catechol to dye and tan leather. The leaves are used as fodder in Nepal.

Observations A medium-sized to fairly large deciduous tree up to 35 m tall, bole up to 200 cm in diameter, bark surface with deep vertical fissures and transverse cracks, dark grey to blackish, inner bark reddish; leaves oblong to ovate-oblong, 7–20 cm × 4–10 cm, base obtuse, often oblique, apex rounded to acute, glabrous to tomentose, with 10–16 pairs of secondary veins, with a pair of stalked glands on the midrib near the base below, petiole 1–2 cm long; flowers in an axillary or terminal spike 6–15 cm long, calyx tube pubescent; fruit broadly ellipsoid, 4–6 cm × 2.5–5 cm, 5-winged, wings coriaceous, glabrous, 1–2 cm broad. *T. alata* is found in mixed deciduous forest, sometimes in dry dipterocarp forest, often on alluvial soils, up to 1000 m altitude. The density of the dark brown wood is about 1040 kg/m^3 at 12% moisture content.

Selected sources 163, 371, 383, 392, 449, 648, 666, 746.

Terminalia archboldiana Exell

Brittonia 2: 137 (1936).

Distribution Papua New Guinea.

Uses The wood is used (in Papua New Guinea as pale yellow terminalia).

Observations A medium-sized tree up to 30 m tall, bark surface fissured and scaly, pale brown; leaves obovate or rhombic-obovate, 3–8 cm × 1.5–4 cm, cuneate at base, glabrous or sometimes pubescent below, with 5–6 pairs of secondary veins, petiole 1–4(–7) mm long; flowers in an axillary spike 2.5–5 cm long, calyx tube sericeous; fruit ovoid, 10–16 mm × 6–7 mm, sparsely pubescent, not winged. *T. archboldiana* is locally common in hill forest or gallery forest in savanna areas, up to 450 m altitude. The density of the pale yellow wood is about 510 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 162, 718.

Terminalia archipelagi Coode

Kew Bull. 23: 299 (1969), fig. 1, 2.

Distribution The Bismarck Archipelago; planted in Lae (Papua New Guinea).

Uses In Papua New Guinea, the wood is used as red-brown terminalia.

Observations A large tree up to 55 m tall, bole branchless for up to 23 m, up to 80 cm in diameter, usually with flying buttresses up to 5 m high and with stilt roots, bark surface flaky, peeling off in long strips, yellow-brown, inner bark fibrous, red with paler streaks, exuding jelly-like exudate; leaves obovate, 20–60 cm × 5–19 cm, gradually tapering at base, glabrous, petiole short or almost absent; flowers in an axillary spike up to 15 cm long, 8–15 mm long, calyx tube glabrous; fruit ellipsoid, 7–9.5 cm × 3.5–4 cm, glabrous, wings undulate and thin. *T. archipelagi* is an emergent and often dominant tree of lowland rain forest on undulating land. The density of the red-brown wood is about 710 kg/m^3 at 12% moisture content.

Selected sources 100, 101, 145, 718.

Terminalia arjuna (Roxb. ex DC.) Wight & Arn.

Prodr. fl. Ind. orient.: 314 (1834).

Synonyms *Pentaptera arjuna* Roxb. ex DC. (1828).

Vernacular names Arjun (En, India). Thailand: rokfa-khao (central).

Distribution Native to India but introduced and frequently planted as an ornamental and roadside tree in Thailand; also planted in plantation trials in Indonesia.

Uses *T. arjuna* is an important source of timber in India and has potential elsewhere in the South-East Asian region; the wood is used as terminalia for the construction of carts and boats, for general construction, agricultural implements and mine props. The transparent gum is used as a drug in India. The bark is used medicinally as a tonic. The tree is also planted for shade and as an ornamental.

Observations A fairly large tree up to 40 m tall, bole with buttresses, bark surface smooth, flaking off in large thin layers, pale whitish-grey; leaves oblong to ovate-oblong, 8–15 cm × 4.5–9 cm, usually obliquely subcordate at base, glabrescent, with 15–25 pairs of secondary veins, petiole 0.5–1.5 cm long; flowers in an axillary or terminal panicle 2.5–6 cm long, calyx tube glabrous outside; fruit broadly ellipsoid, truncate at the top, 3.5–5 cm × 2.5–3.2 cm, glabrous, with 5 leathery wings. *T. arjuna* is common along rivers and streams in central India.

Selected sources 28, 392, 449, 574, 648, 666.

Terminalia bellirica (Gaertner) Roxb.

Pl. Coromandel 2: 54, t. 198 (1805).

Synonyms *Terminalia punctata* Roth (1821), *Terminalia laurinoides* Teijsm. & Binnend. ex Miq. (1855), *Terminalia bellirica* var. *laurinoides* (Teijsm. & Binnend. ex Miq.) Clarke (1878).

Vernacular names Beleric myrobalan, belliric myrabolan, bedda nut tree (En). Myrobalan beleric (Fr). Indonesia: jaha kebo, jaha sapi (Javanese), ulu belu (Sumatra). Malaysia: jelawai, simar kulihap (Peninsular). Burma (Myanmar): thitsein. Cambodia: srâmâr piphéék. Laos: hèèn, nam kièng dam. Thailand: haen-khao, haen-ton (eastern, northern), samo-phiphek (central). Vietnam: b[af]ng n[uw][ows]c, mung tr[awf]ng, b[oo]ng d[ee]u.

Distribution From Sri Lanka, India and Nepal through Burma (Myanmar) Indo-China and Thailand towards Peninsular Malaysia, Sumatra, Java, Borneo (Sabah), the Lesser Sunda Islands, central Sulawesi and the Moluccas; rarely cultivated.

Uses The wood is used e.g. for boxes, furniture, and house construction after being steeped in water to make it more durable. The tree also yields a good-quality firewood and charcoal. Probably more important are the fruits, which contain tannin and a dye and are used to tan leather and dye cloth and matting, and to prepare ink. The kernels of the fruit can be eaten but are somewhat dangerous as they have a narcotic effect. The unripe fruit is purgative and the ripe fruit astringent. In India and Thailand the fruit is used medicinally to treat dropsy, haemorrhoids and diarrhoea.

Observations A large briefly deciduous tree up to 50 m tall, bole branchless for up to 20 m, up to 300 cm in diameter, with large buttresses, bark surface finely longitudinally cracked or fissured, bluish or ash-grey to pale grey-brown, inner bark yellowish; leaves broadly elliptical or obovate-elliptical, 4–18 cm × 2–11 cm, base rounded to cuneate, rufous-sericeous but soon glabrescent, with 6–9 pairs of secondary veins, secondary and tertiary venation prominent on both surfaces, petiole 2.5–9 cm long; flowers in an axillary spike 3–15 cm long, calyx tube densely sericeous or tomentulose; fruit subglobose to broadly ellipsoid, 2–2.8 cm × 1.8–2.2 cm, densely velutinous or sericeous, with 5 well-marked longitudinal ridges. *T. bellirica* is fairly common in monsoon forest, mixed deciduous forest or dry deciduous dipterocarp forest, sometimes associated with teak, rarely in evergreen forest, on periodically dry soils, up to 600 m altitude. The wood is whitish, rather soft, and has a density of 675–900 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 28, 77, 78, 162, 163, 179, 261, 331, 449, 465, 648, 705.

Terminalia brassii Exell

Journ. Bot., Lond. 73: 134 (1935).

Synonyms *Terminalia kajewskii* Exell (1935).

Vernacular names Brown terminalia, swamp oak (En).

Distribution The Bismarck Archipelago and the Solomon Islands; also planted for reafforestation in New Guinea and in plantation trials in these areas, northern Australia and Fiji.

Uses The wood is used as brown terminalia, e.g. for light construction, mouldings, interior finish and veneer. *T. brassii* is potentially a suitable plantation species and may also be used to reafforest lowland swampy areas. A good-quality pulp can be produced from plantation material.

Observations A large tree up to 50 m tall, bole branchless for up to 30 m, up to 150(–250) cm in diameter, with huge flange buttresses, often with stilt roots forming mats up to 6 m up the trunk,

Terminalia brassii Exell – 1, flowering twig; 2, infructescence.

bark surface flaky-scaly, coming off in long strips, with large pustules arranged in patches, inner bark pale brown to white; leaves alternate to subopposite, narrowly oblong to elliptical, (7–)10–15(–18) cm × 3–6 cm, base rounded to subcordate, glabrous or hairy, with 20–35 pairs of secondary veins, petiole 5–12 mm long; flowers in an axillary or terminal panicle 8–13 cm long, calyx tube tomentose; fruit usually more or less ellipsoid, 9–14 mm × 5–11 mm, with 2 papery wings and 3 flanges or crests. *T. brassii* is a pioneer, usually found gregariously in freshwater swamps or along rivers on sandy or even gravelly soils, occasionally scattered in drier areas, up to 250 m altitude. The density of the medium brown to pinkish-fawn to streaky grey wood is 300–600 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 54, 101, 145, 155, 159, 162, 270, 289, 645, 648, 718.

Terminalia calamansanai (Blanco) Rolfe

Journ. Linn. Soc. Bot. 21: 310 (1884).

Synonyms *Terminalia pyrifolia* (Presl) Kurz (1875), *Terminalia blancoi* Merr. (1909), *Terminalia latialata* C.T. White (1929).

Vernacular names Malaysia: jelawai mentalun (Peninsular). Philippines: malakalumpit (general), kalamansanai (Tagalog), magtalisai (Panay Bisaya). Cambodia: popiël khaê, popeal khe, pro pil ke. Burma (Myanmar): lein. Thailand: khimot (central), tinnok (south-eastern), haendaeng (northern). Vietnam: b[oo]ng d[ee]u, ch[af]n r[af]ng, chi[ee]u li[ee]u.

Distribution Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, the Philippines, Sulawesi, New Guinea and the Solomon Islands.

Uses The wood is used as yellow-brown terminalia, e.g. for indoor construction and furniture; it is also employed for foundation piles but is not durable. The bark has been used medicinally in the Philippines.

Observations A medium-sized to fairly large deciduous tree up to 40 m tall, bole up to 200 cm in diameter, with tall, steep plank buttresses up to 10 m high, bark surface shallowly cracked or fissured and flaking, grey to pale yellow-brown, inner bark pale yellow; leaves narrowly obovate to broadly elliptical, 8–20 cm × 3–9 cm, base cuneate, pubescent but usually glabrescent above, with 4–8 pairs of secondary veins, petiole 1–4 cm long; flowers in an axillary spike 6–20 cm long, calyx tube tomentose or sericeous; fruit much broader than long, 1–3 cm × 2–10 cm, pubescent to tomentose, with 2 very broad wings. *T. calamansanai* is common in areas subject to a pronounced dry season and is found in deciduous forest, on roadsides, along rice fields, also near the sea and on limestone cliffs, at low and medium altitudes. The density of the yellow-brown wood is 590–705 kg/m^3 at 12% moisture content.

Selected sources 54, 101, 125, 140, 145, 159, 162, 163, 414, 449, 465, 527, 666, 705, 718.

Terminalia canaliculata Exell

Blumea 7: 327 (1953).

Synonyms *Terminalia beccarii* Exell (1953).

Distribution New Guinea and New Britain.

Uses In Papua New Guinea the wood is used as red-brown terminalia.

Observations A medium-sized semi-deciduous tree up to 30 m tall, bole with buttresses, bark surface flaky, brown or pale brown; leaves obovate to elliptical, 8–17 cm × 2–8 cm, cuneate to more or less tapering at base, soon glabrescent, with 8–13 pairs of secondary veins, petiole 1–4 cm long; flowers in an axillary spike 10–18 cm long, calyx tube sericeous or glabrous; fruit ovoid, flattened, 3.5–4 cm × 2–3 cm, not winged. *T. canaliculata* is a canopy tree of rain forest on low ridges and flat swampy sites, at low altitudes. The density of the red-brown wood is 210–640 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 162, 715, 718.

Terminalia catappa L.

Syst nat. ed. 12, 2: 674 (1767); Mant. pl.: 128 (1767).

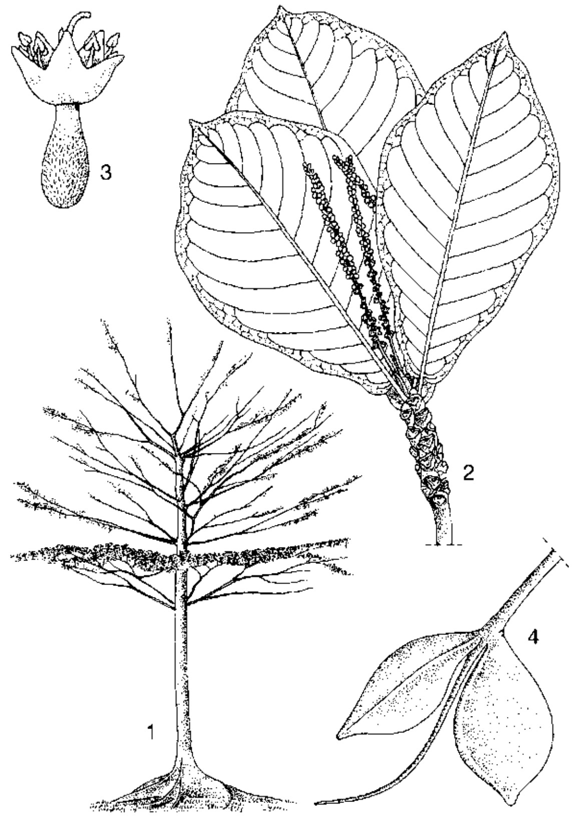
Synonyms *Terminalia moluccana* Lamk (1783), *Terminalia procera* Roxb. (1832), *Terminalia mauritiana* Blanco (1845).

Vernacular names Indian almond, Singapore almond (En). Badamier (Fr). Brunei: telisai. Indonesia: ketapang (general). Malaysia: jelawai ketapang (Peninsular, Sarawak), telisai (Sarawak, Sabah). Papua New Guinea: reddish-brown terminalia (Pidgin). Philippines: talisai (Filipino), almendras (Sp), dalinsi (Bikol). Cambodia: châmbâk barang, kapang, pareang prang. Laos: hu kwang, sômz moox dông, 'hou kouang. Burma (Myanmar): badan. Thailand: hukwang (central). Vietnam: b[af]ng (general), b[af]ng nh[os]c (Bên Tre), mo^2 c[uws]a (Saigon).

Distribution Native from India through Indo-China and Thailand, throughout the Malesian area, to northern Australia and Polynesia; very widely planted throughout the tropics.

Uses The wood is used, in Papua New Guinea as red-brown terminalia, e.g. for house and boat construction, furniture and cabinet-making. Probably more important are the bark and leaves which are used for tanning leather and for dyeing cloth, and making ink; sometimes the roots and green fruits are used for the same purposes. The seed is edible and tasty and contains an oil which is used medicinally as a substitute for true almond oil. The flesh of the fruit is edible but not tasty. The trees are very commonly applied as shade trees in gardens and along roads. The leaves cause sudorific action and are applied to rheumatic joints. The tannin from leaves and bark is used as an astringent in dysentery and thrush, is regarded as diuretic and cardiotonic, and is applied externally on skin eruptions. In the Philippines, a decoction of the leaves is employed as a vermifuge. In Papua New Guinea crushed flowers are mixed with water and the mixture is drunk to induce sterility.

Observations A medium-sized evergreen or



Terminalia catappa L. – 1, habit of leafless and flowering tree; 2, flowering twig; 3, flower; 4, branchlet with fruits.

briefly deciduous tree up to 25(–40) m tall, bole up to 150 cm in diameter, often with buttresses up to 3 m high, bark surface shallowly fissured and slightly flaky, grey to dark grey-brown, inner bark pinkish-brown; leaves usually obovate, sometimes more or less elliptical, 8–25(–38) cm × 5–14(–19) cm, subcordate at base, sometimes hairy below, with (6–)8–12 pairs of secondary veins, petiole 4–15(–20) mm long; flowers in an axillary spike 8–16 cm long, calyx tube sericeous or glabrous; fruit ovoid or ellipsoid, 3.5–8 cm × 2–5.5 cm, with a wing that is inconspicuous or rigid and about 2 mm broad. *T. catappa* occurs along sandy or rocky beaches or on tidal river banks, and is a typical element of *Barringtonia* formations. The density of the red-brown wood is 450–720 kg/m³ at 12% moisture content. See also the table on wood properties.

Selected sources 26, 69, 77, 125, 145, 159, 162, 163, 289, 350, 351, 384, 392, 414, 449, 462, 488, 527, 665, 666, 705, 715, 718, 727.

Terminalia chebula Retz.

Observ. bot. 5: 31 (1788).

Synonyms *Terminalia parviflora* Thwaites (1854), *Terminalia zeylanica* van Heurck & Muell.-Arg. (1870), *Terminalia tomentella* Kurz (1873).

Vernacular names Chebulic myrobalan, chebulic myrabolan, black myrobalan (En). Myrobalan noir, myrobolan noir (Fr). Malaysia: manja lawai, manja puteri, manja patut (Peninsular). Cambodia: sramo, sa mao tchet, srâmâr. Laos: som, 'som² mo¹ khôk. Thailand: samo-thai (central), manae (northern). Vietnam: c[af] lich, chi[ee]u li[ee]u xanh.

Distribution Native in Sri Lanka, India, Nepal, Burma (Myanmar), Thailand, Indo-China and southern China. Introduced to Peninsular Malaysia.

Uses The wood is used, e.g. for furniture, carts and implements. Probably more important are the fruits which are rich in tannin and are used extensively in India to tan leather. A durable yellow dye can be prepared from the fruits mixed with alum; a black dye and ink can be obtained from the fruits mixed with iron. The fruits are edible and have numerous medicinal properties such as laxative, stomachic, and tonic, and show antibacterial and antifungal activity.

Observations A medium-sized tree up to 30 m tall, bole usually short, branchless for up to 10 m, up to 130 cm in diameter, bark surface usually longitudinally cracked with woody scales, dark brown; leaves broadly ovate to ovate-elliptical, 7–15 cm × 4–10 cm, cuneate to slightly cordate at base, glabrescent, with 6–7 pairs of secondary veins, petiole 1–3 cm long; flowers in an axillary or terminal panicle 3–7 cm long, calyx tube glabrous outside; fruit subglobose to ellipsoid, 2.5–5 cm × 1.5–2.5 cm, glabrous, smooth or sometimes 5-angular or ridged. *T. chebula* is divided into 2 varieties: var. *chebula* is a tree whereas var. *nana* Gagnep. is only a small shrub. *T. chebula* occurs scattered in teak forest, mixed deciduous forest and dry evergreen forest, often on clayey-sandy soils, up to 1000 m altitude. The density of the greyish-brown wood is about 880 kg/m³ at 12% moisture content.

Selected sources 163, 178, 392, 449, 468, 666.

Terminalia citrina (Gaertner) Roxb. ex Fleming

As. Res. 11: 183 (1810).

Synonyms *Terminalia arborea* Koord. & Valeton (1903), *Terminalia comintana* Merr. (1909), *Terminalia curtisii* Ridley (1931).

Vernacular names Indonesia: blabah (Javanese), tengeh caah (Sundanese), mertaki (Sumatra). Malaysia: jelawai belang rimau, antoi puteh (Peninsular), talisai jambu (Sabah). Philippines: binggas (general), apunga (Tagalog), bungras (Bikol). Thailand: samo-dingu (central), samo-muak, samo-liam (peninsular).

Distribution From India and Burma (Myanmar) towards Thailand and throughout Malesia except for New Guinea.

Uses The wood is used, e.g. for furniture, light construction, door posts, rafters, beams, joists, flooring, spindles, shuttles, picker sticks, boats and masts. The fruit and bark yield tannin used to tan leather as well as a dark blue dye. The fruits are used in local medicine as a purgative.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 210 cm in diameter, usually with small buttresses up to 3 m high, bark surface smooth and scaly with large thin scales, fawn and brown or greyish-brown, inner bark laminated, pink or yellow-brown with a yellow band at the cambium; leaves alternate to opposite, elliptical to oblong-elliptical, 3–14 cm × 1.8–6.5 cm, rounded to broadly cuneate at base, rufous pubescent to almost glabrous, with 9–12 pairs of secondary veins, petiole 5–25 mm long; flowers in an axillary or terminal panicle 3–6 cm long, calyx tube glabrous outside; fruit ellipsoid to subglobose, 2–3 cm × 0.8–2 cm, glabrous, 5-angled. *T. citrina* occurs scattered but usually frequent in lowland forest and along seashores, up to 200 m altitude. The density of the yellow-brown wood is 750–905 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 26, 77, 99, 125, 162, 384, 414, 449, 527, 556, 705.

Terminalia complanata K. Schumann

K. Schumann & Hollrung, Fl. Kais. Wilh. Land: 83 (1889).

Distribution New Guinea, the Bismarck Archipelago and the Solomon Islands; possibly also in the Moluccas and northern Queensland (Australia).

Uses The wood is used in Papua New Guinea as pale yellow terminalia, e.g. for flooring, light construction, interior finish, mouldings and veneer. The wood has been reported to contain a yellow dye.

Observations A large tree up to 50 m tall, bole straight, with simple or branched buttresses up to 3 m high, bark surface grey, yellow-brown or reddish-brown; leaves usually elliptical, sometimes obovate or oblong, 5–11(–13) cm × 1.5–5 cm, tapering at base, soon glabrescent above, hairy on the veins below, with (7–)9–15 pairs of secondary veins, petiole 7–15 mm long; flowers in an axillary spike 7–14 cm long, calyx tube sericeous; fruit ellipsoid or more or less globose, slightly flattened when ripe, 1.4–2.1 cm × 1.1–1.9 cm, silky hairy but glabrescent, fleshy and not winged. *T. complanata* is locally dominant in riverine swamp forest, but does occur in other forest types, also on ridges, up to 1500 m altitude. The density of the pale yellow wood is 460–600 kg/m^3 at 12% moisture content. See also the table on wood properties.

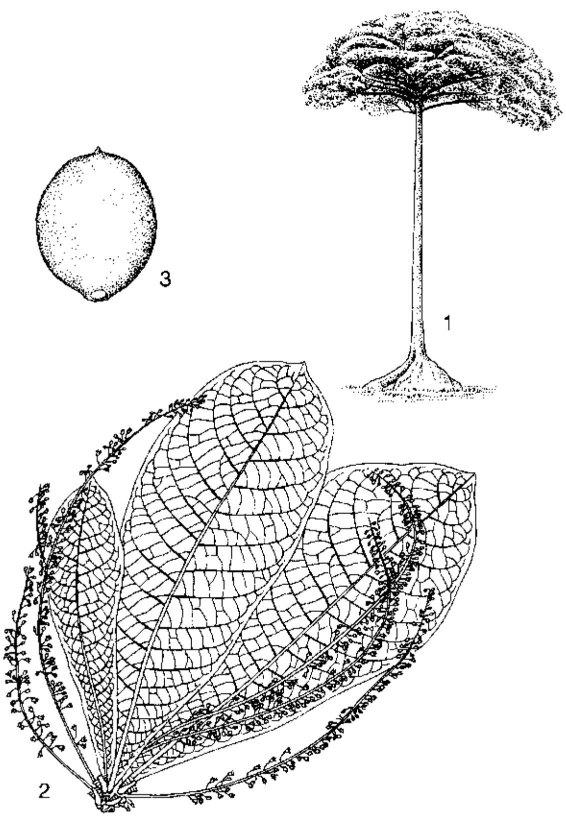
Selected sources 145, 162, 289, 666, 715, 718.

Terminalia copelandii Elmer

Leafl. Philipp. Bot. 5: 1759 (1913).

Synonyms *Terminalia crassiramea* Merr. (1917), *Terminalia gigantea* v. Slooten (1924), *Terminalia catappoides* C.T. White & Francis (1927).

Vernacular names Indonesia: ketapang darat,



Terminalia copelandii Elmer – 1, tree habit; 2, flowering twig; 3, fruit.

mertapang, lahajang pajo (Sumatra). Philippines: lanipau (general), yanipo (Mbo), dalipo (Palopo).

Distribution Sumatra, Borneo, Flores, the Moluccas, the Philippines, New Guinea and the Solomon Islands.

Uses The wood is used, e.g. for house construction, canoe making and veneer; the tree is also planted. The kernels of the fruits are edible. It has potential to stabilize river banks.

Observations A fairly large tree up to 40 m tall, bole straight and cylindrical, usually short but sometimes up to 23 m long, up to 115 cm in diameter, with many large buttresses up to 2 m high, bark surface shallowly longitudinally cracking and flaking into small oblong pieces, grey or brown, inner bark pinkish; leaves obovate, 15–40 cm × 4.5–18 cm, usually subcordate at base, sparsely pubescent and sometimes minutely verrucose below, with (20–)23–30 pairs of secondary veins, petiole very short, up to 10 mm long; flowers in an axillary spike 22–50 cm long, calyx tube fulvous-sericeous; fruit ovoid to ellipsoid, 3.5–6 cm × 2.2–3 cm, nearly glabrous when mature, sometimes flattened or faintly 5-lobed. *T. copelandii* is found in primary forest and swamp forest, both inland and in coastal regions, up to 500 m altitude. It has proven to grow well in monocultures. The density of the yellow-brown wood is 330–620 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 26, 77, 99, 162, 234, 289, 384, 414, 527, 666, 715, 718.

Terminalia darlingii Merr.

Philipp. Journ. Sci., sect. C. Botany 5: 202 (1910).

Vernacular names Philippines: malaputat (general), pagat-pagat (Negrito).

Distribution The Philippines.

Uses The wood is used, e.g. for house posts, beams, joists and general framing.

Observations A medium-sized tree; leaves spatulate, 15–26 cm × 6–9.5 cm, narrowly cuneate and decurrent at base, glabrous or pubescent mainly on the main veins below, petiole 5–7 mm long; flowers in an axillary spike c. 12 cm long, calyx tube fulvous-sericeous; fruit suborbicular to broadly obovoid, 1.7–3 cm × 1.7–2.5 cm, tomentulose or pubescent, winged. *T. darlingii* is still incompletely known from the primary lowland forest. The sapwood is yellowish, the heartwood reddish to dark reddish-brown.

Selected sources 162, 384, 414, 527.

Terminalia eddowesii Coode

Contr. Herb. Austr. 2: 13, fig. 3 (1973).

Distribution Papua New Guinea.

Uses In Papua New Guinea, the wood is used as red-brown terminalia.

Observations A medium-sized tree up to 20 m tall, probably also larger; leaves elliptical to narrowly obovate, (12–)15–23 cm × 6–9.5 cm, tapering at base, virtually glabrous, with 9–11 pairs of secondary veins, petiole 2.5–3.5 cm long; flowers in an axillary spike (10–)12–20 cm long, calyx tube silky hairy outside; fruit narrowly ellipsoid, up to 35 mm × 11 mm when fresh, glabrescent, smooth. *T. eddowesii* is found in riverine and lowland rain forest, up to 150 m altitude. The density of the red-brown wood is about 560 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 718.

Terminalia foetidissima Griffith

Not. pl. asiat. 4: 685 (1854).

Synonyms *Terminalia sumatrana* Miq. (1860), *Terminalia oocarpa* Merr. (1904), *Terminalia borneensis* v. Slooten (1919).

Vernacular names Indonesia: ketapang kancil, ketapang talang (Sumatra), marasesap (Kalimantan). Malaysia: jelawai (Peninsular), telisai (Bisaya, Sarawak), telinsi (Iban, Sarawak). Philippines: talisai gubat (Filipino), bangkalauag (Panay Bisaya), dalinsi (Tagalog, Bikol).

Distribution Peninsular Burma (Myanmar), peninsular Thailand, Peninsular Malaysia, Sumatra, Borneo and the Philippines; possibly also in Vietnam.

Uses The wood is used. The bark yields a yellow or brown dye.

Observations A medium-sized to fairly large tree up to 40 m tall, bole straight, branchless for up to 18 m, up to 100 cm in diameter, if buttresses are present they are prominent, steep and up to 8 m high, bark surface fissured or scaly, pale brown to brown, inner bark pale yellow to pale yellowish-brown; leaves narrowly obovate to obovate-elliptical or obovate, 6–24 cm × 2.5–12 cm, narrowly cuneate at base, glabrous or sometimes rufous-pubescent on the veins below, with 6–13 pairs of secondary veins, petiole 1–3.5 cm long; flowers in an axillary spike 8–16 cm long, calyx tube rufous-tomentose or sericeous to glabrous; fruit subglobose to ovoid, 3.5–5 cm × 2–4 cm, glabrescent, smooth, not winged. *T. foetidissima* is found scattered in primary forest and mixed dipterocarp forest in well-drained locations, generally on leached sandy clay soils, up to 1000 m altitude. The density of the yellow-brown to reddish-brown wood is 660–800 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 99, 125, 162, 384, 414, 449, 474, 527, 666, 705.

Terminalia impediens Coode

Kew Bull. 23: 308, fig. 6 (1969).

Vernacular names Papua New Guinea: okari (general).

Distribution New Guinea.

Uses The wood is used in Papua New Guinea as red-brown terminalia, e.g. for furniture; it is generally consumed locally. The kernel is edible and very tasty.

Observations A fairly large tree up to 42 m tall, bole branchless for up to 21 m, up to 100 cm in diameter, with buttresses up to 3 m high, bark surface flaking with roughly rectangular flakes, grey, inner bark pinkish-brown to straw-coloured at the cambium; leaves obovate, 15–25(–45) cm × 5–12(–20) cm, tapering to subcordate at base, glabrous or hairy below, with 12–16 pairs of secondary veins, petiole short; flowers in an axillary spike 10–30 cm long, calyx tube glabrous outside; fruit ellipsoid, 7–9 cm × 3.5–6 cm, glabrous, smooth and splitting into 2 when ripe. *T. impediens* occurs in lowland forest, in floodplains, at low altitude. The density of the red-brown wood is about 700 kg/m^3 at 12% moisture content.

Selected sources 100, 101, 145, 666, 718.

Terminalia ivorensis A. Chev.

Vég. util. Afr. trop. franç. 5: 152 (1909).

Vernacular names Black afara (En). Framiré (Fr).

Distribution Native to tropical West Africa from Guinea to Cameroon; introduced in many other tropical countries as a promising timber plantation species, e.g. in South America, Fiji, the Solomon Islands and Sarawak.

Uses *T. ivorensis* yields high-quality timber; the wood is used for e.g. fine carpentry, joinery, building, flooring and plywood manufacturing.

Observations A large tree up to 45 m tall, bole straight, branchless for up to 30 m, up to 175 cm in diameter, if present, buttresses are short and up to 1 m high, bark surface longitudinally fissured, dark brown to blackish when old, inner bark yellow; leaves obovate to narrowly obovate, 5–10(–15) cm × 2.5–4.5(–6) cm, cuneate to slightly decurrent at base, glabrous except for the main veins below, with 6–9 pairs of secondary veins, petiole 0.7–2.5 cm long; flowers in an axillary spike 7–10 cm long, calyx tube tomentose outside; fruit oblong, 5–7(–10) cm × 1.5–2(–2.5) cm, densely puberulous, with 2 membranous wings. *T. ivorensis* is found naturally in primary and secondary forest, both evergreen and semi-deciduous, up to 1200 m altitude. The density of the pale yellow to pale greenish-brown wood is 450–675 kg/m^3 at 12% moisture content.

Selected sources 159, 274, 346, 348, 386, 666, 681, 712.

Terminalia kaernbachii Warb.

Bot. Jahrb. Syst. 18: 201 (1893).

Synonyms *Terminalia okari* C.T. White (1922).

Vernacular names Papua New Guinea: okari (general), galip (Pidgin).

Distribution The Aru Islands, New Guinea and the Solomon Islands; introduced to Queensland (Australia).

Uses The wood is used in Papua New Guinea as red-brown terminalia, e.g. for furniture. The palatable kernels are more important, and trees are generally not harvested for timber because of their value as fruit trees.

Observations A medium-sized to fairly large tree up to 35(–45) m tall, bole usually with buttresses, bark surface grey or grey-brown, inner bark purple or mauve, brown towards the cambium; leaves obovate-elliptical to narrowly obovate-elliptical, 12–35 cm × 5–13 cm, cuneate or occasionally rounded at base, remaining tomentose on the main veins above and fulvous or rufous-tomentose especially on the veins below, with 10–18 pairs of secondary veins, petiole 1–2 cm long; flowers in an axillary spike 10–12 cm long, calyx tube fulvous-tomentulose; fruit ellipsoid, slightly flattened, 6–17.5 cm × 4–8 cm, smooth, not winged. *T. kaernbachii* locally occurs commonly but scattered in lowland rain forest and riverine forest, up to 1000 m altitude, but it is more often encountered as planted or maintained trees in secondary forest and semi-cultivated locations. The density of the red-brown wood is about 520 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 101, 145, 162, 228, 269, 718.

Terminalia katikii Coode

Contr. Herb. Austr. 2: 17, fig. 4 (1973).

Distribution New Guinea.

Uses The wood is used in Papua New Guinea as pale brown terminalia.

Observations A fairly large tree up to 40 m tall, bole often with buttresses; leaves obovate, (10–)13–17 cm × 7–9.5 cm, tapering to abruptly narrowed at base, greyish hairy, with (8–)11–14 pairs of secondary veins, petiole 1.5–2.2 cm long; flowers in an axillary spike 7–11 cm long, calyx tube densely hairy; fruit ellipsoid, not or slightly flattened, 21–27 mm × 12–14 mm, sparsely hairy, not winged. *T. katikii* is found in lowland, often swampy forest. The density of the pale brown wood is about 450 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 718.

Terminalia longespicata v. Slooten

Bijdr. Combret. Flacourt. Ned.-Ind.: 19 (1919).

Distribution New Guinea.

Uses The wood is used in Papua New Guinea as pale yellow terminalia. The fleshy part of the fruit is edible.

Observations A large tree up to 45 m tall, bole buttressed, bark surface grey-green to brown; leaves elliptical or obovate-elliptical to narrowly elliptical, 5–13 cm × 2.5–6 cm, cuneate to rounded at base, hairy on the midrib above and rufous-tomentose below, with 13–20 pairs of secondary veins, petiole 0.7–2.1 cm long; flowers in an axillary spike 5–17 cm long, calyx tube rufous-tomentose; fruit ellipsoid-ovoid, flattened, 3.5–4 cm × 2.5 cm, glabrescent, with a thick lateral margin. *T. longespicata* is divided into 2 subspecies: subsp. *sogerensis* (Baker f.) Coode (synonym: *Terminalia sogerensis* Baker f.) differing from subsp. *longespicata* (synonym: *Terminalia phaeoneura* Diels) by the leaves with 8–12 pairs of secondary veins and the ellipsoid-ovoid to slightly depressed circular fruits, and confined to Papua New Guinea. *T. longespicata* is found in lowland forest, along rivers and in swampy locations, at low altitude. The density of the pale yellow wood is 410–630 kg/m^3 at 15% moisture content.

Selected sources 101, 145, 162, 474, 718.

Terminalia macadamii Exell

Blumea 7: 324 (1953).

Distribution Papua New Guinea.

Uses In Papua New Guinea, the wood is used as pale brown terminalia.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 80 cm in diameter, often with buttresses, bark surface green; leaves elliptical to obovate, 8.5–18 cm × 3.5–12 cm, tapering at base, hairy on the midrib above and rufous-tomentulose especially on the veins below, with 9–12 pairs of secondary veins, petiole 1–3 cm long; flowers in an axillary spike 11–18 cm long, calyx tube reddish hairy; fruit oblong-ellipsoid, slightly flattened, 2.5–3.5 cm × 1.3–1.7 cm, glabrescent, obscurely longitudinally ridged when dry. *T. macadamii* is found in rain forest at low altitude. The density of the pale brown or creamy coloured wood is about 510 kg/m^3 at 12% moisture content.

Selected sources 145, 162, 718.

Terminalia megalocarpa Exell

Journ. Bot., Lond. 73: 132 (1935).

Synonyms *Terminalia solomonensis* Exell (1935) p.p.

Distribution New Guinea (not in the Bismarck Archipelago) and the Solomon Islands.

Uses The wood is used in Papua New Guinea as yellow-brown terminalia, e.g. for house construction and canoe making, also as firewood. The outer flesh of the fruit is edible, either raw or baked or roasted.

Observations A medium-sized to fairly large tree up to 40 m tall, bole branchless for up to 12 m, cylindrical; leaves elliptical or sometimes obovate, 9–18 cm × 5–9 cm, cuneate at base, glabrous, with 8–11 pairs of secondary veins, petiole 3–7 cm long; flowers in an axillary spike 10–12 cm long, calyx tube hairy; fruit ellipsoid to subglobose, 4–8 cm long, glabrous, smooth and not winged. *T. megalocarpa* is found in lowland forest; in the Solomon Islands it is often planted or preserved around villages. The density of the yellow-brown wood is about 640 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 229, 289, 718.

Terminalia microcarpa Decne.

Nouv. Ann. Mus. Hist. Nat. Paris 3: 457 (1834).

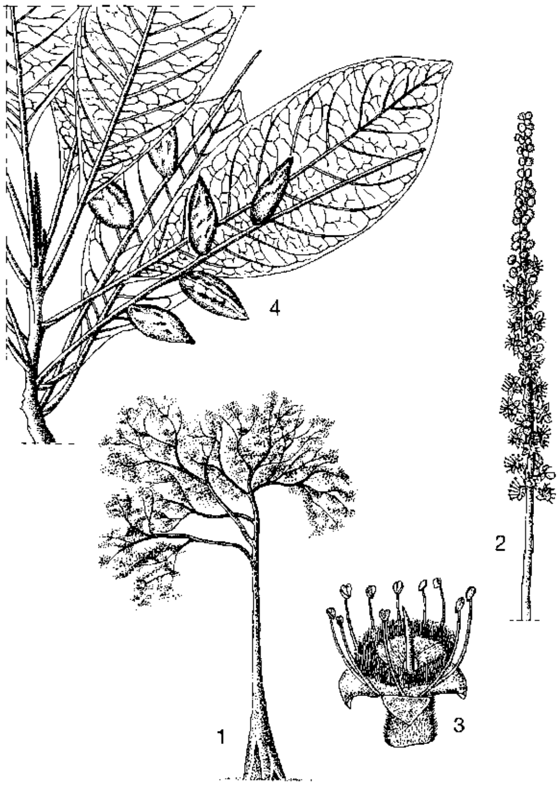
Synonyms *Terminalia edulis* Blanco (1845), *Terminalia javanica* Miq. (1855), *Terminalia hypargyrea* K. Schumann & Lauterb. (1901), *Terminalia foveolata* C.T. White & Francis ex Lane-Poole (1925).

Vernacular names Indonesia: selumpit (Javanese), kunyit-kunyit (Bali), leka sela (Sulawesi). Philippines: kalumpit (Filipino), kalamai (Tagalog), kalomagon (Bikol).

Distribution Java, Borneo, Sulawesi, Timor, the Moluccas, the Philippines, New Guinea and possibly in the Bismarck Archipelago.

Uses The wood is used in Papua New Guinea as red-brown terminalia, e.g. for interior work, beams, rafters, furniture, cabinets, flooring, and ship planking. The fleshy pericarp of the fruit is edible and also used in lotions for eyes and skin.

Observations A large tree up to 45 m tall, bole branchless for up to 20 m, up to 200 cm in diameter, with steep sometimes large buttresses, bark



Terminalia microcarpa Decne. – 1, tree habit; 2, inflorescence; 3, flower; 4, fruiting twig.

surface rugose, slightly fissured, flaking into small irregular flakes, inner bark fibrous, pale yellow; leaves broadly obovate to obovate or elliptical, 6–15(–32) cm × 2–7(–11) cm, cuneate at base, hairy above and below but glabrescent, with 7–13 pairs of secondary veins, petiole 1.5–3.5 cm long; flowers in an axillary spike 6–16 cm long, calyx tube sericeous; fruit ellipsoid to subglobose, 1.5–3 cm × 1–2.5 cm, appressed pubescent, smooth, not winged. *T. microcarpa* is divided into 2 subspecies: subsp. *incana* Coode differs from subsp. *microcarpa* by its narrowly obovate to obovate leaves which are densely and persistently greyish felty hairy. Subsp. *microcarpa* is found in primary evergreen and seasonal deciduous forest, up to 1350 m altitude. Subsp. *incana* is found in New Guinea only, where is grows in savanna woodland or monsoon forest, up to 300 m altitude. The density of the red-brown wood is 470–785 kg/m^3 at 15% moisture content.

Selected sources 77, 99, 101, 125, 162, 384, 414, 474, 505, 527, 715, 718.

Terminalia morobensis Coode

Contr. Herb. Austr. 2: 23 (1973).

Distribution New Guinea.

Uses The wood is used in Papua New Guinea as red-brown terminalia.

Observations A medium-sized tree up to 25 m tall, bole with simple buttresses up to 1 m high; leaves obovate, (15–)17–25 cm × 8–11 cm, tapering at base, sparsely hairy mainly on the veins above and densely hairy below, with 14–17 pairs of secondary veins, petiole 1.5–2 cm long; flowers in an axillary spike 8–15 cm long, calyx tube silvery hairy; fruit ovoid, flattened, (5–)5.5–6(–7) cm × 3.5 cm, with a thick obscure double ridge along the margin of the stone. *T. morobensis* is uncommon in lowland rain forest. The density of the red-brown wood is about 640 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 718.

Terminalia myriocarpa Heurck & Muell.-Arg.

Observ. bot.: 215 (1870).

Vernacular names Laos: khèo^2 nua^2, sam ta. Burma (Myanmar): ye-taukkyan. Thailand: sang (northern). Vietnam: ch[of] xanh.

Distribution India, Burma (Myanmar), Laos, Vietnam, Thailand and northern Sumatra.

Uses The wood is used e.g. for house construction.

Observations A fairly large evergreen tree up to 40 m tall, bole up to 65 cm in diameter, with low buttresses, bark surface scaly, brown; leaves opposite to subopposite, oblong to oblong-lanceolate, 8–20 cm × 2–8 cm, rounded to subcordate at base, tomentulose or appressed pubescent but glabrescent, with 16–30 pairs of secondary veins, petiole 3–7 mm long; flowers in a terminal panicle 10–20 cm long that has many spikes, calyx tube sericeous outside; fruit much wider than long, 3–4 mm × 5–7 mm, sericeous, 2-winged, occasionally a rudimentary third wing present. *T. myriocarpa* is found scattered along streams in evergreen hill forest, at 700–2000 m altitude. The density of wood samples from India is 815–865 kg/m^3 at 15% moisture content.

Selected sources 162, 163, 185, 392, 449, 648.

Terminalia nitens Presl

Abh. Kön. Böhm. Ges. Wiss. V, 6: 574 (1851).

Synonyms *Terminalia merrillii* Elmer (1915).

Vernacular names Philippines: sakat (Filipino), dalinsi (Tagalog), magtalishai (Bikol).

Distribution The Philippines.

Uses The wood is used e.g. for construction under cover, furniture and boat building. The bark yields a straw-yellow dye.

Observations A medium-sized deciduous tree up to 25 m tall, bole branchless for up to 12 m, up to 100 cm in diameter, with small buttresses, bark surface flaky, dark brown, inner bark pale yellow; leaves obovate to narrowly obovate, 7–12 cm × 3.5–6.5 cm, cuneate at base, glabrous or sometimes pubescent on the veins below, with 6–9 pairs of secondary veins, petiole 1–1.5 cm long; flowers in axillary spikes 7–10 cm long, calyx tube usually glabrous; fruit ellipsoid, 3–5 cm × 1.8–2 cm, glabrous, not winged. *T. nitens* occurs in primary forest at low and medium altitudes, often in more open locations in dipterocarp forest. The density of the pale yellow to yellow-brown wood is 670–770 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 125, 162, 384, 414, 527, 666.

Terminalia oreadum Diels

Bot. Jahrb. Syst. 57: 429 (1922).

Distribution New Guinea.

Uses The wood is reputed to be used in Papua New Guinea as pale brown terminalia.

Observations A large tree up to 50 m tall, bole with buttresses up to 2 m high, bark surface pale brown; leaves obovate to broadly or narrowly elliptical, 3–9 cm × 1–4 cm, cuneate at base, silky hairy when young but soon glabrescent, with 4–8 pairs of secondary veins, petiole 3–12 mm long; flowers in an axillary spike 5–10 cm long, calyx tube fulvous-sericeous; fruit flattened ellipsoid to oblong-ellipsoid, 2.5–3.5 cm × 1.5–2 cm, glabrescent, with 2 or sometimes 4 narrow longitudinal ridges. *T. oreadum* occurs as a conspicuous component of the mid-montane forest, at 1200–2000 m altitude. The density of the pale brown wood is about 570 kg/m^3 at 12% moisture content.

Selected sources 145, 162, 718.

Terminalia pellucida Presl

Abh. Kön. Böhm. Ges. Wiss. V, 6: 574 (1851).

Synonyms *Terminalia iwahigensis* Elmer (1913).

Vernacular names Philippines: dalinsi (Tagalog), aritongtong (Iloko), upung-upung (Samar-Leyte Bisaya).

Distribution The Philippines, including Palawan and the Sulu Archipelago.

Uses The wood is used.

Observations A medium-sized tree; leaves obovate or obovate-spatulate to narrowly obovate, 5–12 cm × 2.5–6.5 cm, cuneate at base, glabrous or appressed pubescent on the midrib below, with 8–10 pairs of secondary veins, petiole 0.5–2 cm long; flowers in an axillary spike 5–8 cm long, calyx tube glabrous; fruit ellipsoid, 2.2–4.5 cm × 1.2–2 cm, glabrous, not winged. *T. pellucida* is found in forest at low altitude. The pale brown to dark reddish-brown wood is reported to be heavier, harder and finer-textured than that of *T. microcarpa*.

Selected sources 162, 384, 414, 527.

Terminalia phellocarpa King

Journ. As. Soc. Beng. 66: 330 (1897).

Vernacular names Malaysia: jelawai mempelam babi (Peninsular).

Distribution Peninsular Malaysia and Sumatra.

Uses The wood is reputed to be used.

Observations A medium-sized to fairly large tree up to 36 m tall, bole up to 80 cm in diameter, with short buttresses, many aerial roots present, bark surface fissured and flaky, grey or greyish-brown, inner bark laminated, yellowish; leaves obovate to elliptical, 3.5–12 cm × 1.5–6 cm, cuneate to rounded at base, appressed pubescent on the main veins below but glabrescent, with 5–7 pairs of secondary veins, petiole 1–2.5 cm long; flowers in an axillary spike 3–4 cm long, calyx tube rufous-tomentulose; fruit ellipsoid or subglobose, laterally compressed, 6–7 cm × 4–5 cm, smooth, not winged. *T. phellocarpa* is locally common in seasonal and permanent swamp forest, sometimes on peat and river banks, at low altitude. The density of the yellow-brown wood is about 625 kg/m^3 at 15% moisture content.

Selected sources 104, 140, 162, 465, 705.

Terminalia polyantha Presl

Abh. Kön. Böhm. Ges. Wiss. V, 6: 574 (1851).

Synonyms *Terminalia parviflora* Presl (1851).

Vernacular names Philippines: bagiraua (Filipino), anagap (Tagalog), bangles (Iloko).

Distribution The Philippines; erroneously recorded for Indo-China (Laos).

Uses The wood is used e.g. for house construction and general construction under cover. The bark yields a dye.

Observations A small tree up to 10 m tall, bole up to 20 cm in diameter; leaves ovate to elliptical or suborbicular, 3–8 cm × 1.5–5 cm, cuneate to rounded at base, usually glabrous or sparsely pubescent, sometimes tomentose on the main veins below, with 6–8 pairs of secondary veins, petiole

5–10 mm long; flowers in an axillary and terminal panicle 3–10 cm long, calyx tube glabrous; fruit ellipsoid to suborbicular, 8–15 mm × 7–12 mm, glabrous, (2–)4(–5)-winged. *T. polyantha* is fairly common in dry thickets and secondary forest, at low and medium altitudes. The pale brown to dark reddish-brown wood is heavier and harder than that of *T. microcarpa*.

Selected sources 125, 162, 527, 666.

Terminalia rubiginosa K. Schumann

K. Schumann & Hollr., Fl. Kais. Wilh. Land: 84 (1889).

Distribution The Moluccas and New Guinea.

Uses The wood is used in Papua New Guinea as red-brown terminalia.

Observations A fairly large tree up to 40 m tall; leaves obovate to broadly obovate, 5–13 cm × 2.5–8 cm, tapering at base, glabrous above and fulvous-hairy on the veins below, with 7–13 pairs of secondary veins, petiole 4–13 mm long; flowers in an axillary spike 4–9 cm long, calyx tube rufous-tomentose; fruit ellipsoid to ovoid or subglobose, flattened, 3–5 cm × 2.5–3 cm, pubescent, with at least 2 but often 3–5 thick narrow longitudinal ridges. *T. rubiginosa* is common in primary lowland rain forest. The density of the red-brown wood is 280–560 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 162, 715, 718.

Terminalia sepicana Diels

Bot. Jahrb. Syst. 57: 429 (1922).

Distribution Yapen Island, Papua New Guinea and the Solomon Islands.

Uses The wood is used in Papua New Guinea as pale brown terminalia. The fruit is edible and yields a red dye.

Observations A large tree up to 50 m tall, bole with buttresses up to 2.5 m high, bark surface brown or grey, inner bark pink or brownish-red; leaves obovate-elliptical or elliptical to oblong-elliptical, 6–15 cm × 3–8 cm, cuneate to tapering at base, densely appressed pubescent when young but glabrescent, with 7–9 pairs of secondary veins, petiole 8–15 mm long; flowers in an axillary spike up to 4 cm long, calyx tube sericeous; fruit broadly spindle-shaped, 4–6 cm × 2.5–4.5 cm, pubescent, with (3–)4–5 distinct ridges or narrow wings when dry. *T. sepicana* is found in lowland, often swampy rain forest, at low and medium altitudes. The pale brown wood is comparatively hard and has a density of about 500 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 162, 666, 718.

Terminalia solomonensis Exell

Journ. Bot., Lond. 73: 132 (1935).

Synonyms *Terminalia papuana* Exell (1936), *Terminalia lundquistii* Exell (1953).

Vernacular names Indonesia: keari (Mimika, Irian Jaya).

Distribution New Guinea, the Bismarck Archipelago and the Solomon Islands.

Uses The wood is used in Papua New Guinea as pale brown terminalia.

Observations A large deciduous tree up to 45 m tall, bole usually with a few plank buttresses up to 4 m high, bark surface shedding in large flakes, sometimes only fissured, grey-brown or occasionally reddish; leaves narrowly elliptical to obovate-elliptical, 8–24 cm × (4.5–)6–13 cm, cuneate to tapering at base, glabrous or sometimes pubescent on the main veins below and often conspicuously verrucose on both surfaces, with 8–14 pairs of secondary veins, petiole 1.5–5 cm long; flowers in an axillary spike 5–14 cm long, calyx tube densely tomentose or sericeous; fruit ellipsoid and slightly compressed, 3.5–6 cm × 2–3.5 cm, pubescent but glabrescent, smooth or slightly 3-angled. *T. solomonensis* is generally found in lowland rain forest, but also in grassland and mid-montane forest, up to 1400 m altitude. It has been confused with *T. megalocarpa* and all references to edible fruits of *T. solomonensis* probably relate to the other species. The density of the pale brown wood is about 540 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 162, 666, 718.

Terminalia steenisiana Exell

Blumea 7: 327 (1953).

Distribution Papua New Guinea.

Uses In Papua New Guinea the wood is used as yellow-brown terminalia.

Observations A small to medium-sized tree up to 20 m tall, bark grey-brown; leaves elliptical or oblanceolate to obovate, 6–13 cm × 2.5–6 cm, cuneate to tapering at base, soon glabrescent, with 6–10 pairs of secondary veins, petiole 1–2 cm long; flowers in an axillary spike 6–8 cm long, calyx tube glabrous; fruit ellipsoid to circular, compressed, 2.5–3.5 cm × 1.5–2.5 cm, glabrous, with 2 narrow wings and sometimes with 2–3 additional longitudinal ridges. *T. steenisiana* is common in lowland scrub or monsoon forest. The density of the yellow-brown wood is about 740 kg/m^3 at 12% moisture content.

Selected sources 101, 145, 162, 718.

Terminalia subspathulata King

Journ. As. Soc. Beng. 66: 332 (1897).

Vernacular names Malaysia: jelawai jaha (Peninsular), talisei (Dusun, Sarawak), telinsi (Iban, Sarawak).

Distribution Peninsular Malaysia, Sumatra, Java and Borneo.

Uses The wood is used; *T. subspathulata* is a promising plantation species.

Observations A large to very large tree up to 60 m tall, bole branchless for a considerable length, up to 135 cm in diameter, with plank buttresses up to 9 m high, bark surface narrowly cracked and regularly flaky, pale ochreous-brown to pale grey-brown, inner bark pale lemon-yellow; leaves oblanceolate to subspatulate, 4–14 cm × 1.5–6.5 cm, glabrous, glaucous below, with (5–)8–10 pairs of secondary veins, petiole 2–5 cm long; flowers in an axillary spike 6–20 cm long, calyx tube rufous sericeous; fruit broader than long, 2–3.5 cm × 3.5–8 cm, soon glabrescent, broadly 2-winged. *T. subspathulata* is locally frequent in lowland, often swampy forest, on damp hill sides and occasionally flooded alluvium with clay-rich soils, up to 1350 m altitude. The density of the pale yellow wood is 520–795 kg/m^3 at 15% moisture content.

Selected sources 26, 77, 99, 162, 294, 464, 465, 705.

Terminalia superba Engl. & Diels

Monogr. Afr. Pflanzenfam. 4: 26, t. 14B (1900).

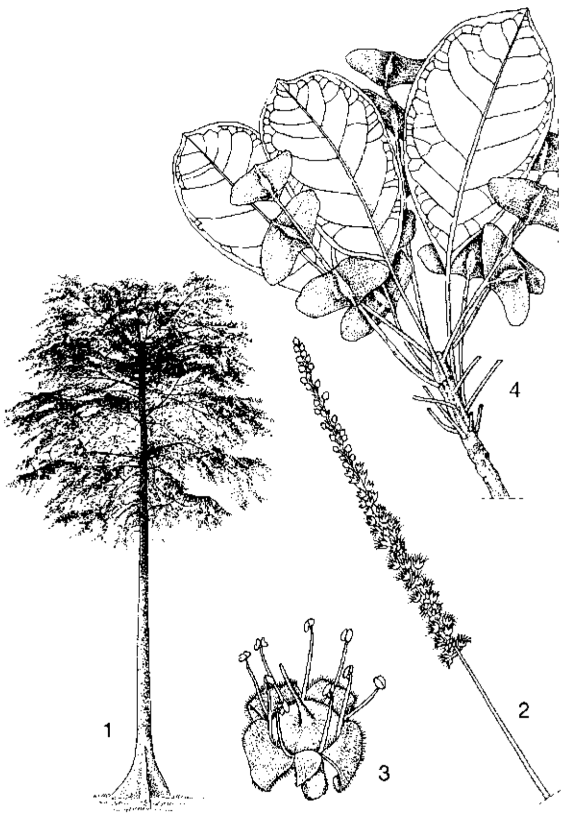
Synonyms *Terminalia altissima* A. Chev. (1909).

Vernacular names Afara, white afara (En). Korina (Am). Limba, fraké (Fr).

Distribution Native to west tropical Africa from Sierra Leone to western Congo and northern Angola (Cabinda); planted in plantations both within and outside its natural range, e.g. in South and Central America, central and east Africa, Hawaii, Fiji and the Solomon Islands. Within the Malesian region further trials exist in Sabah, Kalimantan and the Philippines.

Uses *T. superba* is an important source of timber in Africa; the wood is used mainly as core and face veneer for plywood production. It is a promising fast-growing plantation species.

Observations A large briefly deciduous tree up to 50 m tall, bole cylindrical, straight, branchless for up to 35 m, up to 120(–160) cm in diameter, with plank buttresses up to 6 m high, bark surface smooth, flaking off in small patches, greyish, inner bark yellowish; leaves obovate, (4–)6–14(–20) cm × 2.5–7(–10) cm, glabrous, cuneate at base, with (4–)6–8 pairs of secondary veins, petiole (1.5–)3–5(–7) cm long; flowers in an axillary spike 7–20 cm long, calyx tube tomentose; fruit broader than long, 1.5–2.5 cm × 4–7 cm, glabrous, broadly 2-winged. *T. superba* demands light and grows gregariously in semi-deciduous or evergreen, usually secondary forest and in clearings, up to 1000 m altitude. The sapwood is pale brown, the heartwood dark brown. The density of the wood is 480–650 kg/m^3 at 12% moisture content.



Terminalia superba Engl. & Diels – 1, tree habit; 2, inflorescence; 3, flower; 4, fruiting twig.

Selected sources 159, 210, 348, 359, 375, 386, 666, 681.

Terminalia supitiana Koord.

Versl. Minahasa: 454, 623 (1898).

Vernacular names Indonesia: anjurung, kanjuruang cata, teluse (Sulawesi).

Distribution Northern and central Sulawesi.

Uses The wood is reputed to be used.

Observations A large tree up to 50 m tall; leaves narrowly elliptical, 3–15 cm × 1.2–5 cm, cuneate and decurrent at base, glabrous or sparsely pubescent, with 9–11 pairs of secondary veins, petiole 5–10 mm long; flowers in an axillary spike 3–5 cm long, calyx tube glabrous; fruit ellipsoid, 4–5.5 cm × 2–2.5 cm, glabrous, 2-winged with the wings confluent at base and apex. *T. supitiana* is found in mixed primary forest, up to 500 m altitude. The density of the wood is 620–650 kg/m³ at 15% moisture content.

Selected sources 162, 474.

Terminalia triptera Stapf

Kew Bull.: 103 (1895).

Synonyms *Terminalia obliqua* Craib (1912), *Terminalia tripteroides* Craib (1912), *Terminalia nigrovenulosa* Pierre ex Gagnep. (1916).

Vernacular names Malaysia: jelawai (Peninsular). Burma (Myanmar): than-bo. Cambodia: soy nhi, khseau, prèah' phnoe ou. Laos: 'sêng kham. Thailand: puchao (northern), kamcham (peninsular), khi-ai (central). Vietnam: chi[ee]u li[ee]u, c[aa]y g[aw]n.

Distribution Burma (Myanmar), Indo-China, Hainan, Thailand and Peninsular Malaysia.

Uses The wood is used e.g. for construction, furniture and tool handles. The bark is used locally in Thailand to chew with betel nut and also used medicinally against dysentery.

Observations A small to medium-sized tree up to 30 m tall, bole up to 50 cm in diameter, with small buttresses, bark surface smooth, brownish with shallow longitudinal streaks; leaves opposite to alternate, broadly ovate to elliptical or obovate, 3–12 cm × 1.5–6 cm, rounded to cuneate at base, glabrous or sparsely pubescent below, with 6–8 pairs of secondary veins, petiole 0.5–2 cm long; flowers in an axillary and terminal panicle 2.5–7 cm long, calyx tube glabrous; fruit oblong, 1–3.3 cm × 0.6–1.8 cm, practically glabrous, 3-winged. *T. triptera* is fairly common in mixed deciduous and dry evergreen forest, on limestone, quartzite or shale, up to 100 m altitude.

Selected sources 162, 163, 449, 666, 705.

M.S.M. Sosef (general part, selection of species),
E. Boer (general part),
W.G. Keating (properties),
S. Sudo (wood anatomy),
L. Phuphathanaphong (selection of species)

Toona (Endl.) M.J. Roemer

Fam. nat. syn. monogr. 1: 131, 139 (1846).

MELIACEAE

$x = 13, 14, 23$; *T. ciliata*: $2n = 52, 56, 78$, *T. sinensis*: $2n = 46, 52, 56$

Trade groups Surian: lightweight hardwood, e.g. *Toona ciliata* M.J. Roemer, *T. sinensis* (Adr. Juss.) M.J. Roemer, *T. sureni* (Blume) Merr.

The name surian is also used for the wood of other *Meliaceae* genera such as *Aglaia* and *Chukrasia*, and sometimes also for *Anacardiaceae* (e.g. *Parishia*, *Spondias*) and *Burseraceae* (e.g. *Santiria*).

Vernacular names Surian: toon (general). Indonesia: suren (general). Papua New Guinea: red cedar. Philippines: kalantas (general). Burma (Myanmar): thitkado. Cambodia: chomcha. Thailand: yom-hom (general). Vietnam: l[as]t kh[es]t.

Origin and geographic distribution *Toona* consists of 4 or possibly 5 species and is distributed from Pakistan and China to Australia, and occurs widely throughout Malesia, where 3 or 4 species are found. Fossil records from France, Bulgaria, Japan and India show that the area of distribution used to be much larger. Some species are widely cultivated in the tropics for timber or as ornamentals.

Uses Surian is considered a valuable timber tree, yielding comparatively soft, fragrant wood which is easy to work. The timber is highly prized and seriously overexploited, first in Australia where it once was the most important native timber. Nowadays it is also heavely exploited in many areas in South-East Asia. It is used for light construction work, furniture, joinery, cabinet work, tea-chests, decorative panelling, ceiling boards, packing cases, cigar boxes, ornamental boxes, bent work, boat and canoe building, paddles, oars, piano cases, musical instruments, face veneer, plywood, carving and sculpture.

The wood is used for shiitake mushroom culture. Surian trees may also be planted for ornamental purposes e.g. in roadside plantings, as firebreaks and for reforestation. The leaves are used locally as a vegetable and forage. Some extracts from the bark and the leaves have insect-repellent properties. The bark and leaves are used in traditional medicine. The bark contains tannin which may be used in the preparation of leather, and has been traditionally used for twines and the manufacture of string bags. The flowers are used in India to prepare a red or yellow dye. An aromatic oil can be extracted from the fruits.

Production and international trade Japan imports small amounts of surian from Sabah, Sarawak and Papua New Guinea. *T. calantas* timber is important in the Philippines: in 1981 about 6000 m^3 of sawn timber was exported with a value of US$ 708 000, and in 1987 about 4650 m^3 with a value of US$ 671 000 (US$ 144/m^3).

Properties Surian is a lightweight and comparatively soft wood. The heartwood is pale red to reddish-brown, darkening to dark red-brown on exposure, clearly demarcated from the grey-white, pink or pale red sapwood. The density is 270–530(–670) kg/m^3 at 15% moisture content. The grain is straight to interlocked, sometimes wavy, texture rather coarse and uneven. The wood often has an aromatic cedar-like odour.

At 15% moisture content, the modulus of rupture is 42–85 N/mm^2, modulus of elasticity 7115–10 700 N/mm^2, compression parallel to grain 21.5–45 N/mm^2, compression perpendicular to grain 2–7 N/mm^2, shear 3–9 N/mm^2, cleavage 32–43 N/mm radial and 36–51 N/mm tangential, Janka side hardness 1215–3960 N and Janka end hardness 2585–4605 N.

The rates of shrinkage are moderate to fairly high: from green to 12% moisture content 1.1–4.0% radial and 2.6–7.0% tangential, and from green to oven dry 2.1–5.0% radial and 3.6–8.2% tangential. In Malaysia surian timber is reported to dry rapidly, with only slight warping. However, elsewhere it is reported that the timber is somewhat refractory in drying and prone to warping, collapsing and cupping, particularly in thin planks. Close spacing of stickers and weighting of stacks is recommended. Boards 25 mm thick take 1–3.5 months to air dry. In Malaysia, kiln schedule J is recommended; boards 25 mm thick can be kiln dried from 50% to 10% moisture content in 3–6 days without any degrade.

The wood is easy to saw, cross-cut and plane and the planed surface is smooth; it takes a good polish. Some material tends to produce a woolly finish and it is therefore essential to use sharp tools. Mortising, turning and sanding give moderate results, but boring sometimes gives poor results. The gluing and nailing properties are rated as good, but the nail-holding power is moderate. The timber peels well and produces good-class veneer with a nice figure. It can be peeled into 1.5 mm thick veneer at a 90° peeling angle without pretreatment. Sometimes logs are liable to lateral and end splitting which may result in the veneer breaking during peeling. Surian veneer glued with urea-formaldehyde produces plywood complying with the German standard.

In Malaysia, surian wood is rated as non-durable. Reports from elsewhere indicate that the heartwood is moderately durable but susceptible to drywood termite and borer attack. The heartwood is resistant to impregnation with preservatives or may show an unsatisfactory penetration pattern, but the sapwood is permeable. Wood dust may irritate the mucous membranes or induce bronchitis or dermatitis.

Wood of *T. sureni* contains 61% cellulose, 27% lignin, 11.5% pentosan, 0.8% ash and 0.5% silica. The solubility is 2.3% in alcohol-benzene, 3.0% in cold water, 6.5% in hot water and 10.2% in a 1% NaOH solution. The energy value of the wood is about 21 870 kJ/kg.

Description Monoecious, deciduous or semi-evergreen, medium-sized to fairly large trees up to 40(–60) m tall; bole branchless for 25 m or sometimes more, buttresses absent or small, up to 1.5 m high; bark surface usually fissured, sometimes flaky, and of varying colour, but most often greyish-brown, bark with a strong aromatic or offensive smell, slash varying in colour from pink to dark red; crown usually umbrella-shaped and of moderate density, with long and straight branches. Leaves large and pinnate, arranged spirally, often clustered at the ends of twigs, usually paripinnate, but sometimes with terminal leaflet, without stipules; leaflets subopposite or arranged alternately, entire, serrate or dentate, with 10–20 pairs of secondary veins, usually only slightly pubescent on the veins, often with club-shaped glands and domatia. Inflorescence in leaf axils at the apex of branchlets, paniculate, much-branched and pendulous, with cymose ultimate ramifications. Flowers small, 5(–6)-merous, functionally unisexual, terminal flower of a cymule generally female, other two flowers male, dull white, greenish-white to pale yellow or pink, strongly smelling; calyx small, sepals free or united at base; petals free, much longer than calyx, imbricate in bud, usually thick and fleshy, spreading; disk prominent, cushion-shaped; stamens 5, sometimes alternating with staminodes, free, anthers dehiscent throughout their length and introrse; ovary superior, (4–)5-locular, with 6–10 anatropous ovules arranged in 2 rows in each locule, style 1, short, with fleshy and discoid stigma on top. Fruit a pendulous, ellipsoid or obovoid capsule, membranaceous to thinly woody, with central columella, dehiscing by 5 valves from apex to base. Seed numerous, winged at both ends or only at upper end; cotyledons foliaceous, endosperm thin, radicle laterally exserted. Seedling with epigeal, phanerocotylar germination, first leaves opposite and trifoliolate with lobed or dentate leaflets.

Wood anatomy

– Macroscopic characters:

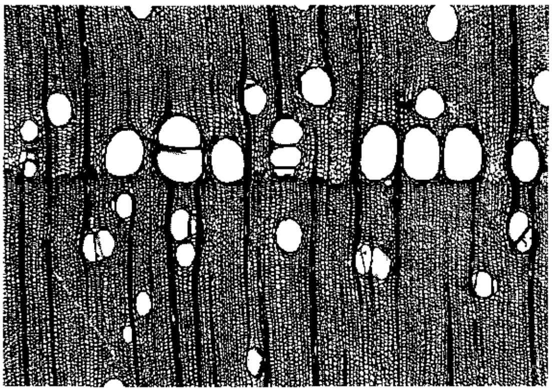
Heartwood pale red to reddish-brown, darkening to dark red-brown on exposure, clearly demarcated from the greyish-white, pink or pinkish-red sapwood. Grain straight, interlocked or sometimes wavy. Texture rather coarse and uneven; prominent growth ring figure present on flat-sawn surfaces; wood somewhat lustrous, feeling dry, fragrant with cedar-like scent, with characteristic acrid taste. Growth rings distinct, delimited by a zone of large earlywood vessels, visible to the naked eye; vessel lines conspicuous on longitudinal surfaces, deposits of reddish-brown gum common, tyloses absent; parenchyma vasicentric and terminal, the vasicentric parenchyma inconspicuous, the terminal distinct; rays of one kind, visible to the naked eye; ripple marks absent; axial intercellular canals of the traumatic type occasionally present.

– Microscopic characters:

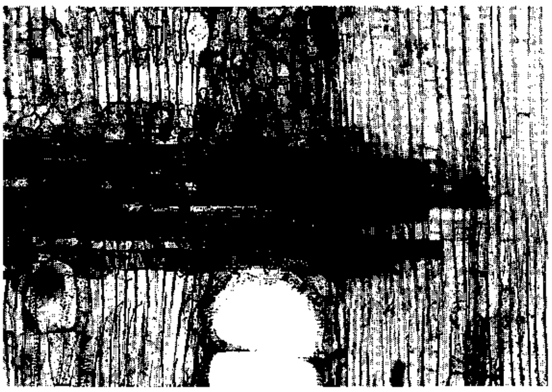
Growth rings distinct. Wood ring-porous. Vessels 20–30/mm^2 in the latewood zone and (8–)9–12 (–15)/mm^2 in the earlywood zone, solitary and in radial multiples of 2–3(–4), generally round to oval, average tangential diameter of earlywood vessels (300–)470–480 µm, of latewood vessels 55–130 µm; perforations simple; intervessel pits alternate, with coalescent apertures, (3–)5–8 µm in diameter; vessel-ray and vessel-parenchyma pits similar but half-bordered; reddish-brown deposits frequent, chalky deposits occasionally present; tyloses scarce to absent. Fibres 0.4–1.4(–1.9) mm long, non-septate, thin-walled to moderately thick-walled, with minute simple to narrowly bordered pits mainly confined to the radial walls. Parenchyma both apotracheal and paratracheal; apotracheal parenchyma mainly confined to the ring boundary and appearing as terminal bands of 4 or more cells wide, strand length 3–6(–8) cells; paratracheal parenchyma vasicentric as narrow borders to the vessels. Rays (3–)4–8(–14)/mm, (1–)2–4(–5)-seriate, up to 0.5 mm high, heterocellular with 1–4 rows of square to upright marginal cells. Silica bodies absent. Axial intercellular canals of the traumatic type occasionally present.

Species studied: *T. ciliata*, *T. sinensis*, *T. sureni*.

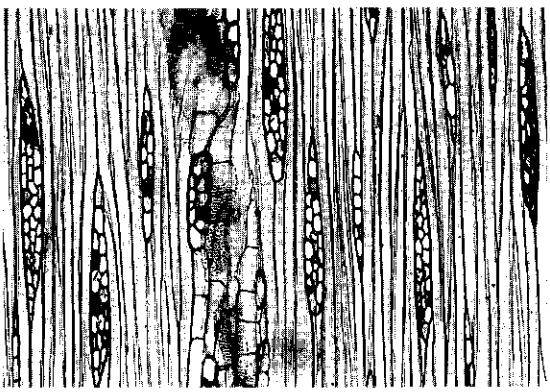
Growth and development The development of seedlings is rather slow during the first year (up to 30 cm tall), but the mean annual diameter increment is 0.8–1.8(–2.5) cm in *T. ciliata* plantations of up to 22 years old, with mean annual



transverse section (×25)



radial section (×75)



tangential section (×75)

Toona ciliata

height increment of 0.9–1.4(–1.8) m. In two plantations of *T. sureni* in Java of 14 and 17 years old, mean annual diameter increment was 1.4 cm and 1.2 cm and mean annual height increment 1.5 m and 1.2 m, respectively. The mean annual height increment of a 7-year-old plantation of *T. sinensis* was 1 m. In Peninsular Malaysia, *T. sureni* grows considerably faster than *T. sinensis*. *T. ciliata* planted in Africa had an average height of 35 m and an average diameter of 70 cm at the age of 40 years.

In areas with a marked dry season all the foliage is shed for a part of the year. The flowers are functionally unisexual, but usually with well-formed vestiges of the opposite sex present. In female flowers the anthers do not open and are shrivelled, in male flowers the ovary has vestigial ovules. Fruit bearing is irregular and for *T. calantas* in the Philippines there may be at least four years between consecutive fruiting years. In Java, *T. sureni* flowers in May and bears fruits from July to October and in the Philippines *T. calantas* flowers in March and fruits mature in January–February. *T. ciliata* is reported to bear ripe fruits almost throughout the year.

Other botanical information There used to be much confusion about the distinction of the genera *Cedrela* (from the New World) and *Toona* (from the Old World). *Cedrela* differs from *Toona* because of the presence of a prominent androgynophore with petals and filaments adnate to it, a cup-like calyx, bigger and more woody fruits and seedlings having entire leaflets.

Toona species are extremely variable, especially in leaf characteristics. This has resulted in a complex taxonomy at the intraspecific level; many subspecies and varieties have been described for all Malesian species. *T. calantas* from the Philippines is possibly no more than a geographical variant of *T. ciliata* or *T. sureni*; its correct taxonomic status has yet to be determined.

Ecology The various species of surian occur from sea-level up to 3000 m altitude, in South-East Asia up to 2000 m. The trees occur scattered in primary forest, but they are usually more numerous in secondary forest. They are generally found on deep, rich, moist, loamy soils with good drainage, the majority of the species preferring alkaline soils.

T. ciliata thrives in regions with annual rainfall as high as 4000 mm, while it is found naturally in areas with annual rainfall of 800–1800 mm. It prefers well-drained, deep, fertile soils, but it avoids both wet, compacted soils and poor sandy soils. *T. sureni* demands fertile and moist soils.

Propagation and planting For South-East Asia the following seed counts per kg are reported: for *T. calantas* 83 000–420 000, for *T. ciliata* 280 000–425 000, for *T. sinensis* 403 000–721 000, and for *T. sureni* 64 000–468 000. In India, seed counts are most variable and seeds appear to be slightly heavier. Fruits should be collected when they start to open. They are left to dry in the sun for several days and, after shelling, seed may be separated by winnowing. Fresh seed of *T. ciliata* shows 60–90% germination in 8–12 days; about 80% of seed of *T. sinensis* stored for two months germinates, but about 45% of seed of *T. sureni* stored for three months germinates. Seed usually retains its viability for only 2–3 months (3–6 months for *T. calantas* in the Philippines), but cool storage can increase this period; seed of *T. ciliata* kept in sealed tins at 4–5°C remained viable for one year. In the Philippines, there is 100% germination of fresh seed of *T. calantas*, but when stored for one month germination was 85% and when stored for two months 47%; when stored at 10–15°C, germination was still 51% after 16 months. Seed can be sown without any pretreatment in beds protected from direct sunlight and rain and covered thinly with fine sand. Two to four weeks after germination the 5–10 cm tall seedlings may be transplanted. Direct seeding is uncommon, as seed may easily be washed away.

Striplings of at least 1 m tall, short stumps (7 cm shoot and 25 cm root), bare-rooted seedlings or seedlings with soil clump may be used for planting. Stumps of 1.5–2.5 cm diameter performed better than those with a diameter of 0.5–1.25 cm. For enrichment line planting of depleted primary forest or poor secondary stands, 1.5–2-year old stumps are used. A 60% rooting was obtained using stem cuttings from 2–4-year-old material of *T. sureni* treated with indolebutyric acid (IBA) and placed in a sawdust medium. Branch cuttings taken from old *T. calantas* trees and planted in nursery beds failed to sprout. Both *T. sinensis* and *T. ciliata* produce root suckers abundantly and they both coppice fairly well.

Spacings most commonly reported are 2 m × 2 m for *T. ciliata* and 1.5 m × 1.5 m for *T. sureni*. In Africa, 4–6 m x 4–6 m is used for *T. ciliata* and in Costa Rica 2–2.5 m × 2–2.5 m. In Hawaii, a spacing trial conducted for *T. ciliata* resulted in the recommended spacing of 2.7 m × 2.7 m. *T. sinensis* may be spaced more closely than the other *Toona* species as the trees develop only small and open crowns.

Because of the danger of *Hypsipyla robusta* attack, it is not recommended to establish pure plantations of surian.

Silviculture and management Natural regeneration of *T. sinensis* is abundant, especially on the sides of ravines where moisture is readily available. Natural regeneration of *T. ciliata* may be abundant in well drained locations free from weed competition, although the very small seeds may be washed away and the young seedlings beaten down by rain. Natural regeneration may be profuse, even in areas outside its natural range.

In the first year weeding is important in plantations of *T. ciliata*. Young surian trees tolerate light shade, but later they need full overhead light and enough crown space. Trees develop best when there is lateral shade. Young plants are susceptible to browsing by game and livestock. Surian is sensitive to fire.

Recommended rotations for surian range from 40–50 years. After 40 years the growth of *T. ciliata* in plantations in Africa is seriously declining. *T. ciliata* trees planted on former skid roads in Hawaii showed significantly reduced growth and a lower survival after only 8 years.

In West Java, surian is being grown in plantations of *Paraserianthes falcataria* (L.) Nielsen to control stem-borer attacks. Results are promising. In a plantation of surian, leaves can be harvested as a vegetable and fodder after 6 months. After 1 year a second thinning is recommended which yields another harvest of fodder. Subsequent thinnings can be used for the production of poles. After the fifth year, bark and fruit can be utilized for the production of aromatic oil.

Diseases and pests *T. ciliata* is attacked by some fungi, the most important of which are: *Ganoderma lucidum* causing root and butt rot, which may be lethal, *Phellinus* spp. causing white rot of fallen timber or gaining access through wounds exposing dead sapwood and *Trametes straminea* (white stringy rot) usually saprophytic but also a wound parasite causing trunk rot.

The most serious pest is the shoot borer *Hypsipyla robusta*, which is a pest of most *Meliaceae*. Main damage is caused by the larvae, which destroy the succulent terminal shoots by boring into the tip and tunnelling in the juvenile stem of saplings and seedlings. Resprouting of the plants, followed by repeated attacks of the insect, generally results in the development of numerous side branches and consequently in badly formed trees with multiple leaders, unsuitable for timber production. *Hypsipyla robusta* may also cause considerable losses of surian seed.

There is some evidence that *Hypsipyla* attack is reduced by planting under shade, possibly because of suppression of lateral shoots which provide the best conditions for its multiplication or because predators are more active under shaded conditions. *T. ciliata* can be planted in pure plantations in Latin America, as it is not attacked by the native *Hypsipyla grandella*. When *Cedrela odorata* L., which is highly susceptible to this shoot borer, is grafted on *T. ciliata* it becomes resistant. Differences in susceptibility of *T. ciliata* are recorded in Australia. The presence of a toxic compound in *T. ciliata* is promising for the breeding of *Hypsipyla* resistant *Meliaceae*.

Yield Plantations of *T. ciliata* are reported to have a mean annual increment of 7–18 m^3/ha. A saw log volume of 395 m^3/ha has been estimated in a 43-year-old trial plantation in Hawaii.

Handling after harvest Fresh logs should be removed immediately from the felling site, as they may readily be attacked by borers and termites.

Genetic resources *T. calantas* is disappearing rapidly from the Philippine forests, where it is reported to be a vanishing timber tree, just like *T. sureni*. Hence, there is an urgent need for the conservation of both species in the Philippines. Elsewhere, stands of surian are also threatened locally because the trees are largely selectively harvested for their valuable timber.

Breeding *T. ciliata* is known to have intraspecific chromosome races based on aneuploidy. There may be a correlation between rate of growth, form and wood quality, and ploidy level, and intensified selection and breeding programmes for this species may result in superior trees for timber plantations. A breeding programme for *T. ciliata* started in Malawi in the late 1960s.

Prospects Surian species provide good-quality timber which can be used for various purposes. Moreover they grow fast and are easy to propagate vegetatively. Surian species, therefore, are worth including in silvicultural trials. They may also have great potential for use in mixed timber plantations to suppress pests of other timber species. The widespread planting of surian for multipurpose uses should be encouraged.

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Selection of species

Toona calantas Merr. & Rolfe

Philipp. Journ. Sci., Bot. 3: 105 (1908).

Synonyms *Toona paucijuga* Merr. (1912), Cedrela calantas (Merr. & Rolfe) Burkill (1930).

Vernacular names Philippines: kalantas (general), danupra (Iloko).

Distribution Throughout the Philippines.

Uses The timber is used as surian, especially for furniture, musical instruments, cigar boxes and plywood. The wood is suitable for shiitake mushroom culture, and may be applied as an aromatic wood for its pleasant cedar smell. Decoctions of bark and flowers are used in local medicine because of their astringent, antiseptic and antispasmodic properties.

Observations A medium-sized tree up to 25 m tall, with terete and straight bole branchless for up to 20 m and up to 100(–150) cm in diameter, buttresses not prominent; leaflets entire, glabrescent above; petals glabrous; fruit comparatively large, (2–)3–4 cm long, valves with numerous lenticels often smaller and denser towards the base of the fruit; seed unequally winged at both ends. *T. calantas* occurs scattered in primary rain forest at low and medium altitudes. The stands have been depleted by logging and shifting cultivation. The correct taxonomic status is uncertain; possibly it is a large-fruited geographical variant of *T. sureni* or *T. ciliata*, although it may be a distinct species. It probably also occurs outside the Philippines. The density of the wood is about 430 kg/m^3 at 15% moisture content.

Selected sources 78, 124, 125, 146, 257, 414, 426, 527, 626, 738.

Toona ciliata M.J. Roemer

Fam. nat. syn. monogr. 1: 139 (1846).

Synonyms *Cedrela toona* Roxb. ex Rottler & Willd. (1803), *Toona australis* Harms (1896), *Toona microcarpa* (C.DC.) Harms (1896), *Toona ternatensis* (Miq.) Bahadur (1988).

Vernacular names Indian mahogany, Indian toon, Burma toon, Australian toon, Australian red cedar (general). Indonesia: suren kapar, suren mal (Java), malapoga (Sulawesi), kukoru (Moluccas). Malaysia: surian limpaga, ranggoh (Sabah). Philippines: danupra (Iloko). Burma (Myanmar): taung-tama, taw thamgo, thit kador. Laos: mai-yom-horm. Thailand: yom-hom (general).

Distribution Pakistan, Nepal, India, Bangladesh, southern China, Indo-China, Thailand, throughout Malesia and northern Australia. The tree is nowadays much cultivated for its timber and as an ornamental or wayside tree throughout the tropics.

Uses The timber is used in house and ship building, for high grade furniture, carvings, tea chests and boxes, musical instruments and pencils. The flowers yield a red or yellow dye which is used to colour silk. Various parts of the plant, but especially the bark, are used medicinally, e.g. as astringent and tonic, to treat dysentery and to heal wounds.

Observations A medium-sized to fairly large tree up to 35(–50) m tall, with bole branchless for up to 24 m and up to 70(–150) cm in diameter, buttressed up to 3.5 m high or without buttresses, bark surface usually fissured and flaky, greyish-white to reddish-brown, bark with aromatic odour when cut; leaflets entire, glabrescent above; petal margins, ovary and disk hairy, style glabrous; columella of fruit concave with apical scarring, fruit valves smooth to minutely lenticellate; seed winged at both ends, wings unequal. *T. ciliata* occurs in primary and secondary rain forest, often along rivers and in valleys, up to 1500 m altitude, rarely higher. The density of the wood is 330–600 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 38, 111, 146, 155, 195, 208, 209, 289, 348, 371, 487, 521, 526, 679, 707, 719.

Toona sinensis (Adr. Juss.) M.J. Roemer

Fam. nat. syn. monogr. 1: 139 (1846).

Synonyms *Cedrela sinensis* Adr. Juss. (1830), *Cedrela serrata* Royle (1839), *Toona serrata* (Royle) M.J. Roemer (1846), *Toona serrulata* (Miq.) Harms (1896).

Vernacular names Indonesia: suren (general), ingul (Sumatra). Malaysia: surian bawang, surian wangi (Peninsular), rangau (Sabah).

Distribution Nepal, India, Burma (Myanmar), China, Thailand, Peninsular Malaysia, Sumatra, Java and Borneo (Sabah); planted as shade and wayside tree in India, Sri Lanka and Europe.

Uses The timber is used for construction, furniture and implements. The leaves serve as a vegetable and as fodder. Various parts of the plant, especially the bark and roots, are used medicinally. The tree is also planted for shade and as an avenue tree.

Observations A medium-sized to fairly large tree up to 40 m tall, with bole branchless for up to 20 m and up to 100 cm in diameter, bark surface fissured, greyish-brown to dark brown, bark with obnoxiously pungent odour when cut; leaflets serrate or dentate, rarely entire, glabrescent above or hairy on veins; petal margins, ovary and disk glabrous; columella of fruit convex without apical scarring, fruit valves smooth to minutely lenticellate; seed winged at one end. *T. sinensis* occurs at 350–2500 m altitude, usually in primary montane forest, often near streams, but also in secondary forest. The density of wood from India is about 450 kg/m^3 at 12% moisture content. See also the table on wood properties.

Selected sources 36, 38, 63, 140, 146, 195, 218, 331, 386, 526, 705.

Toona sureni (Blume) Merr.

Interpr. Herb. amboin.: 305 (1917).

Synonyms *Cedrela febrifuga* Blume (1823), *Toona febrifuga* (Blume) M.J. Roemer (1846), *Cedrela sureni* (Blume) Burkill (1930).

Vernacular names Indonesia: suren (general), serijan, surian amba (Sumatra). Malaysia: surian wangi (Peninsular). Philippines: danupra (general). Burma (Myanmar): ye tama. Thailand: surian.

Distribution Nepal, India, Bhutan, Burma (Myanmar), Indo-China, southern China, Thailand and throughout Malesia to western New Guinea.

Uses The timber is used as surian, e.g. in house building and for utensils. Various parts of the plant, especially the bark, are used in local medicine, as astringent and tonic and to treat diarrhoea; leaf extracts are reported to have antibiotic activity.

Observations A medium-sized to fairly large tree up to 40(–60) m tall, with bole branchless for up to 25 m and up to 100 cm in diameter, in mountainous areas up to 300 cm in diameter, buttress-

Toona sureni (Blume) Merr. – 1, tree habit; 2, flowering twig; 3, sectioned flower; 4, infructescence; 5, seed.

es, if present up to 2 m high, bark surface usually fissured and flaky, whitish, greyish-brown or pale brown, with aromatic odour when cut; leaflets entire, usually hairy on veins above; petal margins, ovary and disk hairy; columella of fruit concave with apical scarring, fruit valves rough and verrucose with conspicuous lenticels; seed winged at both ends. *T. sureni* occurs in primary forest but is more common in secondary forest, often on riparian hillsides and slopes, up to 1700(–2100) m altitude. Locally in Papua New Guinea it can make up up to 6% of the gross volume of the natural forest. In Sulawesi, a large-fruited geographical variant is found, described as *Cedrela celebica* Koord.; perhaps this is a distinct geographical taxon. The density of the wood is 270–670 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 36, 38, 60, 63, 77, 125, 146, 155, 201, 218, 261, 289, 403, 415, 426, 482, 623, 679, 705.

A.N. Gintings (general part),
E. Boer (general part),
S.C. Lim (properties, wood anatomy),
R.H.M.J. Lemmens (selection of species)

Triomma Hook.f.

Trans. Linn. Soc. Lond. 23: 171 (1860).
BURSERACEAE
x = unknown; $2n$ = unknown

Trade groups Kedondong: lightweight to medium-weight hardwood, a single species, *Triomma malaccensis* Hook.f., Trans. Linn. Soc. Lond. 23: 171 (1860), synonyms: *Canarium mahassan* Miq. (1861), *Triomma macrocarpa* Backer ex Thorenaar (1926).

Kedondong is the standard trade name for all timber of the family *Burseraceae*, hence including next to *Triomma* also the timber of *Canarium*, *Dacryodes*, *Garuga*, *Protium*, *Santiria* and *Scutinanthe*. *Triomma* is among the more important sources of kedondong.

Vernacular names Indonesia: resung (Langkat, Sumatra), bayung (Palembang, Sumatra), ranggarai (Balikpapan, Kalimantan). Malaysia: kedondong kijai (Peninsular), kedondong asam (Sabah), seladah (Sarawak).

Origin and geographic distribution *Triomma* is a monotypic genus occurring in Peninsular Malaysia, Sumatra, Bangka and Borneo.

Uses The timber is rather soft and is used for construction under cover, planking, doors, window frames, flooring, furniture, cladding, plywood, particle board, packing cases and pallets. The timber may be suitable for rotary veneer.

The resin may be tapped and used for torches as a combustible; it is aromatic.

Production and international trade Kedondong kijai is traded in Malaysia and is amongst the 10 most important species of kedondong. *Triomma* timber is usually not traded separately but mixed with the timber of other *Burseraceae* genera and sold as kedondong. In 1983, 16350 m^3 of kedondong sawlogs with a total value of US$ 675000 was exported from Peninsular Malaysia (69% to Singapore, 19% to South Korea and 12% to Hong Kong), and in 1984 the export was 9500 m^3 (99% to Singapore and 1% to Japan) with a value of US$ 395000 (US$ 42/m^3). The export of round logs from Sabah was only 1170 m^3 with a value of US$ 75000 (US$ 64/m^3) in 1987, but in 1992 the export of kedondong timber from Sabah was much more: 15000 m^3 (17% as sawn timber, 83% as logs) with a total value of US$ 1.3 million (US$ 170/m^3 for sawn timber and US$ 69/m^3 for logs).

Properties *Triomma* wood is lightweight to medium-weight and moderately soft. The heartwood is brown and not distinctly demarcated from the paler sapwood. The density is 590–850 kg/m^3 at 15% moisture content. The grain is straight to shallowly interlocked, texture moderately coarse and even. Planed surfaces are slightly lustrous.

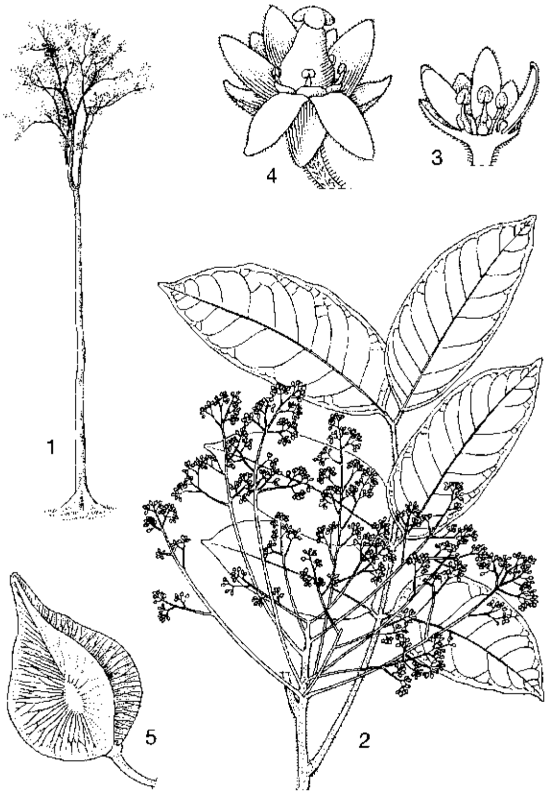
No specific tests on mechanical properties are available, and a general description of kedondong wood is given here.

The rates of shrinkage are moderate. The timber generally air dries well. Kiln-drying schedule J is recommended in Malaysia for kiln drying.

Kedondong wood is often moderately difficult to resaw and cross cut. However, *Triomma* wood contains little or no silica, which makes sawing easier. Planing gives a moderately smooth finish. Usually the wood bores, turns, nails and glues well, and it is easy to rotary peel and produces a good tight veneer. Brittle heart may cause some problems during peeling. Kedondong is likely to be suitable for fibreboard and particle board.

The wood is rated as non-durable in exposed conditions or in contact with the ground. It is readily attacked by fungi and termites, and blue staining can be a serious problem. The sapwood is very susceptible to powder-post beetle attack. The heartwood is resistant to preservative treatment, but the sapwood is more permeable.

Description A dioecious, evergreen, large to very large tree up to 60 m tall; bole branchless for a considerable length, up to 100(–115) cm in diameter, with broad buttresses up to 3 m high; bark surface smooth to slightly scaly or dippled, with few lenticels, greenish-grey or brown, inner bark pink or reddish-brown, exuding a little strongly aromatic, white, pale yellow, or pale red resin; pith of twigs without vascular strands. Leaves arranged spirally, imparipinnate, with (3–)5–11 opposite entire leaflets; rachis glabrous to pilose; stipules absent; leaflets ovate to oblong, (2–)4–15.5 cm × (1–)2–5.5(–6.5) cm, base asymmetrical, apex short-bluntly acuminate, with 7–12 pairs of secondary veins, midrib raised above, secondary and tertiary venation conspicuous on both surfaces. Inflorescence axillary, together pseudoterminal, paniculate, densely tomentose. Flowers actinomorphic, 5-merous, male ones 2 mm long, female ones 3 mm long; sepals and petals free, tomentose on both sides; disk 5-lobed, extrastaminal; stamens 5, episepalous, base of filaments adnate to disk; ovary superior, 3-celled, triangular, glabrous, each cell with 1 ovule, stigma sessile. Fruit a dry capsule, broadly ovoid, 5.5–7.5 cm × 3–5 cm, 3-winged, dehiscing with 3 woody valves; calyx caducous in fruit. Seed enclosed by endocarp ('pyrene'), with broad membranous wings, rounded at base, acuminate at apex, 1–2 cm; cotyledons folded, shallowly 5-lobed. Seedling with epigeal germination; leaves arranged spirally from the beginning, first few leaves simple, subsequent leaves imparipinnate, leaflets initially toothed, later entire.



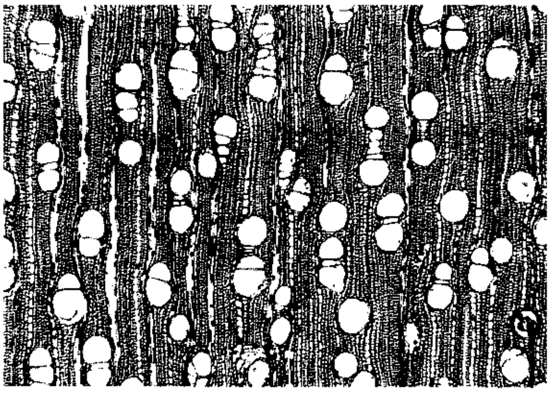
Triomma malaccensis Hook.f. – 1, tree habit; 2, flowering twig; 3, sectioned male flower; 4, female flower; 5, fruit.

Wood anatomy
– Macroscopic characters:
Heartwood brown, indistinctly demarcated from the paler sapwood. Grain straight or shallowly interlocked. Texture moderately coarse and even; wood slightly lustrous. Growth rings usually indistinct; vessels not visible to the naked eye; parenchyma and rays not distinct without a lens; ripple marks absent.
– Microscopic characters:
Growth rings absent or indistinct. Vessels diffuse, 8–13/mm^2, solitary and in radial multiples of 2–3, round to oval or slightly angular, average tangential diameter c. 150 μm; perforations simple; intervessel pits alternate, non-vestured, polygonal, 7–10 μm, occasionally with coalescent apertures; vessel-ray and vessel-parenchyma pits large and simple, or with strongly reduced borders; helical thickenings, deposits and tyloses absent. Fibres c. 1000 μm long, all septate, thin-walled, with simple to minutely bordered pits mainly confined to the radial walls. Parenchyma scarce, paratracheal to vasicentric in narrow sheaths, in 4–8-celled strands. Rays 5–7/mm, (1–)2–3 cells wide, c. 400 μm high, heterocellular with 1(–3) rows of square to upright marginal cells; some rays, containing intercellular canals, wider and taller. Crystals prismatic, common in marginal ray cells, rare in procumbent body ray cells. Intercellular canals with thick-walled epithelial cells present in some of the rays.

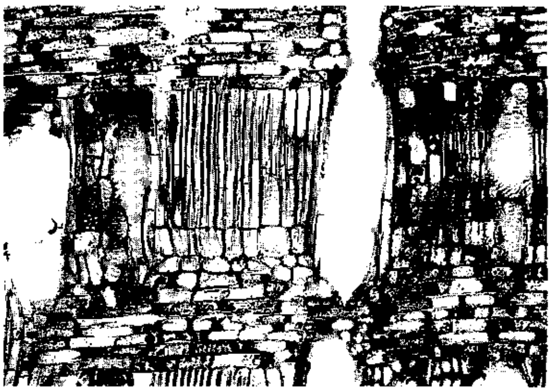
Growth and development Trees have been found flowering throughout the year and fruiting from December to May.

Other botanical information *Triomma* is the only Malesian representative of the African tribe *Bursereae* which has dry dehiscent fruits. This capsule is a primitive fruit type, and *Triomma* might be regarded as an ancient relic.

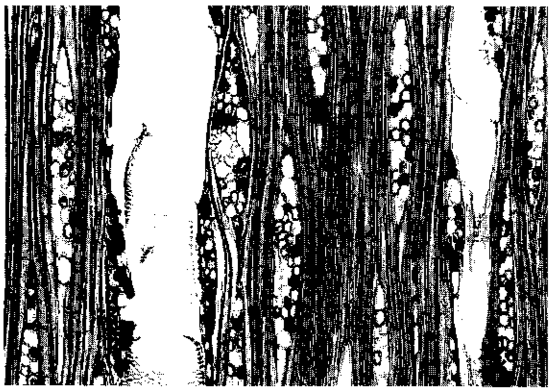
Ecology *T. malaccensis* occurs scattered, mainly in primary lowland rain forest, rarely in secondary forest, up to 400(–1000) m altitude and is never dominant. It prefers well-drained places



transverse section (×25)



radial section (×75)



tangential section (×75)

Triomma malaccensis

and is rarely found in permanently inundated localities. In southern Sumatra, it thrives well on red-yellow podzolic soils, in regions with an annual rainfall of 2500–3200 mm more or less evenly distributed over the year. In Bangka, it grows on regosols and on yellowish-red podzolic soils, in regions with an annual precipitation of 2250–2350 mm. *T. malaccensis* has been found in association with *Castanopsis*, *Diospyros*, *Litsea*, *Lophopetalum*, *Koompassia*, *Palaquium*, *Shorea* and *Syzygium* species.

Propagation and planting *T. malaccensis* can be propagated by seed. Seed germinates readily, starting after up to 16 days. Viability was very high in two very small trials with a total of only 20 seeds.

Silviculture and management Natural regeneration is very scarce, possibly due to low fruit production. Seedlings seem to be very sensitive for competition. *T. malaccensis* is vulnerable to fire: in East Kalimantan a fire killed over 70% of the trees.

Harvesting Trees have tall buttresses, which need to be slashed before the tree is felled; cutting above the buttresses would waste much timber. Moreover, green logs sink and transportation by river is only possible through rafting.

Yield In the Semanggus forest complex in southern Sumatra the volume of exploitable *T. malaccensis* timber was estimated at 8.6 m^3/ha. In forest near Samarinda, East Kalimantan, it was estimated at 2.9 m^3/ha.

Handling after harvest Immediately after sawing the timber should be treated with antistain chemicals.

Genetic resources *T. malaccensis* occurs scattered in the forest and is not cut selectively on a large scale. Therefore, it seems to be not endangered, as long as there are sufficiently large areas of primary forest in western Malesia. It seems to regenerate poorly in logged-over forest.

Prospects Very little is known about *T. malaccensis*. Although it may not have great prospects as a tree for timber plantations, research is desirable to determine its potential value for this purpose.

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Other selected sources 78, 277, 342, 465, 474, 595, 688, 721.

B. Sunarno (general part),
W.C. Wong (properties),
B. Supraptono (wood anatomy)

Vitex L.

Sp. pl. 2: 638 ('938'; 1753); Gen. pl. (Ed. 5): 285 (1754).

VERBENACEAE

$x = 6, 8$; *V. altissima*: $n = 12$, *V. negundo*: $2n = 24, 32$, *V. quinata*: $n = 16$.

Trade groups Vitex: medium-weight to heavy hardwood, e.g. *Vitex altissima* L.f., *V. cofassus* Reinw. ex Blume, *V. glabrata* R.Br., *V. parviflora* A.L. Juss., *V. pinnata* L., *V. quinata* (Lour.) F.N. Williams.

Vernacular names Vitex. Indonesia: gupasa, laban (general), ketileng (Java), serawet (Sulawesi). Malaysia: leban (Peninsular, Sarawak), kulim papa (Sabah). Papua New Guinea: garamut. Philippines: molave, bongoog. Burma (Myanmar): kyetyo. Thailand: tinnok. Vietnam: b[if]nh linh.

Origin and geographic distribution *Vitex* consists of about 150 species and is distributed throughout the tropics and subtropics with a few species in temperate regions. About 30 species occur in Malesia, but only about 8 reach a size which makes them useful for timber. Some shrub-sized species (e.g. *V. negundo* L. and *V. trifolia* L.) are widely cultivated as ornamentals and hedge plants and sometimes naturalized.

Uses *Vitex* timber is used for high-grade construction, interior finishing, flooring, window frames, ship building, wagons and carts, sleepers, railway ties, buffalo yokes, cogwheels, docks, fence posts, paving blocks, furniture, agricultural and household implements, sculpture and carving. The wood is sometimes also used for canoes, cabinets, furniture, carving, tools and toys; it serves as firewood.

A decoction of the wood and bark has medicinal properties, and is particularly used as febrifuge. Some species may produce a fish poison and others a yellow dye, whereas a few species have edible fruits.

Production and international trade *Vitex* timber enters the international trade market in very small amounts from South-East Asia. It is mostly used locally, but has at least some importance as an export timber in Papua New Guinea and Irian Jaya. In Papua New Guinea, it is ranked in MEP (Minimum Export Price) group 3, which in 1992 fetched a minimum price for saw logs of US\$ 50/m^3. However, fairly large amounts of *Vitex* timber are exported from the Solomon Islands, mainly to Japan.

Properties *Vitex* wood is medium-weight and moderately hard to heavy and hard. The heartwood is pale straw-coloured or greyish to pale brown or yellowish-brown, sometimes greenish-brown, and usually not very distinct from the sapwood which is slightly paler and 4–8 cm wide. The density is (340–)520–940(–1010) kg/m^3 at 15% moisture content. The grain is straight or slightly interlocked or wavy, texture fine to moderately fine and even. Freshly-cut wood of *V. cofassus* has a leathery scent.

V. cofassus wood from Papua New Guinea tested at 12% moisture content showed the following mechanical properties: the modulus of rupture 113 N/mm^2, modulus of elasticity 13 600 N/mm^2, compression parallel to grain 64 N/mm^2, compression perpendicular to grain 10.5 N/mm^2, shear 16.5 N/mm^2, cleavage 61 N/mm tangential, Janka side hardness 5520–5650 N and Janka end hardness 6140 N. A test on *V. parviflora* wood from the Philippines showed the following mechanical properties at 40% moisture content: the modulus of rupture 92 N/mm², modulus of elasticity 12 840 N/mm², compression parallel to grain 42 N/mm², compression perpendicular to grain 10 N/mm², shear 10 N/mm², Janka side hardness 6135 N and Janka end hardness 5695 N.

The wood usually seasons well with little degrade, provided stacks are weighted down, and with little to moderate shrinkage. Shrinkage of *V. cofassus* wood from green to 15% moisture content is 0.9–1.5% radial and 2.6–3.6% tangential, from green to 12% moisture content about 1.8% radial and 4.1% tangential, and from green to oven dry 3.5–4.2% radial and 6.8–8.0% tangential. Wood of *V. parviflora* shrinks 2.3% radial and 3.6% tangential from green to 15% moisture content, and 5.4% radial and 7.7% tangential from green to oven dry. Kiln drying from green condition to 12% moisture content takes 9–10 days, and after preliminary air drying to 25% moisture content about 4 days. Checking of *V. cofassus* wood may be severe during kiln drying. Warping may develop in back-sawn boards, but weighting of stacks and close spacing of stickers may prevent this. A high-humidity treatment is recommended after drying to relieve stresses. Once dry, the wood is stable in service.

In spite of its comparatively high density, the wood is easy to work as it contains no silica. It planes and machines well and a good finish can be obtained. It is rather difficult to split and nail, but it holds nails well and can be polished to a very smooth surface. The gluing and painting properties are variable. The steam bending properties are good. *V. cofassus* wood is probably not suitable for slicing because of discoloration and some difficulties in cutting. For peeling the logs should be heated, whereas the irregular, fluted logs may cause problems.

Vitex wood is durable, even when used outside and in contact with the ground; stakes may last over 5 years under tropical conditions. It is fairly resistant to fungal, termite and *Lyctus* beetle attack, but not to marine wood borers. The heartwood is difficult to treat with preservatives and the sapwood moderately difficult; in a test using wood of *V. cofassus* and a pressure treatment the heartwood absorbed only 32 kg/m³ of preservative and the sapwood 172 kg/m³.

Wood of *V. parviflora* contains 73% holocellulose, 36% α-cellulose, 39% lignin and 1.6% ash. The solubility is 7.8% in alcohol-benzene, less than 1% in cold water, 2.3% in hot water and 7.0% in a 1% NaOH solution.

A yellow extract is obtained when shavings are soaked in water for a few hours, and a yellow resin exudes when the wood is treated with lime. The wood often takes on a yellowish-green or greenish-brown tint when boiled in water, and it has an appreciable flavone content.

Description Shrubs and small to medium-sized trees, sometimes large, up to 45 m tall, with crooked or straight bole, up to 125(–200) cm in diameter, usually without buttresses but sometimes with distinct buttresses, often strongly fluted; bark surface rather smooth, shallowly fissured or flaky, pale grey to pale yellowish-brown, inner bark pale yellow to bright orange; crown often spreading. Leaves opposite, palmately compound with 1–7(–9) leaflets (leaves seemingly simple in *V. cofassus* with only one leaflet present, but articulation present in petiole), without stipules. Flowers in a terminal panicle or axillary cluster, bisexual, zygomorphic; calyx cup-shaped, with 5 lobes; corolla with a short tube, 2-lipped, upper lip 2-lobed, lower lip much larger and 3-lobed, pubescent outside; stamens 4, inserted on the corolla tube, exserted, didynamous; ovary superior, 2–4-chambered, with 1 filiform style having a bifid stigma. Fruit a juicy or dry drupe, sessile on the often enlarged calyx, 1–4-seeded. Seed obovoid or oblong, lacking endosperm. Seedling with epigeal germination; cotyledons green and leafy; leaves opposite, conduplicate, first ones simple, margins toothed.

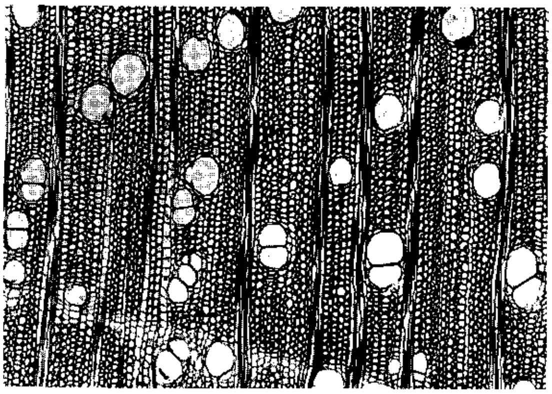
Wood anatomy

– Macroscopic characters:

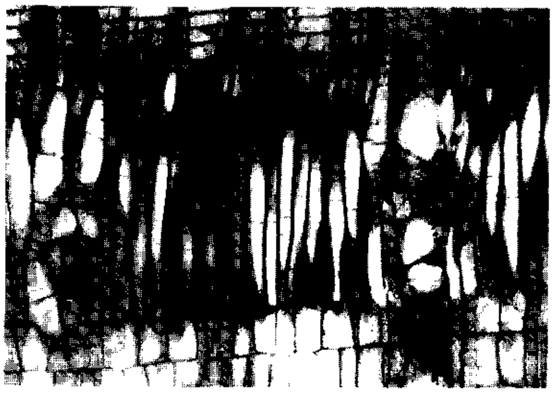
Heartwood greyish-white, grey, yellowish-grey, olive-grey or purplish-grey, through shades of reddish or olive-brown to brown, not distinctly demarcated from the sapwood. Grain straight, or more or less wavy on radial surfaces. Texture moderately fine to fine; the wood is dull to slightly lustrous, and without characteristic odour or taste. Growth rings distinct, but inconspicuous, generally 2–5/cm; vessels medium-sized to small, usually invisible or hardly visible to the naked eye; parenchyma relatively sparse, sometimes visible as very narrow bands; rays moderately fine to fine, just visible or not visible to the naked eye, inconspicuous on radial surfaces; ripple marks absent.

– Microscopic characters:

Growth rings usually distinct, demarcated by denser fibrous tissue in the outer portion of the growth ring and frequently by a narrow line of parenchyma or by larger earlywood vessels. Wood diffuse-porous or semi-ring-porous; in the latter



transverse section (×25)



radial section (×75)

tangential section (×75)

Vitex quinata

case vessels largest in the inner third of the growth ring, quite evenly distributed, 10–26 (–31)/mm^2, predominantly solitary and in radial rows of 2–4, rarely in longer rows or clusters, generally oval, average maximum tangential diameter 120–180 μm; perforation plates simple; intervessel pits alternate, numerous, oval to rounded or hexagonal, 6–10 μm in diameter; vessel-ray pits numerous, with reduced borders to simple, oval or round, 5–11 μm in diameter; gummy inclusions occasionally present, white deposits sometimes occluding the vessel segments; tyloses abundant or sparse. Fibres 0.5–1.6 mm long, thin-walled to medium thick-walled, septate, with simple, slit-like pits, mainly confined to the radial walls. Parenchyma scanty, paratracheal to vasicentric, sometimes scanty apotracheal diffuse and in narrow marginal bands, in 3–6-celled strands. Rays 5–7(–10)/mm, mostly multiseriate, 1–4(–6) cells wide, up to 1.8 mm high, homocellular with all cells procumbent or weakly heterocellular. Crystals prismatic, usually 1–2 per cell in ray parenchyma cells; gummy deposits scarce to abundant in parenchyma and ray cells and in fibres. Silica absent. Axial intercellular canals absent.

Species studied: *V. altissima*, *V. leucoxylon* L.f., *V. peduncularis* Wallich, *V. pinnata*, *V. quinata*.

Growth and development Young *Vitex* trees grow moderately slowly. *V. altissima* showed a mean annual diameter increment of 0.6 cm in Burma (Myanmar), *V. glabrata* 0.8 cm in Burma (Myanmar), *V. parviflora* 0.7–1 cm in the Philippines, *V. pinnata* 0.6 cm in Burma (Myanmar) and slightly over 1 cm in Java, and *V. quinata* 1.2 cm in Java. One-year-old seedlings of the last two species may reach 2 m in height in East Java, and the mean annual height increment for the first 15 years after planting is 1 m. The mean annual height increment of *V. parviflora* in the Philippines is recorded as much less, only 0.4 m, although in some plantations a height growth of over 1 m/year has been reached.

The crown often covers more than half of the total height of the tree and is wide spreading, and sheds its leaves partially or entirely during the later part of the dry season. However, most species are evergreen. The trees usually flower in the rainy season and fruits ripen within a few months. Planted *V. parviflora* trees have been observed to start flowering 5–6 years after planting, but in Java trees of *V. pinnata* and *V. quinata* do not start to flower until 11–12 years old.

Other botanical information *Vitex* is usually placed in the subfamily *Viticoideae* together with

Callicarpa, *Clerodendrum*, *Gmelina*, *Premna* and *Tectona*. *Premna* is probably most closely related, but can be distinguished by its simple leaves and very small flowers. *Teijsmanniodendron* is very similar to *Vitex*. It differs in the swollen stalk apices of leaves and leaflets. In general, *Vitex* species can be recognized easily by their opposite, palmately compound leaves (but 1-foliolate in *V. cofassus*) and their indehiscent fruits seated on the persistent calyx. *Viticipremna philippinensis* (Turcz.) H.J. Lam, the timber of which is used in the Philippines, is often treated under the synonym *Vitex turczanihowii* Merr.; it differs in the 4-merous corolla.

Ecology *Vitex* occurs most commonly in comparatively dry regions in lowland forest, often in deciduous forest on rocky ground, on grassy slopes and on dry limestone soils, but sometimes also in littoral rain forest or hill forest, occasionally up to 2000 m altitude. It is usually found in regions with distinct wet and dry seasons. *Vitex* species often occur gregariously in secondary forest (e.g. *V. pinnata*). *V. pinnata* is a pioneer tree species and may grow in alang-alang (*Imperata cylindrica* (L.) Raeuschel) vegetation and may even occur in recently burnt grasslands (e.g. in South Kalimantan); it is moderately fire-resistant. In primary forest, *Vitex* is found in places with little overhead shade such as river banks and gaps. *V. parviflora* occurs in the Philippines in secondary forest and open primary forest in association with *Intsia*, *Pahudia*, *Sindora*, *Toona* and *Wrightia* species. *V. cofassus* may predominate together with *Pometia pinnata* J.R. Forster & J.G. Forster in forest in Papua New Guinea, and associated with *Araucaria*, *Elmerrillia* and *Spondias* species.

Propagation and planting The number of seeds per kg is 10 000–12 000 for *V. pinnata*, about 10 500 for *V. cofassus*, 10 000–18 000 for *V. parviflora*, and about 7000 for *V. quinata*. Seed starts to germinate 10–40 days after sowing, and germination rates differ between the species: 60–80% for *V. pinnata*, 25–35% for *V. parviflora* and only 0–20% for *V. cofassus*. Removing the pericarp and soaking the seed in hot water (70°C) may enhance the germination rate considerably; up to 70% for *V. parviflora* and *V. cofassus*. *V. pinnata* seed can be stored for one year, provided the pulp is removed. Dark brown fruits of *V. parviflora* are ripe and ready for seed collection; ripe fruits should be collected from the trees.

Seed of *V. cofassus* is sown 1 cm apart in rows 15 cm apart or broadcast, and covered with 1 cm of soil. Mulching of the seed-bed is recommended to reduce evaporation during the dry season. *V. pinnata* does not need shade in the nursery to obtain a high germination rate.

Propagation by stumps and wildlings is also practised, but the production of stem cuttings has not been very successful to date. The use of stumps was recommended for *V. cofassus* in Sulawesi (Indonesia) because it does not regenerate very well under natural conditions, which makes it difficult to collect large numbers of wildlings. Root suckers are produced, but it is not known whether these can attain a size required for quality timber.

Under a dense forest canopy, the germination of *V. pinnata* is completely inhibited, but seed remains dormant and viable for more than 6 months. Seed under light shade differentiates into two fractions: one fraction with seed germinating within 2 months, the other one with seed remaining dormant and only germinating when exposed to full sunlight.

Planting should be done early in the rainy season. Generally *V. cofassus*, *V. pinnata* and *V. quinata* are planted at 1 m × 3 m in Java, occasionally at 1 m × 1–2 m on very fertile soils. In the Philippines, *V. parviflora* is generally planted using bare-rooted seedlings at 2 m × 2 m, but plantations for wildling production are spaced 2 m × 6 m. Spacings have not been tested for maximum stand development in plantations.

Silviculture and management Survival of young trees is enhanced by removing weeds 3–4 months after planting and from then on annually up to 10 years. *V. parviflora* is suggested for the Philippines as a tall tree in shelterbelts. *Vitex* is not very sensitive to the effect of fire.

Diseases and pests *Vitex* trees are not very susceptible to attacks of wood fungi. In the Philippines and Java, however, some insect pests are known to cause serious damage to 9–25-year-old trees. The most prevalent and destructive insect is the carpenter moth (*Xyleutes ceramicus*). Its larvae may damage the cambium of trunk and branches. Mixed planting with resistant species is recommended.

It is undesirable to have *Vitex* near teak plantations as it serves as an alternative food plant for *Hyblaea purea* (teak defoliator) at the time teak is leafless.

Beetles of *Leucopholis irrorata* and *Anomala* sp. and an unidentified Melothonthid beetle have been observed to defoliate *V. parviflora*. Young trees of *V. pinnata* in Java were attacked by black bug (*Tingide* spp.) and young leaves and branches of *V. quinata* by *Zeuzera coffea*. *Cromerus kals-*

hoveni, a top-sucking insect ('tip wilter') has been observed on *V. quinata*, whereas larvae of *Chalcolampra pustulata* bore into the shoots of *V. pinnata*.

Harvesting Trees may attain the required dimensions for sawn timber in 60 years. Sustainable management of natural *Vitex* forest is recommended by selectively logging and harvesting trees with a minimum diameter of 35 cm. In addition, manual felling and the use of cables for yarding are recommended. Brittle heart may be present in logs as is the case in *V. cofassus*; it is about 15 cm in diameter.

Yield A 29-year-old plantation of *V. parviflora* in the Philippines planted at 2 m × 2 m yielded 76 m^3/ha (mean annual increment 2.6 m^3/ha). A 15.5-year-old plantation of *V. quinata* in Java, spaced at 1 m × 3 m on fertile soil yielded 84 m^3/ha of clear-bole timber (mean annual increment 5.4 m^3/ha), whereas a 13.5-year-old plantation of *V. pinnata* on fertile soil produced 53 m^3/ha (mean annual increment 3.9 m^3/ha). A 10-year-old plantation of *V. cofassus* on fertile soil yielded only 8 m^3/ha (mean annual increment 0.8 m^3/ha). All yields are irrespective of wood from thinnings. The timber volume of a clear bole of *V. cofassus* is about 2.3 m^3.

Genetic resources Most *Vitex* species do not seem to be readily liable to genetic erosion as they are widespread and generally regenerate easily and abundantly after disturbance of the forest. However, some species which occur only very locally may become more easily endangered, e.g. *V. erioclona* H.J. Lam, an endemic and rare species of Sulawesi, the wood of which is reportedly favoured for boats and building materials, and *V. urceolata* Clarke, a rare tree in Peninsular Malaysia. In 1960 *V. parviflora* was considered to be nearly extinct in those areas in the Philippines where it used to abound, because of its extensive utilization for house construction and railway ties. Nowadays, it is one of the protected species in the Philippines.
Appreciable variation in wood characteristics in some species is reflected in the different vernacular names local people give the various forms, e.g. for *V. cofassus* in the Moluccas and for *V. quinata* in Sulawesi.

Prospects Although *Vitex* trees are rather slow-growing, planting may be worth while as they produce high-quality timber and can be planted successfully in dry areas. *Vitex* is not recommended for large-scale plantations because there is still a lack of knowledge on aspects of silviculture, vegetative propagation and breeding. Research on these aspects is desirable.

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Selection of species

Vitex altissima L.f.

Suppl. pl.: 294 (1782).

Distribution India, Bangladesh, Sri Lanka, Indo-China, Sumatra and New Guinea; possibly also Java.

Uses The timber is used for construction, cabinet-work, furniture, turnery, agricultural implements and cart wheels; it is highly prized in India and Sri Lanka. A yellow dye can be extracted from the wood. The juice from the bark is used externally against rheumatic swellings and chest pains. The tree seems to have good prospects as an ornamental.

Observations A medium-sized tree up to 25(–33) m tall; leaves 3-foliolate, petiole winged towards the apex, leaflets slightly pubescent below; inflorescence axillary and terminal, paniculate; calyx lobes subequal, c. 1 mm long, corolla whitish-purple to violet; fruit subglobose, 5–8 mm in diameter, bluish-black when mature. *V. altissima* is common in forests in India and Sri Lanka, but probably rather rare in Malesia. The density of the wood is 800–1010 kg/m^3 at 15% moisture content; the wood is hard and durable.

Selected sources 36, 115, 120, 185, 234, 344, 438, 648, 706.

Vitex cofassus Reinw. ex Blume

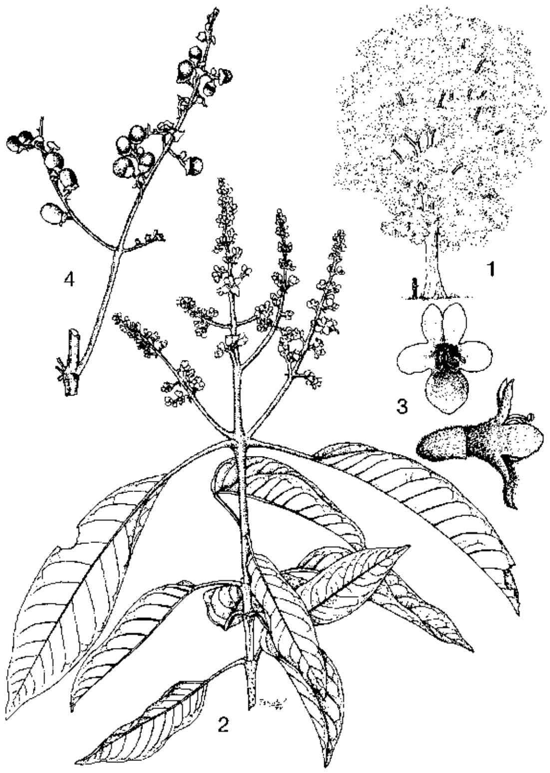
Bijdr. fl. Ned. Ind.: 813 (1826).

Vernacular names Indonesia: gofasa, gupasa (general), sassuwar (Irian Jaya). Papua New Guinea: vitex, garamut, bitum.

Distribution Sulawesi, the Moluccas, New Guinea, the Bismarck Archipelago and the Solomon Islands.

Uses The timber is used for house construction, boats and domestic utensils such as bowls and platters, and is exported in fairly large amounts from Papua New Guinea and the Solomon Islands.

Observations A medium-sized to fairly large tree, up to 40 m tall, with bole up to 130 cm in diameter, extremely deeply and strongly fluted; leaves 1-foliolate (sometimes 2–3-foliolate in young trees), leaflets glabrous or pubescent below; inflorescence terminal, paniculate; calyx without or with very small lobes, corolla whitish to pale purple; fruit subglobose, c. 5 mm (–12 mm) in diameter, dark violet when mature. *V. cofassus* is common, locally co-dominant, in lowland forest, sometimes in montane forest up to 2000 m altitude. The density of the wood is 530–940 kg/m^3 at 15% moisture content; the wood is strong and durable. See also the table on wood properties.



Vitex cofassus Reinw. ex Blume – 1, tree habit; 2, flowering twig; 3, flower, front view and side view; 4, infructescence.

Selected sources 12, 66, 115, 145, 164, 180, 218, 227, 228, 234, 289, 341, 344, 439, 482, 526, 558, 706, 731.

Vitex glabrata R.Br.

Prodr.: 512 (1810).

Vernacular names Indonesia: ketileng, bigbul, gentileng (Java). Philippines: bongoog (general), talang-pulo (Camarines), ampapalut (Balabac). Thailand: khainao (general), khihen (north-eastern), khomkhwan (central). Vietnam: b[if]nh linh nh[ax]n.

Distribution India, Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia (rare), Java, Sulawesi, Timor, New Guinea and northern Australia.

Uses The timber is used for house construction and furniture, e.g. in the Philippines. The fruits are edible.

Observations A medium-sized tree up to 25 m tall, with bole branchless for up to 15 m and sometimes up to 125 cm in diameter; leaves 3–5-foliolate, leaflets (nearly) glabrous; inflorescence axillary, lax; calyx lobes minute, subequal, corolla yellowish-white; fruit ovoid or obovoid, up to 25 mm long, pulpy, purplish-black when mature. *V. glabrata* occurs in mixed evergreen forest (especially along edges), sometimes also in deciduous forest or grassland, up to 1000 m altitude. The density of the wood is 720–780 kg/m^3 at 15% moisture content.

Selected sources 36, 73, 234, 341, 344, 414, 425, 440, 474, 527, 600, 648, 705, 706.

Vitex longisepala King & Gamble

Kew Bull.: 112 (1908).

Vernacular names Malaysia: leban bunga, leban kunyit, halban (Peninsular).

Distribution Peninsular Malaysia.

Uses The timber is only available in small dimensions, and used locally, e.g. for utensils.

Observations A small to medium-sized tree, bole often crooked; leaves 3-foliolate, leaflets pubescent and glandular below; inflorescence axillary; calyx lobes subequal, c. 6 mm long, corolla yellow; fruit ovoid, c. 7.5 mm long, becoming black when mature. *V. longisepala* is widely distributed in Peninsular Malaysia, mainly in montane forest.

Selected sources 78, 341, 441, 705.

Vitex parviflora A.L. Juss.

Ann. Mus. Hist. nat. Paris 7: 76 (1806).

Synonyms *Vitex littoralis* Decne. (1834), *Vitex timoriensis* Walp. (1845).

Vernacular names Indonesia: kayu kula, fuli kaa (Timor). Philippines: molave, amugauan, sagat (general).

Distribution The Philippines, Sulawesi, Timor, the Moluccas; possibly also Sabah and Java; planted in Central America.

Uses The timber is used in the Philippines for numerous purposes such as house building (both outside and inside), ship building and carving. The trees are planted in reforestation projects in the Philippines. The bark and wood are used in local medicine, as a styptic, emetic and antitoxic and to treat jaundice and dropsy. The leaves are used as a fodder.

Observations A medium-sized to fairly large tree, up to 30(–38) m tall, bole up to 125(–200) cm in diameter and branchless for up to 20 m, but often much shorter and crooked, with buttresses; leaves 3-foliolate, leaflets glabrous below; inflorescence terminal and in the upper leaf axils, paniculate, rather lax; calyx lobes absent or indistinct, corolla bluish; fruit subglobose, c. 5 mm in diameter, bluish-black when mature. *V. parviflora* was widely distributed and common in secondary and open primary forest in the Philippines, but it has been depleted due to logging and shifting cultivation. The density of the wood is about 940 kg/m^3 at 15% moisture content; the wood is hard and durable. See also the table on wood properties.

Selected sources 6, 8, 11, 84, 115, 124, 125, 133, 174, 187, 234, 341, 344, 348, 349, 358, 407, 414, 426, 442, 514, 527, 690, 698.

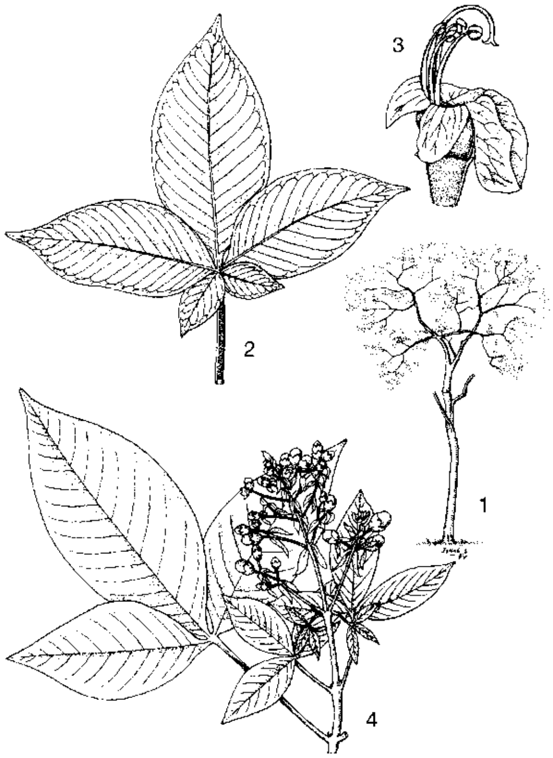
Vitex pinnata L.

Sp. pl. 2: 638 ('938'; 1753).

Synonyms *Vitex pubescens* Vahl (1794).

Vernacular names Indonesia: laban (general), kalapapa (Kalimantan), gulimpapa (Sulawesi). Malaysia: leban tandok (Peninsular), leban buas (Sarawak), kulim papa (Sabah). Philippines: hairy-leafed molave. Burma (Myanmar): kyetyoh. Thailand: tinnok (central, northern), samo-tinpet (peninsular). Vietnam: b[if]nh linh l[oo]ng.

Distribution India, Sri Lanka (rare), Bangladesh, Burma (Myanmar), Indo-China, Thailand,



Vitex pinnata L. – 1, tree habit; 2, leaf; 3, flower; 4, fruiting twig.

Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi, the Lesser Sunda Islands and the Philippines (Palawan); introduced in tropical Africa and South America.

Uses The timber is not of commercial importance because it is usually not available in larger dimensions. It is, however, locally favoured for construction, boats and implements, and it is used as fuelwood. The leaves and bark are used in local medicine against stomach-ache, as febrifuge and to heal wounds.

Observations A small to medium-sized tree, up to 25(–30) m tall, with often crooked bole up to 70 cm in diameter; leaves (3–)5-foliolate, leaflets pubescent below; inflorescence terminal, paniculate, with prominent bracts; calyx lobes subequal, c. 2 mm long, corolla bluish-white to violet; fruit subglobose, 7–13 mm in diameter, purplish-black when mature. *V. pinnata* is common in many areas, especially in more open habitats, secondary forest and on river banks. The density of the wood is 800–950 kg/m^3 at 15% moisture content; the wood is hard and durable.

Selected sources 18, 31, 36, 47, 51, 69, 73, 77, 78, 120, 134, 135, 148, 149, 218, 219, 220, 234, 261, 302, 303, 331, 341, 344, 371, 442, 443, 456, 473, 529, 531, 642, 648, 674, 705, 706.

Vitex quinata (Lour.) F.N. Williams

Bull. Herb. Boiss. 2, 5: 431 (1905).

Synonyms *Vitex heterophylla* Roxb. (1832), *Vitex sumatrana* Miq. (1861), *Vitex celebica* Koord. (1898).

Vernacular names Indonesia: ketileng, laban (general), gofasa (Sulawesi). Malaysia: leban bunga, leban tandok (Peninsular). Philippines: kalipapa (general). Burma (Myanmar): kyetyo-po. Thailand: sakhang, makhang, ipae (north-eastern).

Distribution India, Burma (Myanmar), the Andaman Islands, Indo-China, southern China, Thailand, Peninsular Malaysia, Sumatra, Java, the Philippines, Sulawesi, Timor and the Moluccas.

Uses The timber is used locally for house construction and boats, especially in Sulawesi, where the logs may have large dimensions.

Observations A medium-sized to large tree, up to 45 m tall, with bole up to 100(–150) cm in diameter; leaves (3–)5-foliolate, leaflets glabrous (except midrib below); inflorescence terminal, spreading, paniculate; calyx lobes subequal, small or minute (up to 2.5 mm long), corolla yellowish or purplish; fruit subglobose to pear-shaped, up to 12 mm long, purplish-black when mature. *V. quinata* is found in forest up to 1300 m altitude. The density of the wood is reported as only 340–660 kg/m^3 at 15% moisture content in Indonesia.

Selected sources 36, 73, 78, 218, 234, 261, 302, 303, 331, 341, 344, 443, 474, 529, 600, 705, 706.

Vitex vestita Wallich ex Schauer

DC., Prodr. 11: 692 (1847).

Vernacular names Indonesia: marambueng (Sumatra). Malaysia: leban, leban nasi, halban (Peninsular). Burma (Myanmar): tauksha. Thailand: khotngu (north-eastern), tinnok-khao (south-eastern).

Distribution Burma (Myanmar), Thailand, Peninsular Malaysia, Sumatra, Bangka, Borneo; possibly also Java.

Uses The wood is used for rafters. It is also used as fuel.

Observations A small to medium-sized tree; leaves 3-foliolate, leaflets villous and glandular below; inflorescence axillary, dichotomous, usually 2 per axil; calyx lobes subequal, minute, corolla yellowish, glandular; fruit subglobose, c. 6 mm in diameter. *V. vestita* is locally common, especially along forest edges, up to 500 m altitude. The wood is whitish-brown and has a density of about 580 kg/m^3 at 15% moisture content and is not durable.

Selected sources 36, 78, 234, 341, 344, 441, 454, 459, 705, 706.

B. Sunarno (general part, selection of species),
R.H.M.J. Lemmens (properties),
Ani binti Sulaiman (wood anatomy)

Wrightia R.Br.

On Asclepiad.: 762 (1810).

APOCYNACEAE

$x = 11$; *W. arborea* and some species from India: $2n = 22$

Trade groups Lanete: lightweight to medium-weight hardwood: *Wrightia arborea* (Dennst.) Mabberley, *W. laevis* Hook.f., *W. pubescens* R.Br.

Vernacular names Lanete (Philippines). Indonesia: mentaos (Javanese), bintaos (Sundanese). Malaysia: jeliti. Thailand: mok-man. Vietnam: m[uws]c, th[uwf]ng.

Origin and geographic distribution *Wrightia* consists of 26 species which are confined to the Old World tropics. They occur from East Africa through India, Burma (Myanmar), Indo-China, southern China, Thailand and the Malesian region (probably excluding Borneo) eastwards towards the Solomon Islands and north-eastern Australia. Most of the species are found in India and Indo-China, and only 5 in the Malesian area.

Uses Lanete wood is used especially for carving, but also for furniture, funnel products, and veneer. It is used for carved fancy boxes, musical instruments, cabinet work, picture frames, inlaying, kitchen utensils, chairs, chests, turnery, window sills, scabbards, wooden shoes, chopsticks, parang sheaths and blowpipe mouths. The wood of *W. tinctoria* R.Br. is used extensively in India for carving and lacquer work; it is becoming scarce.

The plants have medicinal properties and are used locally against e.g. eye diseases and dysentery. The bark of *W. arborea* is reported to be useful as antidote to snake bite and scorpion sting; it is also used in local medicine. An indigo-yielding glucoside present in the seeds, roots and leaves of several species is used for dyeing in India and Indo-China. Sap of *W. tinctoria* from India added to milk reportedly has preservative properties; the milk will remain fresh for some time, the taste remaining unaltered. The bark of *W. pubescens* has milk-clotting properties and is used in Indonesia in the preparation of 'litsusu', a cheese-like product. Several species of *Wrightia* are planted as ornamentals, and in the Philippines *W. pubescens* is used for reforestation.

Production and international trade If lanete is traded as logs or sawn timber, only very small amounts are involved. The dimensions of the timber are usually too small to make it important on the international market. In the Philippines, it reaches the market in the form of small logs 20–30 cm in diameter and 1.5–2 m long. It is usually processed locally and particularly used for carving. In Bali, the estimated demand of wood for this purpose is 420 m^3/year. No statistics are available on the trade of products made from lanete wood.

Properties Lanete is a lightweight to medium-weight and rather soft to moderately hard wood. The heartwood is creamy white to pale yellow, sometimes with a pinkish tinge, and not clearly demarcated from the sapwood. The density is 410–620(–785) kg/m^3 at 15% moisture content. The grain is straight to slightly interlocked, texture fine to very fine; the wood is glossy.

A test of *W. arborea* wood in Thailand at 14% moisture content showed the following mechanical properties: the modulus of rupture 90 N/mm^2, modulus of elasticity 6575 N/mm^2, compression parallel to grain 35 N/mm^2, compression perpendicular to grain 8 N/mm^2, shear 17.5 N/mm^2, and Janka side hardness 4765–5000 N.

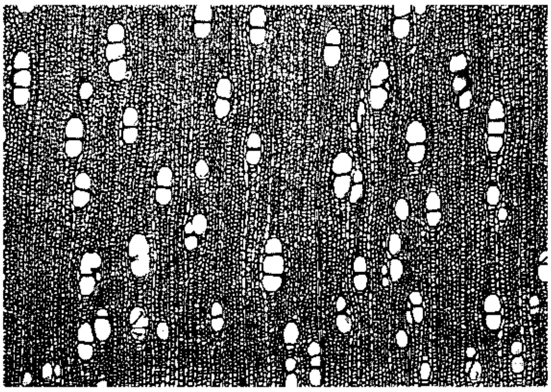
The timber air dries well without serious degrade, but rapid drying is necessary to prevent blue stain or sap staining. Treatment with the preservatives sodium pentachlorophenate, cuprisulphate and sodium tetraborate has been unsatisfactory. The wood is easy to work; it carves and turns particularly well. It is not durable when exposed to the weather or in contact with the ground, and is susceptible to termite attack. However, wood of *W. pubescens* from the Philippines is reported to be moderately resistant to termite and powder-post beetle attack.

Description Deciduous or evergreen shrubs or small to fairly large trees, up to 40 m tall, rarely climbers; bole cylindrical, straight, occasionally crooked, up to 60 cm in diameter, not buttressed but often fluted at base; bark surface fissured longitudinally, pale grey to yellowish-brown, inner bark granular or fibrous, yellow, exuding milky latex; branchlets glabrous or puberulous, with elliptical, white or greyish lenticels. Leaves decussate, simple, entire, pinnately veined, petiolate to subsessile; petiole bearing few to numerous pectinate glands in its axil, leaf blade eglandulose; stipules absent. Inflorescence terminal or axillary, aggregated dichasial to monochasial. Flowers actinomorphic, bisexual, 5-merous, usually fragrant; calyx deeply divided, lobes imbricate; corolla with a cylindrical to campanulate tube, lobes overlapping to the left, with a conspicuous and variously shaped corona; disk absent; stamens inserted on the corolla tube, epipetalous, anthers narrow, coherent into a cone and adherent to the stigma; ovary superior, consisting of 2 free or slightly connate carpels, united towards the apex by the style, pistil head subcapitate or subcylindrical, provided with a basal collar. Fruit consisting of a pair of pendulous follicles completely connate or connate only at the very base, terete or compressed, dehiscent throughout by an adaxial suture. Seeds many per follicle, narrowly fusiform, with a basal tuft of hairs; embryo erect; cotyledons broad and convolute. Seedling with epigeal germination; cotyledons leafy; hypocotyl elongated; all leaves opposite.

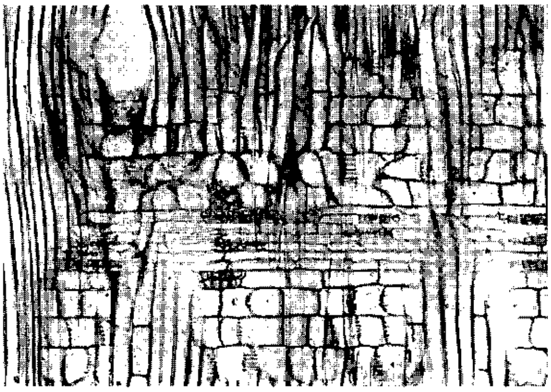
Wood anatomy

– Macroscopic characters:

Heartwood whitish to pale yellow, not distinctly demarcated from the sapwood. Grain straight or shallowly interlocked. Texture fine; wood surfaces lustrous. Growth rings not distinct; vessels small and only visible with a hand lens; parenchyma



transverse section (×25)



radial section (×75)

tangential section (×75)

Wrightia laevis

and rays not visible with the naked eye; parenchyma visible with hand lens on moist surfaces.
– Microscopic characters:
Growth rings absent or indistinct and then marked by differences in fibre diameter and wall thickness. Vessels diffuse, usually 17–25(–28)/mm^2, solitary and predominantly in radial multiples of 2–5(–8), 70–90(–100) μm in tangential diameter; perforations simple; intervessel pits alternate, vestured, fine, c. 3 μm in diameter; vessel-ray and vessel-parenchyma pits almost similar to intervessel pits but half-bordered; tyloses absent. Fibres 0.9–1.4 mm long, non-septate, ranging from very thin-walled to thick-walled, walls usually c. 3 μm thick, with slit-like pits with minute borders and more numerous in the radial than in the tangential walls. Parenchyma apotracheal, diffuse-in-aggregates, abundant, mostly in 8-celled strands. Rays 12–18/mm, 1–2(–3)-seriate, 450–2000(–2800) μm high, markedly heterocellular with more than 4 rows of upright marginal cells and multiseriate portions almost as narrow as the much taller-celled uniseriate ones (Kribs type heterogeneous I, sometimes II). Crystals prismatic, elongated and styloid, in chambered cells, up to 30 in radial chains, in upright and procumbent ray cells. Latex tubes absent.
Species studied: *W. laevis*, *W. pubescens*.

Growth and development Lanete trees exhibit Troll's architectural model. The leader shoot of the seedling bends over after 3–5 nodes and becomes plagiotropic. New shoots are produced on top of each other (continual superposition) and each shoot adds a little to the height before becoming plagiotropic. The axes contribute partly to the trunk, partly to branches. The basal part of each shoot becomes erect after leaf fall, by secondary growth.
In natural forest in India, *W. arborea* grows 7.5–25 cm during the first year, but subsequent growth is more rapid. If young trees are watered regularly and are free from weed competition, they may grow up to 115 cm in the first year. After three years, untended plants are 80 cm tall, whereas plants benefiting from regular watering and weeding are up to 3.9 m tall. The mean annual diameter increment of *W. arborea* in India is 0.4–0.8 cm.
Well-tended plants of *W. arborea* start producing viable seed after three years. The plumose seeds are dispersed by wind.

Other botanical information *Wrightia* belongs to the tribe *Nerieae* of the subfamily *Apocynoideae* and is most closely related to the genus

Pleioceras. It differs from the latter by e.g. its dichasial or monochasial inflorescence, the glabrous mouth of its corolla tube, and its comparatively short and simple alternating supplementary corona segments. *Pleioceras* has its flowers in thyrses and the corolla tube has a pubescent mouth. It has long and compound alternating supplementary corona segments.

Ecology Lanete is found in a variety of habitats, ranging from evergreen rain forest to savanna and thickets along the beach. The altitudinal range is from sea-level to 1800 m. The timber-producing species are generally found in lowland or hill evergreen to deciduous primary or secondary forest, or sometimes in thickets. *W. arborea* is found in areas with an annual rainfall of 875–3750 mm; it is a moderate light demander.

Propagation and planting *Wrightia* can be propagated by seed in the nursery or by direct sowing. The latter was successful in India for *W. arborea*. As seed is dispersed by wind, the fruits should be collected from the trees. One fruit contains 30–40 seeds and in *W. arborea* there are 53 000–60 000 seeds/kg. It may not be possible to store seed for longer periods: *W. arborea* seeds in India lose viability after one year. Fresh seeds display a high viability and germinate rapidly; the germination period for *W. religiosa* (Teijsm. & Binnend.) Benth. (a shrub-like species) in Malaysia is 10–14 days. Special care must be taken when planting seedlings out in the field, as plants may easily die back or die completely.

Silviculture and management In general, lanete tolerates drought fairly well. Natural regeneration is often plentiful and is best on loose ground where weeds are absent. Plants suffer seriously from weeds and weeding seems a prerequisite for good plantation establishment. *W. arborea* coppices well and recovers well after frost damage, as has been observed in India.

Diseases and pests In India, the fungus *Cercospora wrightia* causes leaf spot disease of *W. tinctoria*.

Genetic resources Several *Wrightia* species are becoming scarce as the wood is in demand for carving. *W. pubescens* subsp. *laniti* is considered to be a vanishing timber species in the Philippines and the wood of *W. pubescens* subsp. *pubescens* is reportedly becoming scarce in Bali where it is used for handicrafts. *W. tinctoria* stands have been depleted in India. However, in other areas such as Vietnam, lanete is regarded less at risk of genetic erosion as it is widespread and regenerates easily.

Prospects Lanete may have prospects for small-scale and local planting in South-East Asia. It is comparatively easy to propagate, grows fairly rapidly, the wood is suitable for handicrafts and sculptures, and the trees can also be used for other purposes such as reforestation and as an ornamental.

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Selection of species

Wrightia arborea (Dennst.) Mabberley

Taxon 26: 533 (1977).

Synonyms *Wrightia tomentosa* (Roxb.) Roem. & Schultes (1819), *Wrightia hamiltoniana* Wallich (1828), *Wrightia wallichii* A.DC. (1844).

Vernacular names Burma (Myanmar): letthoke, taungsalat. Thailand: mok-man (general), muk-man (Nan), nae-kae (Karen-Mae Hong Son). Vietnam: m[uws]c l[oo]ng, th[uwf]ng m[uws]c l[oo]ng.

Distribution India, Sri Lanka, Burma (Myanmar), southern China, Laos, Vietnam and Thailand.

Uses The wood is used as lanete, e.g. for general construction, pencils, carving, turnery, wooden shoes and packaging. An indigo-yielding glucoside used to dye clothes in India can be obtained from the seeds, roots and leaves. In India, the bark of stem and roots is regarded as an antidote against snake bites and scorpion stings. In Burma (Myanmar), the bark is used to treat renal complaints.

Observations A small to medium-sized tree up to 20 m tall, bole up to 35 cm in diameter, bark surface greyish, branches puberulent; leaves elliptical to broadly ovate or broadly obovate, 6–18 cm × 3–8 cm, puberulent but glabrescent above, with 10–15 pairs of secondary veins, petiole 0.3–0.8 cm long; flowers pale yellowish, pinkish or reddish, corolla subrotate, the tube 3–7 mm long, the lobes 8–16 mm long, stamens inserted at the mouth of the tube; follicles coherent, broadly fusiform, 17–35 cm long, densely and conspicuously lenticellate. *W. arborea* is fairly common and found in deciduous forest and thickets, often along streams, on sandy or rocky soils, up to 1650 m altitude. The density of the wood is 545–785 kg/m^3 at 15% moisture content. See also the table on wood properties.

Selected sources 78, 86, 185, 216, 252, 467, 494, 647, 648.

Wrightia laevis Hook.f.

Fl. Brit. India 3: 654 (1882).

Vernacular names Malaysia: susun kelapa hutan (Peninsular). Philippines: lanete, Sorsogon lanete (Filipino).

Distribution From southern China, Burma (Myanmar), Indo-China, and Thailand to Peninsular Malaysia, Sumatra, the Philippines, New Guinea, the Bismarck Archipelago and northern Australia.

Uses The wood is used as lanete, e.g. for parang sheaths and blowpipe mouths.

Observations A medium-sized to fairly large tree up to 40 m tall, bole up to 60 cm in diameter, branches glabrous; leaves narrowly elliptical to elliptical or sometimes ovate to obovate, 7–18 cm × 2.5–8 cm, glabrous or minutely puberulent on the veins below, with 6–9(–11) pairs of secondary veins, petiole 0.5–1.0 cm long; flowers white to pale yellow, corolla subrotate, the tube 1.5–3 cm long, the lobes 5–14 mm long, stamens inserted at the mouth of the tube; follicles free or sometimes coherent at the tip, terete-fusiform, 20–35 cm long, lenticellate and finely striate. *W. laevis* is divided into 3 subspecies. Subsp. *laevis* (synonyms: *Wrightia hainanensis* Merr., *Wrightia balansae* Pitard, *Wrightia macrocarpa* Pitard), having a glabrous inflorescence and a corona about as long as the stamens, is found in mainland South-East Asia, Peninsular Malaysia and Sumatra. Subsp. *millgar* (F.M. Bailey) Ngan (synonyms: *Wrightia millgar* F.M. Bailey, *Wrightia sorsogonensis* Elmer), having a puberulent inflorescence and a corona about as long as the stamens, is found in Sumatra, the Philippines, New Guinea, the Bismarck Archipelago and northern Australia. Subsp. *novoguineensis* Ngan, having a puberulent inflorescence and a corona longer than the stamens with fimbriate elements, is found in New Guinea. *W. laevis* is found locally frequently in evergreen or deciduous primary and secondary forest, also in thickets, on sandy to clayey soils, sometimes on limestone, usually at low or medium altitudes. The density of wood samples from Irian Jaya is 410–480 kg/m^3 at 15% moisture content.

Selected sources 78, 252, 467, 647, 705, 715.

Wrightia pubescens R.Br.

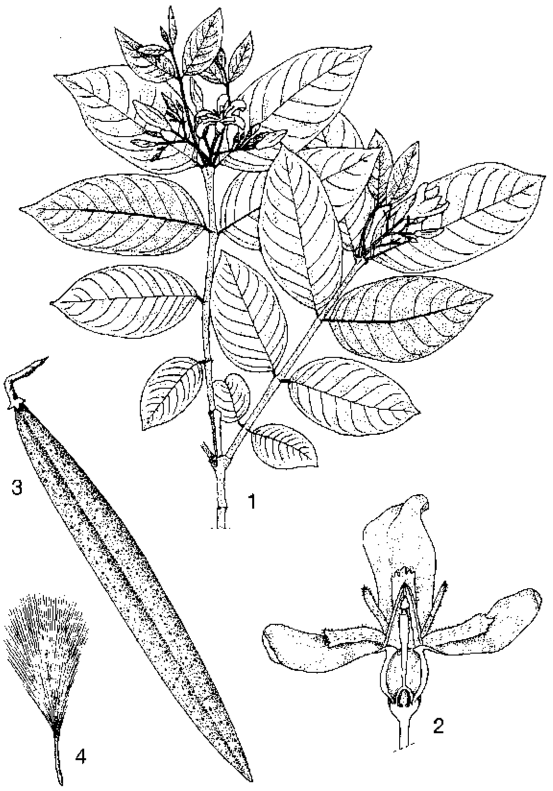
Mem. Wern. Soc. 1: 73 (1811).

Vernacular names Indonesia: mentaos (Javanese), bintaos, benteli lalaki (Sundanese). Malaysia: jeliti, mentoh, metih-metah (Peninsular). Philippines: lanete (general), anantong (Zambales), manlagosi (Mindoro). Laos: mouk. Thailand: mok (central), mukkuea (Chanthaburi), mok-man (Chon Buri, Nakhon Ratchasima). Vietnam: th[uwf]ng m[uws]c l[oo]ng.

Distribution Southern China, Cambodia, Vietnam, Thailand, throughout the Malesian area but probably not in Borneo, towards the Solomon Islands and northern Australia.

Uses *W. pubescens* is the main source of lanete; the wood is used for e.g. general construction, pencils, musical instruments, wayang figures and carving. The latex has been used against severe dysentery. In the Philippines, the trees are sometimes used for reforestation. The bark is commonly used in Indonesia as a coagulant for the manufacture of 'litsusu', a traditional cheese-like product.

Observations A medium-sized to fairly large tree up to 35 m tall, bole columnar, up to 50 cm in diameter, bark surface deeply fissured, branchlets



Wrightia pubescens R.Br. – 1, flowering twig; 2, sectioned flower; 3, fruit; 4, seed.

glabrous to densely puberulent when young; leaves narrowly ovate or ovate to oblong-ovate or elliptical, 5–15 cm × 2–7 cm, glabrous to densely puberulent above, with 8–15 pairs of secondary veins, petiole 0.4–0.8 cm long; flowers white to yellow or pink or even dark red, corolla subrotate, the tube 5–7 mm long, the lobes 10–20 mm long, stamens inserted at the mouth of the tube; follicles coherent, fusiform, 15–30 cm long, finely striate and obscurely to conspicuously lenticellate. *W. pubescens* is highly variable and has been subdivided into 5 subspecies, 3 of which are found in the Malesian area. Subsp. *pubescens* (synonyms: *Wrightia calycina* A.DC., *Wrightia spanogheana* Miq.), with calyx about as long as corolla tube, occurs from Java and Sulawesi eastward to northern Australia. Subsp. *candollei* (S. Vidal) Ngan (synonym: *Wrightia candollei* S. Vidal), with calyx about 2/3 as long as corolla tube, is endemic to the Philippines. Subsp. *laniti* (Blanco) Ngan (synonyms: *Wrightia javanica* A.DC., *Wrightia laniti* (Blanco) Merr., *Wrightia tomentosa* (Roxb.) Roem. & Schultes var. *cochinchinensis* Pierre ex Pitard), with calyx about 1/4 as long as corolla tube, occurs from mainland South-East Asia to Sumatra, Java and the Philippines. *W. pubescens* is quite common in evergreen and deciduous forest, thickets, and savanna, on periodically or permanently dry locations, up to 1000 m altitude. The density of the wood is 470–615 kg/m^3 at 12% moisture content.

Selected sources 78, 124, 125, 234, 252, 303, 414, 467, 494, 527, 574, 633, 647, 690, 698, 705.

Nguyen Ba (general part, selection of species),
Nguyen Nghia Thin (general part, selection of species),
N. Tonanon (properties),
S. Sudo (wood anatomy)

Table on wood properties of selected species

This table lists the wood properties of species for which information was available in the literature. For much-tested species, a selection has been made which reflects the variability of the wood properties over the area of distribution of the species.

Explanation of abbreviations

gr = green condition
AFR = Africa
AND = the Andaman Islands
AUS = Australia
BUR = Burma (Myanmar)
FIJ = Fiji
IJA = Irian Jaya
INA = India
IND = Indonesia
KAL = Kalimantan
MAL = Malaysia
NCA = New Caledonia
PHI = the Philippines
PMA = Peninsular Malaysia
PNG = Papua New Guinea
SAB = Sabah
SAM = Samoa
SAR = Sarawak
SUL = Sulawesi
THA = Thailand
VIE = Vietnam

Botanical name Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Acacia wattle																											
A. aulacocarpa	297	3	AUS	715	12	0.60	12	1.4	4.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A. crassicarpa	297	5	AUS	670	12	0.58	12	1.0	2.3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A. leucophloea	.	.	.	.	.	.	.	.	.	.	.	526	.	IND	870	14	85–86	10340–10780	51.5–53.5	.	8–10.5	.	.	.	.	.	.
A. mangium	452	1	AUS	.	.	0.50	.	.	.	.	.	452	1	AUS	560	11	106	11600	60	.	.	.	.	.	.	.	.
Aglaia aglaia																											
A. cucullata	60	6	PNG	.	.	0.44	.	.	.	.	.	60	6	PNG	.	gr	49.5	9730	25.5	2.5	7.5	.	48.5	2850	2535	.	3340
	.	.	.	.	.	.	.	.	.	.	.	60	6	PNG	535	12	85	11660	46	.	12.5	.	68.5	3785	.	.	.
	731	8	PNG	450–570	15	0.43–0.52	15	2.0–3.0	4.8–7.1	4.5–6.8	8.0–10.7	731	.	PNG	510	15	75	9435	.	.	.	.	.	.	.	.	.
A. lawii	731	7	PNG	590–770	15	0.55–0.72	15	1.4–1.8	2.7–3.9	4.1–5.0	6.9–8.4	731	.	PNG	800	14.5	144.5	15780	.	.	.	.	.	.	.	.	.
A. spectabilis	.	.	.	.	.	.	.	.	.	.	.	526	.	VIE	560	12	81	.	55	.	.	.	.	.	.	.	.
Ailanthus white siris																											
A. integrifolia	145	.	PNG	370	12	0.32	12	2.1	3.7	.	.	60	5	PNG	.	gr	34	7865	19	.	3.5	27.5	.	.	1315	.	.
	60	.	PNG	.	.	0.32	.	.	.	.	.	60	5	PNG	390	12	54.5	9175	36	.	5.5	29.5	23	.	1715	.	.
	731	10	PNG	330–390	15	0.30–0.36	15	1.0–1.5	2.3–4.0	2.8–4.2	5.2–8.1	731	.	PNG	400	13.5	62	9065	.	.	.	.	.	.	.	.	.
A. triphysa	297	3	AUS	435	12	0.36	12	2.1	4.7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Artocarpus terap																											
A. elasticus	.	.	.	.	.	.	.	.	.	.	.	684	.	IND	.	58	38.5	7740	21.5	.	4.5–5	37.5	33.5	.	.	3860	2315
	.	.	.	.	.	.	.	.	.	.	.	526	.	IND	490	12.5	49–50	7410–8530	26.5–28	.	5–5.5	.	.	.	.	.	.

Botanical name Trade name	Physical properties: source	Physical: number of trees tested	Physical: origin of trees	Physical: density (kg/m³)	Physical: at moisture content of (%)	Physical: specific gravity (moisture content 0%)	shrinkage green to moisture content (m.c.): m.c. (%)	shrinkage green to m.c.: rad. (%)	shrinkage green to m.c.: tang. (%)	shrinkage green to oven-dry: rad. (%)	shrinkage green to oven-dry: tang. (%)	Mechanical properties: source	Mechanical: number of trees tested	Mechanical: origin of trees	density when tested (kg/m³)	moisture content when tested (%)	modulus of rupture (N/mm²)	modulus of elasticity (N/mm²)	compression parallel to grain (N/mm²)	compression perpendicular to grain (N/mm²)	compression shear (N/mm²)	cleavage rad. (N/mm)	cleavage tang. (N/mm)	Janka hardness rad. (N)	Janka hardness tang. (N)	Janka hardness side (N)	Janka hardness end (N)
A. scortechinii	363	.	PMA	385–495	12	.	.	.	.	3.2	7.7	363	3	PMA	785	70	34	9970	30	3	6.5–7.5	53.5	53	3215	2925	.	3545
	.	.	.	.	.	.	.	.	.	.	.	363	.	PMA	450	16	35.5	10300	35	3	9–9.5	32	36	2650	2070	.	3760
keledang *A. lanceifolius*	363	3	PMA	.	.	0.74	.	.	.	2.9	6.3	363	3	PMA	1070	63	.	.	52.5	6	10	.	.	7455	7515	.	7490
	.	.	.	.	.	.	.	.	.	.	.	363	3	PMA	750	13.5	.	.	65.5	9.5	10–11	.	.	5365	5830	.	7560
A. rigidus	363	3	PMA	.	.	0.53	.	.	.	2.3	6.1	363	3	PMA	935	95	46.5	11590	38.5	4	9–9.5	60.5	71.5	3865	3915	.	4435
	.	.	.	.	.	.	.	.	.	.	.	363	3	PMA	610	15	52.5	12225	47.5	5	9.5–10.5	45	47.5	4865	5085	.	5780
Azadirachta sentang *A. excelsa*	.	.	.	.	.	.	.	.	.	.	.	591	2	THA	580	10.5	94	9770	52.5	.	16	.	.	4045	3980	.	.
neem *A. indica*	637	.	INA	.	.	.	.	.	.	4.5	6.2	637	.	INA	.	gr	71.5	8365	39	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	637	.	INA	.	12	79	6960	46	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	637	.	AFR	.	gr	76	7730	36.5	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	637	.	AFR	.	12	99	8765	51	.	.	.	.	.	.	.	.
Beilschmiedia medang	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bischofia Bishop wood *B. javanica*	.	.	.	.	.	.	.	.	.	.	.	526	1	PHI	730	12	102–111	10500–11300	45.5–49.2	8.5–10	17	.	.	.	.	7445–8180	9645–10600
	297	.	AUS	670	12	0.54	12	2.6	6.2	.	.	61	5	FIJ	.	gr	57	8280	25.5	7	8.5	52	60	5940	5675	.	4915
	.	.	.	.	.	.	.	.	.	.	.	61	5	FIJ	845	12	106	11455	59.5	13	21	83	118	9055	8235	.	11325
	.	.	.	.	.	.	.	.	.	.	.	140	5	INA	1140	gr	48	8675	23	6	.	.	.	.	.	4070	3895
	.	.	.	.	.	.	.	.	.	.	.	140	5	INA	755	9.5	98	11700	59	9	.	.	.	.	.	6095	7275

Botanical name / Trade name	Physical properties: source	Physical properties: number of trees tested	Physical properties: origin of trees	Physical properties: density	Physical properties: at moisture content of	Physical properties: specific gravity (moisture content 0%)	shrinkage: green to moisture content (m.c.): m.c.	shrinkage: green to moisture content (m.c.): rad.	shrinkage: green to moisture content (m.c.): tang.	shrinkage: green to oven-dry: rad.	shrinkage: green to oven-dry: tang.	Mechanical properties: source	Mechanical properties: number of trees tested	Mechanical properties: origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	compression: parallel to grain	compression: perpendicular to grain	compression: shear	cleavage: rad.	cleavage: tang.	Janka hardness: rad.	Janka hardness: tang.	Janka hardness: side	Janka hardness: end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
B. javanica	404	.	.	550–1000	15	.	15	1.8	4.1	3.9	7.5	404	.	.	.	gr	49	7250	24	.	8	48	58	.	.	3775	4115
	.	.	.	.	.	.	.	.	.	.	.	404	.	.	.	15	63	6660	34	.	12	59	80	.	.	4195	5695
Burckella burckella																											
B. macropoda	731	6	PNG	590–790	15	0.55–0.74	15	1.5–2.1	4.1–4.9	3.9–5.0	8.3–9.3	731	.	PNG	770	14	120	14110	.	.	.	.	.	.	.	.	.
Canarium kedondong																											
C. australianum	.	.	.	.	.	.	.	.	.	.	.	59	.	AUS	.	gr	59.5	.	29.5	.	8–9	.	.	4070	4450	.	.
C. indicum	60	.	.	.	.	0.56	.	.	.	.	.	60	3	PNG	.	gr	74	12905	37	.	9	66.5	.	.	5205	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	3	PNG	660	12	109	14630	60.5	.	13	60	.	.	5205	.	.
C. littorale	9	.	PMA	.	.	.	15	2.4	4.1	.	.	9	.	PMA	.	gr	.	.	29.5	3	7	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	140	.	PMA	850	85	.	.	29.5	3	.	.	.	3205	3250	.	3825
C. luzonicum	526	1	PHI	.	.	0.48	.	.	.	.	.	526	1	PHI	570	12	77.5–85	7370–7950	38–41	8–9.5	13.5–14	.	.	.	.	3275–3600	5160–5670
C. megalanthum	.	.	.	.	.	.	.	.	.	.	.	9	.	PMA	.	gr	65	11700	35	4.5	9.5	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	9	.	PMA	.	15	81	12900	43.5	6.5	12	.	.	.	.	.	.
Castanopsis berangan																											
C. acuminatissima	60	6	PNG	.	.	0.53	.	.	.	.	.	60	6	PNG	.	gr	56.5	12005	28	.	7.5	42	69	4760	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	6	PNG	670	12	95	15455	57	.	8–10.5	.	65	4115	3895	.	.
C. argentea	404	.	IND	550–850	15	.	.	.	.	3.7	9.6	404	.	IND	.	gr	63.5	11860	32.5	.	5–6.5	59.5	68	.	.	4185	4705
	.	.	.	.	.	.	.	.	.	.	.	404	.	IND	.	15	96	10095	53.5	.	7–8	64	79.5	.	.	4645	5500

Botanical name Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Castanospermum black bean *C. australe*	731	7	PNG	590–730	15	0.54–0.69	15	0.9–5.8	1.6–10.3	3.0–9.3	5.1–14.9	731	.	PNG	660	13	78.5	9085	.	.	.	.	.	.	.	.	.
	728	.	PNG	680–1000	12	0.59–0.89	12	3.0–8.1	5.8–12.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	713	.	AUS	.	.	0.57	12	4.8	9.7	.	.	713	.	AUS	1095	gr	64	14100	35	7.5	6.5	.	57	.	.	4670	4450
	297	.	AUS	710	12	0.58	12	1.8	5.8	.	.	713	.	AUS	770	12	102	13500	57	8.5	12.5	.	71.5	.	.	6895	8230
Cedrela Spanish cedar *C. odorata*	526	1	PHI	.	.	0.37	.	.	.	.	.	526	1	PHI	525	12	64	5950–6910	27.5–30	3.5–4	6.5	.	.	.	.	1765–1940	2495–2740
	223	.	SAM	.	.	.	12	1.5	2.2	.	.	223	.	SAM	630	gr	53	6900	23	.	5.5	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	223	.	SAM	410	12	67	7600	34	.	8.5	.	.	.	.	.	.
Chukrasia surian batu *C. tabularis*	364	1	PMA	880	15	0.77	15	1.3	1.7	.	.	250	1	PMA	1155	53	78	12400	38	8.1	11.5	70	86	.	.	6740	.
	.	.	.	.	.	.	.	.	.	.	.	250	1	PMA	880	16	94	14300	56	11	15.5	60	71	.	.	8990	.
	95	.	.	.	.	0.57	.	.	.	.	.	95	.	.	.	gr	58	8210	28	.	.	.	.	.	.	4715	.
	.	.	.	.	.	.	.	.	.	.	.	95	.	.	675	13	82	10835	47.5	.	.	.	.	.	.	5830	.
Cinnamomum camphor-wood *C. iners*	77	13	.	380–685	15	.	.	.	.	.	.	77	5	BUR	850	66	65	10915	33	5.5	7	.	.	.	.	3190	.
	.	.	.	.	.	.	.	.	.	.	.	77	1	BUR	590	12	93.5	12570	52	5.5	7.5	.	.	.	.	4390	.

Botanical name / Trade name	Physical properties: source	number of trees tested	origin of trees	density (kg/m³)	at moisture content of (%)	specific gravity (moisture content 0%)	shrinkage green to moisture content (m.c.): m.c. (%)	rad. (%)	tang. (%)	shrinkage green to oven-dry: rad. (%)	tang. (%)	Mechanical properties: source	number of trees tested	origin of trees	density when tested (kg/m³)	moisture content when tested (%)	modulus of rupture (N/mm²)	modulus of elasticity (N/mm²)	compression parallel to grain (N/mm²)	compression perpendicular to grain (N/mm²)	shear (N/mm²)	cleavage rad. (N/mm)	cleavage tang. (N/mm)	Janka hardness rad. (N)	tang. (N)	side (N)	end (N)
C. porrectum	403	.	IND	400–860	15	.	.	.	.	3.3	5.7	403	.	IND	.	gr	42.5	7840	22.5	.	5	53.5	51.5	.	.	2340	2745
	.	.	.	.	.	.	.	.	.	.	.	403	.	IND	.	15	55	8330	36.5	.	6.5–7	51	57.5	.	.	2360	2370
	.	.	.	.	.	.	.	.	.	.	.	526	.	IND	630	15	55–57.5	8090–8335	56.5–61.5	.	6.5–8	.	.	.	.	.	.
Coelostegia																											
punggai																											
C. griffithii	206	1	PMA	.	.	.	15	1.3	1.6	.	.	364	1	PMA	995	64	71	14300	38.5	4	8.5	51	60	.	.	4450	.
	.	.	.	.	.	.	.	.	.	.	.	364	1	PMA	720	16.5	95	15800	54	5.5	9	37	42	.	.	5340	.
Copaifera																											
swamp																											
sepetir																											
C. palustris	77	.	SAR	530–865	15	.	12	2.0	3.0	.	.	77	7	SAR	830	54	81	10145	39	.	10.5	24.5	39	.	.	4230	.
	.	.	.	.	.	.	.	.	.	.	.	77	7	SAR	655	12	125	12700	64	.	16	24.5	42	.	.	6275	.
Cordia																											
cordia																											
C. dichotoma	60	5	PNG	.	.	0.40	.	.	.	.	.	60	5	PNG	.	gr	51.5	7935	27.5	.	5–6	59.5	47	2850	2670	.	.
	145	.	PNG	460	12	0.40	12	1.3	3.8	.	.	60	5	PNG	460	12	64.5	8555	41.5	.	6–6.5	48	41.5	2335	2485	.	.
Cryptocarya																											
medang																											
C. alleniana	145	.	PNG	420	12	0.34	12	1.4	4.3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C. spec.	145	.	PNG	540–660	12	0.43–0.50	12	4.1	8.4	.	.	60	5	PNG	.	gr	39.5	9175	18	.	8	.	40.5	2425	1315	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	5	PNG	545	12	80.5	12145	48	.	10	.	67	3025	.	.	.

Botanical name / Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Dacrycarpus podocarp *D. imbricatus*	61	5	FIJ	.	.	0.44	.	.	.	.	.	61	5	FIJ	.	gr	52	8555	24.5	.	6.5–7	35.5	40.5	2515	2625	.	3115
	.	.	.	.	.	.	.	.	.	.	.	61	5	FIJ	525	12	77.5	9175	47	.	10.5–12	38	54	3295	3825	.	5585
Dacrydium sempilor *D. nidulum*	61	2	FIJ	.	.	0.51	.	.	.	.	.	61	2	FIJ	.	gr	67	10075	35.5	.	9	47	47.5	4160	4185	.	4605
	.	.	.	.	.	.	.	.	.	.	.	61	2	FIJ	620	12	106	11590	61.5	.	14–15	38	54.5	5430	5430	.	8635
Dillenia simpoh *D. grandifolia*	77	1	PMA	710–930	15	.	15	2.2	3.9	.	.	77	1	PMA	920	59	.	.	39.5	3.5	5.5–9.5	.	.	4270	4095	.	4985
	377	.	PMA	.	.	.	16	2.2	3.9	.	.	377	.	PMA	.	gr	76	14300	39	5	8	.	.	.	.	.	.
	404	.	.	680–920	15	.	.	.	.	.	.	404	.	.	.	gr	62	13425	.	.	5–7	25.5	48	.	.	3305	4255
	.	.	.	.	.	.	.	.	.	.	.	404	.	.	.	15	102.5	17445	.	.	7–9.5	32.5	49	.	.	4255	7225
D. indica	77	.	.	560–650	15	.	.	.	.	.	.	77	.	.	.	gr	62	7590–8625	27.5–31	.	7–7.5	.	.	.	.	2850–3560	.
	.	.	.	.	.	.	.	.	.	.	.	77	.	.	575–640	12	86.5–96.5	11110–12420	43.5–49	.	8.5–9.5	.	.	.	.	4050–4450	.
D. obovata	.	.	.	.	.	.	.	.	.	.	.	197	.	IND	.	47	.	9800–28615	32.5–55	.	6–15	24.5–102	24.5–124.5	.	.	4500–6860	.
D. papuana	613	.	.	.	.	0.63	.	.	.	4.1	8.8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
D. philippinensis	526	1	PHI	.	.	0.65	.	.	.	.	.	526	1	PHI	750	12	.	.	38–41	10.5–12	14	.	.	.	.	5940–6530	8035–8830

Botanical name Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Diospyros black ebony *D. philippinensis*	335	3	.	.	.	0.80	.	.	.	.	.	335	3	.	.	gr	74	11315	.	.	10	.	.	.	.	7745	.
streaked ebony *D. celebica*	403	.	SUL	1010–1270	15	.	.	.	.	6.2	7.8	403	.	SUL	.	gr	90.5	13130	42.5	.	8.5–10	56	63.5	.	.	.	4755
	.	.	.	.	.	.	.	.	.	.	.	403	.	SUL	.	15	110.5	14700	60	.	5.5–6.5	49	67.5	.	.	6420	7205
	.	.	.	.	.	.	.	.	.	.	.	526	.	IND	1090	15	110.5–115.5	14280–14710	60–65.5	.	.	.	.	.	.	.	.
D. pilosanthera	335	1	.	.	.	0.81	.	.	.	.	.	335	1	.	.	gr	73	13870	32	.	.	.	.	.	.	6630	.
Dracontomelon dao *D. dao*	526	2	PHI	660	15	0.53	.	.	.	.	.	526	2	PHI	.	72	92.5–101	11600–12500	46–49.5	7.5–8.5	10.5–11	.	.	.	.	5030	5580
	60	7	PNG	.	.	0.46	.	.	.	.	.	60	7	PNG	.	gr	59	9660	29.5	4.5	7–8	34.5	50.5	3225	3425	.	3740
	.	.	.	.	.	.	.	.	.	.	.	60	7	PNG	540	12	81.5	11455	46	7.5	10.5–11	48	67	3650	3780	.	4050
	166	.	PNG	540	12	.	12	2.1	4.6	.	.	278	.	PNG	.	gr	64.5	10425	30	.	.	.	.	.	3390	.	3655
	.	.	.	.	.	.	.	.	.	.	.	278	.	PNG	.	12	55.5	.	.	.	.	.	.	.	3860	.	4010
	731	9	PNG	390–670	15	0.36–0.63	15	0.7–1.4	2.4–3.7	2.5–4.0	5.7–7.9	731	.	PNG	610	13.5	98.5	11075	.	.	.	.	.	.	.	.	.
	728	.	PNG	270–810	12	0.34–0.56	12	1.2–1.8	3.0–4.0	.	.	335	9	.	460–540	12	81.5–101	11455–12560	46–49.5	.	10.5–11	.	.	.	.	.	3695–5030
	404	.	.	370–790	15	.	.	.	.	3.6	7.5	404	.	.	.	gr	38	6500	21.5	.	5–6	25	32	.	.	1510	2400
	.	.	.	.	.	.	.	.	.	.	.	404	.	.	.	15	59	8840	38.5	.	5	44.5	50.5	.	.	2755	2930

Botanical name Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Duabanga																											
Duabanga																											
D. grandiflora	.	.	.	.	.	.	.	.	.	.	.	526	.	MAL	510	12	63	7065–8235	34.5–38	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	591	4	THA	565	12	73.5	7830	44	7	11	.	.	4275	4040	.	.
	.	.	.	.	.	.	.	.	.	.	.	140	.	INA	450	12	63.5	8285	38	.	.	.	.	.	.	3050	4740
D. moluccana	526	1	PHI	445	15	0.37	.	.	.	.	.	526	1	PHI	.	gr	43–61	7800–8100	19.5–33.5	2.5–4	5.5–8.5	.	.	.	.	2020	2560
	60	5	PNG	.	.	0.32	.	.	.	.	.	60	5	PNG	.	gr	30	5490	21.5	.	4	.	33.5	1335	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	5	PNG	380	12	43	6670	30	.	6	.	37.5	1380	.	.	.
	173	.	.	.	.	.	.	.	.	3.7	7.2	173	.	.	.	12	89.5	7350	39	.	.	.	.	.	.	.	.
Durio																											
durian																											
D. carinatus	403	.	.	400–670	15	.	.	.	.	3.5	6.6	403	.	.	.	gr	49.5	11780	29	.	4.5–5	38.5	41.5	.	.	1960	2450
	.	.	.	.	.	.	.	.	.	.	.	403	.	.	.	15	76.5	12740	41.5	.	4.5–5	36	40	.	.	2850	3305
D. oxleyanus	724	.	PMA	610	15	.	15	2.4	4.0	.	.	724	.	PMA	.	gr	55	10600	27.5	3	7	.	.	.	.	.	.
	403	.	.	630–660	15	.	15	3.0	4.0	.	.	724	.	PMA	.	15	74	11700	39	4	8	.	.	.	.	.	.
D. zibethinus	526	1	PHI	545	15	0.45	.	.	.	.	.	526	1	PHI	.	gr	48–77	8160–10300	22.5–42.5	3.5–4	6–10	.	.	.	.	2350–3210	2970–3955
	403	.	.	420–690	15	.	.	.	.	3.0	4.9	403	.	.	.	gr	48	8700	25.5	.	5.5–6.5	43.5	51	.	.	2105	2575
	.	.	.	.	.	.	.	.	.	.	.	403	.	.	.	15	60.5	9595	35.5	.	4.5–5	37	46.5	.	.	2685	3565
Dyera																											
jelutong																											
D. costulata	557	.	MAL	435	15	.	15	0.8	2.0	.	.	557	.	MAL	.	gr	38	7900	21	2	5	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	557	.	MAL	.	15	50	8100	27	2.5	6	.	.	.	.	.	.

Botanical name Trade name	Physical properties: source	number of trees tested	origin of trees	density (kg/m³)	at moisture content of (%)	specific gravity (moisture content 0%)	shrinkage green to moisture content (m.c.): m.c. (%)	rad. (%)	tang. (%)	shrinkage green to oven-dry: rad. (%)	tang. (%)	Mechanical properties: source	number of trees tested	origin of trees	density when tested (kg/m³)	moisture content when tested (%)	modulus of rupture (N/mm²)	modulus of elasticity (N/mm²)	compression parallel to grain (N/mm²)	compression perpendicular to grain (N/mm²)	shear (N/mm²)	cleavage rad. (N/mm)	cleavage tang. (N/mm)	Janka hardness rad. (N)	tang. (N)	side (N)	end (N)
D. costulata	526	3	MAL	.	.	0.36	.	.	.	.	.	526	3	MAL	435	16	50–59	7400–8100	27–30.5	2.5–3	6–6.5	36	41	.	.	1740–1780	.
	403	.	.	220–560	15	.	12	1.3	3.6	.	.	403	.	.	.	gr	35.5	5390	23	.	3.5–4	48	53	.	.	1175	1725
	.	.	.	.	.	.	.	.	.	.	.	403	.	.	.	15	36	5780	17.5	.	3–3.5	20.5	28.5	.	.	775	1255
Elmerrillia wau beech *E. tsiampacca*	612	.	KAL	.	.	.	.	.	.	3.7	6.7	60	5	PNG	.	gr	47.5	8280	26.5	.	7.5	.	60	3360	.	.	.
	60	5	PNG	.	.	0.41	.	.	.	.	.	60	5	PNG	480	12	79.5	9800	45.5	.	11	.	35	3025	.	.	.
Fagraea tembesu *F. fragrans*	526	2	MAL	.	.	0.72	.	.	.	.	.	526	2	MAL	865	17	95–107	14000–14100	52–62.5	8–9	10.5–12.5	37	40	.	.	6540–6970	.
	404	.	.	720–930	15	.	.	.	.	3.4	6.6	404	.	.	.	gr	88.5	14715	51.5	.	5–5.5	58.5	58.5	.	.	5050	6180
	.	.	.	.	.	.	.	.	.	.	.	404	.	.	.	15	73.5	12360	52.5	.	6–6.5	49.5	54	.	.	3985	5445
F. gracilipes	61	5	FIJ	.	.	0.85	.	.	.	.	.	61	5	FIJ	.	gr	105	14005	58.5	.	13.5–14.5	78	72.5	8765	8920	.	7075
	.	.	.	.	.	.	.	.	.	.	.	61	5	FIJ	980	12	130	16010	71.5	.	16.5–17	73.5	63	9055	9390	.	8920
Falcatifolium sempilor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Botanical name Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Gluta rengas *G. renghas*	403	.	IND	590–840	15	.	.	.	.	2.3	4.3	403	.	IND	.	gr	52.5	10390	31.5	.	5–6	40.5	40.5	.	.	3155	3430
	403	.	.	.	.	.	.	.	.	.	.	403	.	IND	.	15	70.5	10975	43	.	3.5–4.5	38	49	.	.	2970	3125
G. torquata	389	.	PMA	.	.	.	15	1.0	1.8	.	.	364	3	PMA	1025	68	81	14000	41.5	5.5	10.5	62	71	.	.	6010	.
	.	.	.	.	.	.	.	.	.	.	.	364	3	PMA	755	15.5	111	14900	49.5	7.5	13	57	67	.	.	6190	.
Gymnacranthera penarahan	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hevea rubberwood *H. brasiliensis*	193	.	IND	.	.	.	.	.	.	2.6	6.1	193	.	IND	.	12	74	8035	36.5	10	11	.	.	.	.	5270	6145
	538	3	MAL	.	.	0.55	17	0.8	1.2	.	.	538	3	MAL	640	17	66	9240	32.5	4.5	11	54	72	.	.	4320	.
	628	.	PHI	.	.	.	12	1.2	2.5	2.5	4.8	628	.	PHI	.	gr	46.5	6520	18.5	4.5	7	.	.	.	.	3520	3290
	554	.	INA	.	.	0.56	.	.	.	2.6–3.1	5.7–6.5	554	.	INA	630	12	59	6070	33	10	10.5	.	.	6260	6810	.	7320
Homalium malas *H. foetidum*	527	.	PHI	810–990	15	0.83	.	.	.	.	.	527	.	PHI	940	13	105	15580	41.5	15	12	.	.	.	.	8240	9310
	60	5	PNG	.	.	0.72	.	.	.	.	.	60	5	PNG	.	gr	105	16285	54.5	.	9–11.5	54.5	120.5	7120	7300	.	.
	145	.	PNG	740–840	12	.	12	2.6	4.9	.	.	60	5	PNG	905	12	152	19180	84	.	14–24	37.5	.	10860	8990	.	.
	613	.	PNG	.	.	0.77	.	.	.	5.2	7.5	613	.	PNG	.	32	80	.	50	.	13.5–14	.	.	.	.	.	.

Botanical name / Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
H. foetidum	404	.	.	770–1060	15	.	.	.	.	4.6	13.2	404	.	.	.	gr	93.5	14015	48.5	.	8–10	58	101	.	.	4275	6105
	.	.	.	.	.	.	.	.	.	.	.	404	.	.	.	15	118.5	13620	56	.	8–8.5	57	72.5	.	.	5900	6685
H. longifolium	140	.	PMA	.	.	.	.	.	.	4.1	8.1	140	.	PMA	1190	48	.	.	56.5	10	12.5–15.5	.	.	9655	8500	.	8900
H. tomentosum	.	.	.	.	.	.	.	.	.	.	.	140	5	INA	1055	40.5	91	13060	47.5	.	.	.	.	.	.	8365	8500
	.	.	.	.	.	.	.	.	.	.	.	140	5	INA	895	8.5	132	15195	69.5	.	.	.	.	.	.	11970	13795
Kokoona mata ulat *K. littoralis*	206	2	PMA	.	.	.	15	2.6	3.0	.	.	364	1	PMA	1025	36	102	16300	53	7	10.5	68	73	.	.	6800	.
Koordersiodendron ranggu *K. pinnatum*	.	.	.	.	.	.	.	.	.	.	.	278	.	IJA	.	80	71	10625	40	.	9–10.5	.	.	.	3395	.	3660
	.	.	.	.	.	.	.	.	.	.	.	278	.	IJA	.	12	130	15540	71	.	12.5–14	.	.	.	3865	.	4015
	58	.	IJA	700–830	12	.	12	4.0–5.0	6.5–8.0	.	.	58	.	IJA	.	gr	62–73	10700–12400	31–36	.	7.5–9	.	.	.	.	.	.
	77	.	.	410–1020	15	.	.	.	.	.	.	77	3	SAB	1150	54	.	15295	47	.	12.5	80.5	92	6410	6220	.	6295
	.	.	.	.	.	.	.	.	.	.	.	77	3	SAB	770	17.5	.	17030	58	.	13.5	76	87	.	.	7480	6865
	394	.	MAL	690–915	15	.	15	1.7	2.6	.	.	394	.	MAL	.	15	146	16600	74	.	17.5	.	.	.	.	.	.
	527	.	PHI	675	15	.	.	.	.	.	.	527	.	PHI	1040	43	80	11500	32	9.5	10.5	.	.	.	.	6650	5200
	526	1	PHI	845	15	0.69	.	.	.	.	.	526	1	PHI	.	gr	66	12600	36.5	.	10–15.5	.	.	.	.	5710	4770

Botanical name Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Libocedrus libocedrus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lithocarpus mempening																											
L. sundaicus	403	.	.	500–690	15	.	15	2.6	8.7	.	.	364	3	PMA	1185	65	83	16900	46	.	11	60	90	.	.	6850	.
	206	3	PMA	.	.	.	15	1.9	4.2	.	.	364	3	PMA	880	18	115	19400	61.5	.	13	51	77	.	.	7830	.
Litsea medang																											
L. confusa	.	.	.	.	.	.	.	.	.	.	.	684	.	IND	310	56	33.5	6075	18	.	3–4	35	37	.	.	1450	1530
	.	.	.	.	.	.	.	.	.	.	.	684	.	IND	300	15	38	7250	27	.	2–3	44	50	.	.	1090	1285
L. cordata	409	1	PHI	.	.	.	12	2.0	5.1	3.9	8.6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
L. costalis	206	3	PMA	.	.	.	15	1.2	2.7	2.6	6.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	364	3	PMA	370	15	0.31	.	.	.	.	.	364	3	PMA	495	60	.	.	18	1.5	4	.	.	.	.	1650	.
L. crassifolia	546	.	SAR	350–880	15	.	.	.	.	1.5	4.0	546	.	SAR	.	gr	48	8105	21	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	546	.	SAR	.	15	56	9190	30	.	8	.	.	.	.	.	.
L. firma	206	3	PMA	.	.	.	15	2.0	3.9	3.6	7.0	364	3	PMA	595	45	51	9400	25	2.5	6	41	45	.	.	1560	.
	.	.	.	.	.	.	.	.	.	.	.	364	3	PMA	495	15	64	10100	35	3	7.5	49	53	.	.	2310	.
L. irianensis	731	6	PNG	480–560	15	0.44–0.52	15	1.1–1.7	3.5–4.0	3.2–4.3	7.4–7.8	731	.	PNG	520	13.5	77.5	11075	.	.	.	.	.	.	.	.	.
L. leytensis	484	1	PHI	.	.	.	12	2.4	5.1	4.3	8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
L. magnifica	.	.	.	.	.	.	.	.	.	.	.	364	1	PMA	720	75	44	7900	23	3	6	37	44	.	.	1870	.
Mangifera machang																											
M. altissima	527	.	PHI	.	.	0.70	.	.	.	.	.	527	.	PHI	870	38	88	12640	29.5	7.5	10	.	.	.	.	4675	4820
M. foetida	388	.	PMA	.	.	.	15	0.9	1.8	.	.	388	.	PMA	.	gr	68	12800	36.5	5	9	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	388	.	PMA	.	15	90	14300	48	6	13	.	.	.	.	.	.

Botanical name / Trade name	Physical properties: source	number of trees tested	origin of trees	density (kg/m³)	at moisture content of (%)	specific gravity (moisture content 0%)	shrinkage green to moisture content: m.c. (%)	shrinkage green to m.c.: rad. (%)	shrinkage green to m.c.: tang. (%)	shrinkage green to oven-dry: rad. (%)	shrinkage green to oven-dry: tang. (%)	Mechanical properties: source	number of trees tested	origin of trees	density when tested (kg/m³)	moisture content when tested (%)	modulus of rupture (N/mm²)	modulus of elasticity (N/mm²)	compression parallel to grain (N/mm²)	compression perpendicular to grain (N/mm²)	shear (N/mm²)	cleavage rad. (N/mm)	cleavage tang. (N/mm)	Janka hardness rad. (N)	Janka hardness tang. (N)	Janka hardness side (N)	Janka hardness end (N)
M. indica	388	.	PMA	.	.	.	16	1.2	1.9	.	.	388	.	PMA	.	gr	44	6700	22	.	9	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	388	.	PMA	.	15	57	7500	32	.	12	.	.	.	.	.	.
	526	1	MAL	.	.	0.59	.	.	.	.	.	526	1	MAL	705	17.5	57–65	7500–7600	32–39	.	12–15	54	57	.	.	5650–6055	.
	77	.	.	.	.	.	15	1.2	1.9	3.0	4.9	77	5	INA	1010	73	.	8955	29	.	8.5	.	.	.	.	4005	.
	.	.	.	.	.	.	.	.	.	.	.	77	5	INA	655	12.5	.	10890	43	.	9	.	.	.	.	4860	.
M. laurina	388	.	PMA	.	.	.	15.5	1.0	1.9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M. minor	60	5	PNG	.	.	0.32	.	.	.	.	.	60	5	PNG	.	gr	61	11180	32.5	.	9	.	50.5	3740	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	5	PNG	610	12	88.5	12695	51.5	.	11.5	.	60.5	4360	.	.	.
Mesua penaga *M. ferrea*	526	3	MAL	.	.	0.97	.	.	.	.	.	526	3	MAL	1120	16.5	155–171	19300–19500	79.5–93	16–17	23	63	75	.	.	14860–15530	.
	394	.	PMA	945–1185	15	.	15	4.3	5.5	.	.	140	.	INA	1105	36.5	114.5	16000	61	.	.	.	.	.	.	9745	9990
	140	.	PMA	930–1185	15	.	.	.	.	.	.	140	.	INA	975	12.5	166	19760	86	.	.	.	.	.	.	12860	16265
	.	.	.	.	.	.	.	.	.	.	.	591	3	THA	1120	14	225	22610	62	20.5	17	.	.	15680	13695	.	.
Myristica penarahan *M. buchneriana*	60	5	PNG	.	.	0.40	.	.	.	.	.	60	5	PNG	.	gr	49.5	9865	23.5	.	6.5–8	42.5	38	2135	3515	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	4	PNG	450	12	72	11245	43.5	.	9	.	.	2425	.	.	.
M. gigantea	140	.	PMA	625–690	15	.	15	1.2–3.8	2.0–4.1	4.6	6.9	140	.	PMA	900	60	.	.	35.5	3.5	7.5–9.5	.	.	4540	4230	.	4760
	436	.	PMA	.	.	.	15	2.1	3.2	.	.	436	.	PMA	.	gr	.	.	35	3	8	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	436	.	PMA	.	15	.	.	43.5	5.5	9.5	.	.	.	.	.	.
M. iners	198	.	IND	490–570	15	.	15	0.9	4.0	1.5	7.2	199	.	IND	.	15	71	8430	42	.	.	.	.	.	.	3125	4165
M. maingayi	436	.	PMA	.	.	.	14	2.2	3.1	.	.	436	.	PMA	.	gr	51	9380	25.5	4	8	.	.	.	.	.	.

Botanical name Trade name	Physical properties											Mechanical properties															
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Nageia podocarp																											
N. vitiensis	61	7	FIJ	.	.	0.39	.	.	.	.	.	61	7	FIJ	.	gr	47.5	6625	24	3.5	6.5	33	36	2225	2225	.	3225
	.	.	.	.	.	.	.	.	.	.	.	61	7	FIJ	465	12	72	7865	42.5	7	10	25.5	32	2870	2780	.	5230
N. wallichiana	145	.	PNG	540	12	0.46	12	1.8	6.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nothofagus New Guinea beech																											
N. spec.	60	12	PNG	.	.	0.65	.	.	.	.	.	60	12	PNG	.	gr	74.5	15250	37	.	10.5	87	90	5160	3315	.	.
	145	.	PNG	830	12	0.64	12	3.7	8.4	.	.	60	12	PNG	825	12	127.5	19115	69	.	11–18.5	77.5	96.5	6185	.	.	.
Ochanostachys petaling																											
O. amentacea	206	3	PMA	.	.	.	15	1.9	3.8	.	.	364	3	PMA	1155	57	.	.	45.5	6	10	.	.	.	.	6590	.
	.	.	.	.	.	.	.	.	.	.	.	364	3	PMA	915	16.5	.	.	56	6.5	10	.	.	.	.	6360	.
	404	.	.	730–1090	15	.	15	1.9	3.8	.	.	404	.	.	.	gr	96	8525	49	.	7.5	54	70.5	.	.	4310	6115
Octomeles binuang																											
O. sumatrana	.	.	.	.	.	.	.	.	.	.	.	356	5	SAB	480	50	37	5300	22	.	4.5	23	32	.	.	1380	.
	.	.	.	.	.	.	.	.	.	.	.	356	5	SAB	350	12	52	6300	33	.	6	29	39	.	.	1650	.
	.	.	.	.	.	.	.	.	.	.	.	352	2	PHI	.	gr	33.5	5600	16	2	3.5	.	.	.	.	1570	.
	.	.	.	.	.	.	.	.	.	.	.	352	2	PHI	.	12	41.5	6400	24	2	4	.	.	.	.	1960	.
	.	.	.	.	.	.	.	.	.	.	.	644	10	IJA	275–390	12	33.5–47	4700–6200	22–34	2.5–4	4–5.5	.	.	990–1700	1110–1800	.	1340–2240
	60	10	PNG	.	.	0.32	.	.	.	.	.	60	10	PNG	.	gr	38	6800	23.5	2.5	4.5	52	51	1580	1490	.	2220
	297	6	PNG	370	12	0.31	12	1.9	4.3	.	.	60	11	PNG	365	12	55	8500	37.5	3.5	5.5	64	57	1490	1670	.	1960

Botanical name Trade name	Physical properties											Mechanical properties														
							shrinkage												compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
O. sumatrana	404	.	.	160–480	15	.	.	.	.	3.0	6.9	404	.	.	.	gr	29.5	7050	19	.	2.5–3	21	23	.	.	1000	1550
	.	.	.	.	.	.	.	.	.	.	.	404	.	.	.	15	37	6860	22	.	2.5–3	26	25.5	.	.	610	1105
Parishia lelayang																											
P. insignis	546	.	SAR	690	15	.	.	.	.	2.2	6.3	546	.	SAR	.	gr	62	10995	27	.	8	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	546	.	SAR	.	15	94	12515	49	.	13	.	.	.	.	.	.
Pentace melunak																											
P. burmanica	380	5	INA	.	.	0.56	.	.	.	3.1	6.5	380	5	INA	640	12.5	89.5	11110	50.5	9.5	9.5–12	91	93.5	5720	5895	.	6785
P. triptera	363	3	PMA	.	.	0.50	.	.	.	4.2	7.6	363	3	PMA	595	16	85	12030	44	4.5	10.5–11	.	.	4215	4035	.	5220
	237	.	PMA	.	.	.	15	1.4	2.5	3.5	6.5	237	.	PMA	.	63	69	10600	35.5	.	7.5	.	.	.	.	4050	.
	.	.	.	.	.	.	.	.	.	.	.	237	.	PMA	.	16	85	12000	43.5	.	11	.	.	.	.	4090	.
Pentaspadon pelajau																											
P. velutinus	140	.	PMA	485–825	15	.	15	1.0–2.0	1.9–4.3	4.0	6.7	140	3	PMA	840	47	.	.	34.5	3.5	8.5–12	.	.	4185	3870	.	4585
	526	4	PMA	560	15	0.46	.	.	.	.	.	526	4	PMA	.	47	53–80	8600–10500	32–43.5	3–4	8–10.5	49	46	.	.	4000	.
	.	.	.	.	.	.	.	.	.	.	.	591	1	THA	635	12	81.5	8250	38.5	8	17	.	.	4095	4135	.	.
Phyllocladus sempilor																											
P. hypophyllus	145	.	PNG	570	12	0.50	12	1.6	3.4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Botanical name / Trade name	Physical properties						shrinkage					Mechanical properties							compression			cleavage		Janka hardness			
							green to moisture content (m.c.)			green to oven-dry																	
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
Podocarpus podocarp *P. neriifolius*	77	.	AND	530	12	.	.	.	.	3.3	5.7	77	5	AND	625	34.5	34.5	9240	31.5	.	5.5	.	.	.	.	2570	.
	.	.	.	.	.	.	.	.	.	.	.	77	5	AND	545	14.5	50.5	10460	48.5	.	8	.	.	.	.	3815	.
	61	9	FIJ	.	.	0.52	.	.	.	.	.	61	9	FIJ	.	gr	72	9385	35.5	6	9.5	44.5	53.5	3850	3915	.	4915
	404	.	.	480–790	15	.	.	.	.	3.3	5.7	61	9	FIJ	620	12	98.5	10765	56	11	13	32	40.5	4985	5050	.	7920
Prumnopitys black podocarp *P. amara*	60	5	PNG	.	.	0.36	.	.	.	.	.	60	5	PNG	.	gr	44	8420	21	.	6	.	30	1980	.	.	.
	145	.	PNG	410	12	.	12	1.3	3.4	.	.	60	5	PNG	430	12	64.5	9520	40.5	.	10	.	46	2005	.	.	.
Pterocymbium amberoi *P. beccarii*	60	7	PNG	.	.	0.32	.	.	.	.	.	60	7	PNG	.	gr	36	7580	16.5	.	3.5	16.5	28.5	1355	1155	.	1510
	.	.	.	.	.	.	.	.	.	.	.	60	7	PNG	365	12	46	8405	30	.	4	.	34.5	1535	1625	.	.
	145	.	PNG	340–380	12	0.29–0.33	12	1.9	5.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	613	.	PNG	325	12	.	.	.	.	2.9	7.6	613	.	PNG	.	12	54	.	30	.	7.5	23	23	.	.	.	.
Quercus mempening *Q. argentata*	.	.	.	.	.	.	.	.	.	.	.	364	1	PMA	1200	52	101	16300	49	9.5	13	69	115	.	.	9260	.
	.	.	.	.	.	.	.	.	.	.	.	364	1	PMA	930	16.5	120	18100	62.5	12	16	78	66	.	.	10640	.
Q. lineata	403	.	IND	940–1100	15	.	.	.	.	.	.	403	.	IND	.	gr	76	15680	33.5	.	8.5–10.5	83.5	.	.	.	5320	5780
	.	.	.	.	.	.	.	.	.	.	.	403	.	IND	.	15	127	17740	53	.	9–11.5	92	.	.	.	5735	6860

Botanical name / Trade name	Physical properties: source	number of trees tested	origin of trees	density (kg/m³)	at moisture content of (%)	specific gravity (moisture content 0%)	shrinkage: green to moisture content (m.c.): m.c. (%)	rad. (%)	tang. (%)	green to oven-dry: rad. (%)	tang. (%)	Mechanical properties: source	number of trees tested	origin of trees	density when tested (kg/m³)	moisture content when tested (%)	modulus of rupture (N/mm²)	modulus of elasticity (N/mm²)	compression: parallel to grain (N/mm²)	perpendicular to grain (N/mm²)	shear (N/mm²)	cleavage: rad. (N/mm)	tang. (N/mm)	Janka hardness: rad. (N)	tang. (N)	side (N)	end (N)
Santiria kedondong																											
S. griffithii	196	.	IND	600–920	15	.	.	.	.	4.8	8.2	196	.	IND	.	gr	90.5	15680	53	.	.	.	.	.	.	5390	6245
S. laevigata	196	.	IND	470–860	15	.	15	1.8	3.2	.	.	196	.	IND	.	gr	54	11660	31	.	.	.	.	.	.	2575	2695
	.	.	.	.	.	.	.	.	.	.	.	9	.	PMA	.	gr	64	11200	32	.	8	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	9	.	PMA	.	15	81	12100	43	.	11	.	.	.	.	.	.
S. rubiginosa	196	.	IND	660–1070	15	.	.	.	.	.	.	196	.	IND	.	gr	83.5	15190	45	.	.	.	.	.	.	5085	6075
S. tomentosa	196	.	IND	490–810	15	.	.	.	.	.	.	196	.	IND	.	gr	64	11270	34.5	.	.	.	.	.	.	2890	3575
Sterculia sterculia																											
S. ceramica	627	1	PHI	.	.	0.27–0.31	.	.	.	.	.	627	1	PHI	.	gr	31.5	6240	15.5	2	4	.	.	.	.	1150	1350
	.	.	.	.	.	.	.	.	.	.	.	627	1	PHI	.	12	44	7070	23.5	2.5	4	.	.	.	.	1340	1950
S. macrophylla	731	.	PNG	250–450	15	.	15	0.8–1.3	3.2–4.2	2.3–3.5	6.5–8.0	731	1	PNG	410	13	54	7320	.	.	.	.	.	.	.	.	.
S. shillinglawii	60	5	PNG	.	.	0.26	.	.	.	.	.	60	5	PNG	.	gr	27	5410	14	.	3	.	26	910	890	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	5	PNG	315	12	32	5975	21	.	4	.	23.5	1115	.	.	.
Swintonia merpauh																											
S. floribunda	206	3	PMA	.	.	.	17	0.8	1.5	.	.	364	3	PMA	1075	70	77	14700	40.5	4.5	11	55	71	.	.	5200	.
	.	.	.	.	.	.	.	.	.	.	.	364	3	PMA	755	17	103	16300	51.5	7	12.5	43	53	.	.	5340	.
	.	.	.	.	.	.	.	.	.	.	.	380	.	BUR	865	58	62	11700	29	.	.	.	.	.	.	3290	3360
	.	.	.	.	.	.	.	.	.	.	.	380	.	BUR	655	13.5	82	13200	40	.	.	.	.	.	.	4580	3780
S. schwenkii	206	1	PMA	.	.	.	15	1.4	2.0	4.1	5.8	364	5	PMA	1105	81	76	14200	37.5	4.5	10.5	57	67	.	.	4720	.
	.	.	.	.	.	.	.	.	.	.	.	364	5	PMA	720	17.5	97	15700	47.5	6.5	13.5	54	65	.	.	5610	.

Botanical name / Trade name	Physical properties: source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	shrinkage green to moisture content (m.c.): m.c.	rad.	tang.	shrinkage green to oven-dry: rad.	tang.	Mechanical properties: source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	compression: parallel to grain	perpendicular to grain	shear	cleavage: rad.	tang.	Janka hardness: rad.	tang.	side	end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
S. spicifera	206	3	PMA	.	.	.	17	0.9	1.8	.	.	364	3	PMA	1170	83	80	16800	39.5	.	13	60	75	.	.	4320	.
	.	.	.	.	.	.	.	.	.	.	.	364	3	PMA	755	16.5	108	18100	56.5	.	13.5	50	71	.	.	6010	.
Syzygium kelat																											
S. buettnerianum	60	5	PNG	.	.	0.62	.	.	.	.	.	60	5	PNG	.	gr	68	12900	40.5	.	8	.	31	5290	3050	.	4050
	347	.	PNG	865	12	0.72	.	.	.	.	.	60	5	PNG	775	12	114	16900	70	.	13	.	28	7700	.	.	.
	728	.	PNG	730–810	12	0.68–0.78	12	1.7–4.3	5.7–6.7	.	.	543	.	NCA	1020	12	118	12700	74	.	9	.	.	.	.	.	.
	483	.	NCA	910	12	.	.	.	.	6.9	12.3	483	.	NCA	910	12	135	15000	68	.	.	.	.	.	.	.	.
	72	4	AUS	830	12	0.65	12	4.1	8.4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
S. effusum	72	8	.	880	12	0.69	12	4.4	7.8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
S. griffithii	206	.	PMA	.	.	.	15	1.9	3.3	5.0	9.0	364	3	PMA	1075	62	.	.	43	4.5	8.5	.	.	.	.	5780	.
	.	.	.	.	.	.	.	.	.	.	.	364	3	PMA	850	16	116	17600	59	6	13	.	.	.	.	6540	.
S. polyanthum	.	.	.	.	.	.	.	.	.	.	.	134	.	IND	700	17	88	12300	45	.	8	33	56	.	.	.	5250
	.	.	.	.	.	.	.	.	.	.	.	526	.	IND	770	14	94–95	10910–11370	42–44	.	5.5–7	.	.	.	.	.	.
Terminalia terminalia																											
T. bellirica	.	.	.	.	.	.	.	.	.	.	.	140	5	INA	990	46	76.5	12680	41	.	.	.	.	.	.	5450	5185
	.	.	.	.	.	.	.	.	.	.	.	140	5	INA	800	13	111.5	15080	61	.	.	.	.	.	.	6365	5965
T. brassii	60	9	PNG	.	.	0.39	.	.	.	.	.	60	9	PNG	.	gr	43.5	8350	21	.	5–5.5	34.5	44.5	2290	2780	.	3015
	.	.	.	.	.	.	.	.	.	.	.	60	9	PNG	465	12	68	9935	37	.	8–8.5	42.5	48	2650	2870	.	.
T. catappa	.	.	.	.	.	.	.	.	.	.	.	526	.	MAL	710	15	73.5–76.5	10600–10950	40.5–44	5–5.5	9–10.5	.	.	.	.	.	.
T. citrina	556	.	INA	755–800	12	.	.	.	.	5.3–5.5	7.8–8.5	556	.	INA	1020	62	39–116.5	5975–20590	27.5–51	.	3–14	.	.	2925–8320	3220–6965	.	3660–7975
	.	.	.	.	.	.	.	.	.	.	.	556	.	INA	.	12	97–109	12460–13045	55–59	.	11.5–13.5	.	.	6585–8280	6865–8660	.	8260–10495

Botanical name Trade name	Physical properties: source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	shrinkage green to moisture content (m.c.): m.c.	shrinkage green to m.c.: rad.	shrinkage green to m.c.: tang.	shrinkage green to oven-dry: rad.	shrinkage green to oven-dry: tang.	Mechanical properties: source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	compression: parallel to grain	compression: perpendicular to grain	shear	cleavage: rad.	cleavage: tang.	Janka hardness: rad.	Janka hardness: tang.	Janka hardness: side	Janka hardness: end
				kg/m³	%		%	%	%	%	%				kg/m³	%	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm	N/mm	N	N	N	N
T. complanata	60	15	PNG	.	.	0.40	.	.	.	.	.	60	15	PNG	.	gr	53.5	8900	30	.	6–6.5	42	48	2470	2670	.	3625
	.	.	.	.	.	.	.	.	.	.	.	60	15	PNG	465	12	75	9935	46	.	9–9.5	46	51	2895	3315	.	4985
T. copelandii	526	5	PHI	.	.	0.44	.	.	.	.	.	526	5	PHI	545	12	82.5–90	11100–12000	42.5–46	5–6	9.5–10	.	.	.	.	3320–3650	4705–5170
T. kaernbachii	60	5	PNG	.	.	0.45	.	.	.	.	.	60	5	PNG	.	gr	57.5	9520	27.5	.	8	.	60	3495	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	5	PNG	540	12	85.5	11870	48	.	11	.	65	3670	.	.	.
T. nitens	526	1	PHI	.	.	0.56	.	.	.	.	.	526	1	PHI	705	12	80–87	11200–12100	.	11.5–13	.	.	.	.	.	5015–5510	7615–8370
Toona surian *T. ciliata*	526	.	MAL	330	15	0.28	.	.	.	.	.	526	.	MAL	.	95	29–43	5700–6600	14.5–23	.	4.5–6.5	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	591	2	THA	530	14	85	8210	32	6	9	.	.	3960	3840	.	.
T. sinensis	.	.	.	.	.	.	.	.	.	.	.	140	5	INA	575	15	82	10700	45	7	.	.	.	.	.	3915	4605
T. sureni	201	1	PMA	.	.	0.29	.	.	.	.	.	201	1	PMA	335	15.5	42	7115	21.5	2	5.5	32	36	.	.	1215	.
	60	7	PNG	.	.	0.31	.	.	.	.	.	60	7	PNG	.	gr	35.5	6280	19.5	.	5	.	38	1600	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	60	8	PNG	375	12	59	7865	32	.	5–8	.	50.5	1735	1670	.	.
	404	.	.	270–670	15	.	.	.	.	4.3	8.2	404	.	.	.	gr	24	5585	14.5	.	4	19.5	32.5	.	.	675	1815
	.	.	.	.	.	.	.	.	.	.	.	404	.	.	.	15	52	8475	28.5	.	3–4	43	51	.	.	2050	2585
Triomma kedondong	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vitex vitex *V. cofassus*	60	6	PNG	.	.	0.61	.	.	.	.	.	60	6	PNG	.	gr	80	11800	42	.	12	.	84.5	5430	4850	.	5430
	.	.	.	.	.	.	.	.	.	.	.	60	7	PNG	705	12	113	13595	64	10.5	16.5	.	61	5650	5520	.	6140
	731	12	PNG	570–740	15	0.53–0.70	15	0.9–1.5	2.6–3.6	3.5–4.2	6.8–8.0	731	.	PNG	680	14	101.5	10975	.	.	.	.	.	.	.	.	.

Botanical name Trade name	Physical properties											Mechanical properties																
							shrinkage												compression			cleavage		Janka hardness				
							green to moisture content (m.c.)			green to oven-dry																		
	source	number of trees tested	origin of trees	density	at moisture content of	specific gravity (moisture content 0%)	m.c.	rad.	tang.	rad.	tang.	source	number of trees tested	origin of trees	density when tested	moisture content when tested	modulus of rupture	modulus of elasticity	parallel to grain	perpendicular to grain	shear	rad.	tang.	rad.	tang.	side	end
				kg/m^3	%		%	%	%	%	%				kg/m^3	%	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm	N/mm	N	N	N	N
V. cofassus	145	.	PNG	700–800	12	0.61	12	1.8	4.1	.	.	526	.	IND	840	15.5	83.5–89	12010–12260	55–61.5	.	7–9	.	.	.	.	.	.
V. parviflora	527	.	PHI	940	15	0.71	15	2.3	3.6	5.4	7.7	527	.	PHI	990	40	92	12840	42	10	10	.	.	.	.	6135	5695
Wrightia lanete *W. arborea*	.	.	.	.	.	.	.	.	.	.	.	591	3	THA	620	14	90	6575	35	8	17.5	.	.	5000	4765	.	.

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Glossary

See also the introduction of Prosea 5(1) for an explanation of terms concerning tree architecture (1.4.2), wood structure (1.4.2), climatic types (1.5.1), soils (1.5.2) and wood properties including kiln schedules (1.6)

abaxial: on the side facing away from the axis or stem (dorsal)
abortivum: agent inducing abortion
abscission: the natural detachment of leaves, branches, flowers or fruits
accrescent: increasing in size with age
acicular: needle-shaped; sharp pointed
acorn: the fruit of the oak
actinomorphic: radially symmetrical; applied to flowers which can be bisected in more than one vertical plane
acumen: the point of an acuminate leaf; the drip-tip
acuminate: ending in a narrowed, tapering point with concave sides
acute: sharp; ending in a point with straight or slightly convex sides
adaxial: on the side facing the axis (ventral)
adnate: united with another part; with unlike parts fused, e.g. ovary and calyx tube
adventitious: not in the usual place, e.g. roots on stems, or buds produced in other than terminal or axillary positions on stems
air layering: a form of layering in which soil (rooting medium) is brought to the branch to be layered; the ball of soil in a polyethene cover is wrapped around th girdled branch; after adventitious roots grow out above the girdle, the layer can be separated
albumen: the nutritive material stored within the seed, and in many cases surrounding the embryo (endosperm)
aliform: wing-shaped
aliform axial parenchyma: parenchyma surrounding or to one side of the vessel and with lateral extensions
alkaloid: large group of organic bases containing nitrogen and usually oxygen that occur for the most part in the form of salts with acids; usually optically and biologically active
alluvium: soil material deposited by running water in recent geological time
alternate: leaves, etc., inserted at different levels along the stem, as distinct from opposite or whorled
ambrosia beetle: see pinhole borer
amplexicaul: stem-clasping, when the base of a sessile leaf or a stipule is dilated at the base, and embraces the stem
anastomosis: cross connection of branches or roots; union of one vein or parenchyma band with another, the connection forming a reticulation
anatropous (ovule): reversed, with micropyle close to the side of the hilum and the chalaza at the opposite end
andosol: a young tropical soil originating from weathering of volcanic ash
androecium: the male element; the stamens as a unit of the flower
androgynophore: a column on which stamens and carpels are borne
androgynous: having male and female flowers on the same inflorescence
androphore: a stalk supporting the androecium or stamens
aneuploidy: having a chromosome number that is not an exact multiple of the usual haploid number (n)
annular: ring-shaped
anther: the part of the stamen containing the pollen
anthesis: the time the flower is expanded, or, more strictly, the time when pollination may take place
anthracnose: a disease characterized by distinctive limited lesions on stem, leaf or fruit, often accompanied by dieback and usually caused by a *Gloeosporium* or a *Colletotrichum*, imperfect fungi. The perfect state of the fungus, when known, is *Gnomonia* or *Glomerella*
antispasmodic: an agent that prevents or relieves spasms, or a remedy for spasms
aperture: gap or mouth
apetalous: without petals or with a single perianth
apex (plural apices): tip or summit of an organ
aphrodisiac: a food or drug stimulating sexual desire

apical: at the point of any structure
apiculate: ending abruptly in a short point
apomixis: reproduction by seed formed without sexual fusion (apomictic)
apotracheal: not associated or contiguous with vessels or vascular tracheids
appressed (adpressed): lying flat for the whole length of the organ
arboreal: of, relating to, or resembling a tree; inhabiting or frequenting trees
arbuscular: branched like a tree
architectural model: model discribing the branching habit of a tree as determined by the pattern of activity of axes, the pattern including timing, postioning and fate (e.g. terminating in an inflorescence) of active axes
areole: irregular squares or angular spaces marked out on a surface, e.g. of a fruit; a small cell or cavity
areolate: with irregular squares or angular spaces marked out on a surface, e.g. of a fruit; with small cells or cavities
aril: an expansion of the funicle enveloping the seed, arising from the placenta; sometimes occurring as a pulpy cover (arillus)
arillate: possessing an aril
arilloid: like an aril
articulate: jointed, or with places where separation takes place naturally
ascending: curving or sloping upwards
astringent: an agent or substance causing shrinkage of mucous membranes or raw or exposed tissues
attenuate: gradually tapering
auricle: a small lobe or ear
auriculate: eared, having auricles
axil: the upper angle between the leaf and the stem
axile: (placenta) belonging to or situated in an axis
axillary: arising from the axil
axis: the main or central line of development of a plant or organ
back-sawn: = plain-sawn
barbate: bearded, having long weak hairs in tufts
bark: the tissue external to the vascular cambium collectively, being the secondary phloem, cortex and periderm
basifixed: attached or fixed by the base
batik: an Indonesian method of hand-printing textiles by coating parts of the fabric with wax to resist dye, dipping in a cold dye solution, boiling off the wax, and repeating the process for each colour used
beak: a long, prominent and substantial point, applied particularly to prolongations of fruits
berry: a juicy indehiscent fruit with the seeds immersed in pulp; usually several-seeded without a stony layer surrounding the seeds
BFCA solution: a mixture of boron, fluorine, chromium and arsenic compounds used to preserve wood
bicanaliculate: with two longitudinal grooves
bifid: cleft into two parts at the tip
biseriate: arranged in two rows
bisexual: having both sexes present and functional in the same flower
blade: the expanded part, e.g. of a leaf or petal
blockboard: a plywood in which the core layers are replaced by blocks of wood
blue stain: a common form of bluish discoloration, generally of sapwood, caused by various fungi
bole: the main trunk of a tree, generally from the base up to the first main branch
bordered pit: a fibre pit in which the membrane is overarched by the secondary cell wall
brachyblast: a short reproductive branch
bract: a reduced leaf subtending a flower, flower stalk or the whole or part of an inflorescence
bracteole: a secondary bract on the pedicel or close under the flower
breeding: the propagation of plants or animals to improve certain characteristics
bristle: a stiff hair or a hair-like stiff slender body
brittle heart: the defective core of a log, characterized by abnormal brittleness
broadcast: to sow seed scattered, not in lines or pockets
bronchitis: inflammation of the bronchial tubes
budding: the process of inserting a scion, which consists of the bud in a leaf axil on a shield of rind, with or without a small piece of wood attached, into a plant (rootstock) with the intention that it will unite and grow there
bullate: surface much blistered or puckered
butt: the base of the trunk from which the roots spring
buttress: the enlargement of the base of trunks of emergent tropical trees that ranges from a small spur or swelling to massive structures, partly root, partly stem, reaching as high as 10 m up the stem, thin and flat to thick, twisted or anastomose
caducous: falling off early
calyptriform: shaped like a cap
calyx: the outer envelope of the flower, consisting of sepals, free or united
cambium: a layer of nascent tissue between the wood and bark, adding elements to both

campanulate: bell-shaped
canopy: the uppermost leafy layer of a tree or a forest
capitate: headed, like the head of a pin in some stigmas, or collected into compact headlike clusters as in some inflorescences
capitellate: diminutive of capitate
capsule: a dry dehiscent fruit composed of two or more carpels and either splitting when ripe into valves, or opening by slits or pores
cardiotomic: tending to increase the tonus of the heart muscle
carina: keel
carpel: one of the foliar units of a compound pistil or ovary; a simple pistil has only one carpel
cartilaginous: hard and tough
cataphyll: reduced or scale-like leaf present in certain seedlings on the lower stem nodes and sometimes elsewhere on the seedling stem
caudate: with a tail-like appendage
cauliflorous: flowers borne on the stem from the old wood, separate from the leaves
cauline: belonging to the stem or arising from it
CCA-preservative: copper-chrome-arsenic solution used to preserve wood
cellulose: the residue when hemicellulose is extracted from the holocellulose; often referred to as a-cellulose
cement board: wood-wool board
chalaza: basal part of the ovule or seed where it is attached to the funicle and the point at which vascular tissues enter and spread into the ovule
chartaceous: papery
check (in wood): small separation of the wood fibres along the grain forming a crack or fissure not penetrating as far as the opposite or adjoining side of a piece of sawn timber
chipboard: a fibreboard made from wood chips
chiropterophilous: attracting bats which perform pollination or fruit dispersal
ciliate: with a fringe of hairs along the edge
circumscissile: dehiscing or falling off along a circular line
cladode: a branch of a single internode simulating a leaf
clavate: club-shaped or thickened towards the end
cleavage: a measure of the resistance of wood to splitting
clone: a group of plants originating by vegetative propagation from a single plant and therefore of the same genotype
coalescent aperture: slit-like opening or mouth of a pit united to form grooves on the inner surface of the secondary cell wall
collapse (in wood): a defect due to abnormal and irregular shrinkage and resulting in a wrinkled or corrugated appearance of the surface and sometimes also an internal honeycombing
collar: the boundary between the above- and underground portions of the axis of a plant
collateral: standing side by side
columella: a persistent central axis round which the carpels of some fruits are arranged
comose: tufted
compound: of two or more similar parts in one organ, as in a compound leaf or compound fruit
compression parallel to grain: a measure of the compression strength parallel to the direction of the fibres necessary to bring about failure in a sample (maximum crushing strength)
compression perpendicular to grain: a measure of the compression strength perpendicular to the direction of the fibres necessary to bring about failure in a sample (stress at limit proportionality)
concave: hollow
concolourous: similarly coloured on both sides or throughout; of the same colour as a specified structure
conduplicate: folded lengthwise
cone: the fruit of a pine or fir tree (gymnosperms), largely made up of imbricated scales
confluent: blended into one, passing by degrees from one into the other
conical: having the shape of a cone (cone-shaped)
connate: united
connective (botany): tissue between the pollen sacs of an anther
conspecific: belonging to the same species
contorted: twisted or bent
convex: having a more or less rounded surface
copal: a recent or fossil resin from various trees
coppice: a small wood which is regularly cut at stated intervals, the new growth arising from the stools
cordate: heart-shaped, as seen at the base of a leaf, etc., which is deeply notched
corewood: the often darker inner portion of the heartwood
coriaceous: of leathery texture
corolla: the inner envelope of the flower consisting of free or united petals
corona: any appendage or extrusion between the corolla and stamens
corymb: a flat-topped indeterminate inflorescence in which the branches or pedicels sprout from different points, but attain approximately the same level, with the outer flowers opening first

corymbose: flowers arranged to resemble a corymb

cotyledon: seed-leaf, the primary leaf. Dicotylous embryos have two cotyledons and monocotylous embryos have one

cover crop: a crop planted to prevent soil erosion and to provide humus and/or fodder

crassula: the thicker portion of the intercellular layer and primary cell walls between primary pit-fields

crenate: the margin notched with blunt or rounded teeth

crenulate: slightly crenate, with small teeth

cross cut: cut across the grain, cross sectioned

crossfield: the rectangle formed by the walls of a ray cell and an axial tracheid, as seen in a radial section

cross-pollination: the transfer of pollen from one flower to the stigma of a flower of another plant

crown: the aerial expanse of a tree, not including the trunk

cryptocotylar: of germination, condition in which the cotyledons remain enveloped in the persistent fruit wall and/or testa

cultivar: an agricultural or horticultural variety that has originated and persisted under cultivation, as distinct from a botanical variety

cuneate: wedge-shaped; triangular, with the narrow end at the point of attachment, as the bases of leaves or petals

cupping: the curvature of a piece of sawn timber across its width

cupressoid pit: a crossfield pit in earlywood with an ovoid, included aperture that is narrower than the lateral space on either side between the aperture and the border, as in *Cupressus*

cupular: furnished with or subtended by a cupule

cupule: the cup of fruits such as the acorn, consisting of an involucre composed of adherent bracts

cursorial: adapted for running

cuspidate: abruptly tipped with a sharp rigid point

cuticle: the outermost skin of plants, consisting of a thin continuous fatty film

cutting: portion of a plant, used for vegetative propagation

cyme: a determinate inflorescence, often flat-topped, in which each growing point ends in a flower and the central flowers open first

cymose: bearing cymes or inflorescences related to cymes

cymule: a diminutive, usually few-flowered cyme or portion of one

dammar: a soft, clear to yellow resin used largely in varnishes and printing inks

damping-off: a disease of seeds or seedlings caused by fungi which cause various effects, from failure to germinate to the dying off of the seedling

deciduous: shedding or prone to shedding, applied to leaves, petals, etc.

decoction: a preparation made by boiling a medicinal plant in water

decurrent: extending down and adnate to the petiole or stem, as occurs in some leaves

decussate: of leaves, arranged in opposite pairs on the stem, with each pair perpendicular to the preceding pair

degrade: of timber, any effect that lowers the grade or quality

dehiscent: opening spontaneously when ripe, e.g. capsules, anthers

deltoid: shaped like an equilateral triangle

demulcent: a usually mucilaginous or oily substance capable of soothing or protecting an abraded mucous membrane

dendroid (hairs): tree-like in form, or branching

dentate: prominently toothed with the pointed teeth directed outwards

denticulate: minutely toothed

depulping: removing the outer, soft, fleshy part of a fruit

dermatitis: inflammation of the skin typically marked by reddening, swelling, oozing, crusting or scaling

dichasium (plural dichasia): a cymose inflorescence with 2 equal or nearly equal lateral branches arising below the terminal flower, this pattern being repeated or not (compound and simple dichasium respectively)

dichotomous: forked, parted by pairs

didynamous: with the stamens in two pairs, two long and two short ones

dieback: the dying off of parts of the above-ground structure of the plant, generally from the top downward

dimorphic: of two forms

dioecious: with unisexual flowers and with the staminate and pistillate flowers on different plants (dioecy)

dippled (bark surface): with depressions or indentations

dipteran: two-winged fly

discoid: with a round thickened lamina and rounded margins

discolourous: dissimilarly coloured on both sides or throughout; of a different colour as a specified structure

disk: a fleshy or elevated development of the receptacle within the calyx, corolla or stamens, often lobed and nectariferous

dispersal: the various ways by which seeds are scattered, e.g. by wind, water or animals

distal: situated farthest from the place of attachment

distichous: regularly arranged in two opposite rows on either side of an axis

diuretic: an agent increasing the urinary discharge

divaricate: extremely divergent

domatium (plural domatia): a modified projection that provides shelter for other organisms

dormancy: a term used to denote the inability of a resting plant or plant part (e.g. the seed, or in tree crops usually the buds) to grow or to leaf out, even under favourable environmental conditions

dorsal: back; referring to the back or outer surface of a part or organ (abaxial)

dorsifixed: attached by the back, as in the case of the attachment of anthers to a filament

dorsi-ventral: used of an organ which has dorsal and ventral surfaces

dropsy: an abnormal accumulation of serous fluid in connective tissue, causing puffy swelling

drupaceous: resembling a drupe

drupe: a fleshy one-seeded indehiscent fruit with the seed enclosed in a strong endocarp

druse (anatomy): a globular cluster of cristals

dyspepsia: a condition of disturbed digestion

dyspeptic: relating to or having dyspepsia

earlywood: the less dense wood formed during the early stage of annual growth

ecto-: in compositions, referring to the outside or the outer surface or part

ectomycorrhiza: see mycorrhiza

eglandulose: without glands

ellipsoid: a solid object which is elliptical in section

elliptical: oval in outline but widest about the middle

emarginate: notched at the extremity

embryo: the rudimentary plant within a seed, developed from a zygote (sexual) or from other nuclei in the embryo sac or cells of the nucellus or integuments (apomictic)

emergent: of a tree, one of which the crown reaches distinctly above the forest canopy

emetic: an agent that induces vomiting

endemic: exclusively native to a specified or comparatively small region; also used as a noun for a taxon thus distributed

endo-: prefix, referring to the inside or the inner surface or part

endocarp: the innermost layer of the pericarp or fruit wall

endosperm: the starchy or oily nutritive material stored within some seeds, sometimes referred to as albumen; it is triploid, having arisen from the triple fusion of a sperm nucleus and the two polar nuclei of the embryo sac

energy value: the heat produced by the combustion of a unit weight of fuel

enrichment planting: a term embracing various measures for improving the percentage of desirable species in a natural forest

entire (botany): with an even margin without teeth, lobes, etc.

entomophilous: applied to flowers which are pollinated by insects

eophyll: the first fully developed foliar leaf above the cotyledons in a seedling *epicalyx*: an involucre of bracts below the flower, resembling an extra calyx

epicotyl: the young stem above the cotyledons

epidermis: the true cellular skin or covering of a plant below the cuticle

epigeal: above the ground; in epigeal germination the cotyledons are raised above the ground

epimatium: the scale bearing the ovule in conifers

epipetalous: borne upon or placed before the petals

episepalous: borne upon or placed in front of the sepals

epithelium: the layer of secretory parenchymatous cells that surrounds an intercellular canal or cavity

evergreen: bearing foliage all year long; a plant that changes its leaves gradually

exalbuminous: lacking albumen

excentric: one-sided, out of the centre

exocarp: the outer layer of the pericarp or fruit wall

exsert, exserted: protrude beyond, as stamens beyond the tube of the corolla

ex situ: in an artificial environment or unnatural habitat

extrafloral: of nectaries, outside the flower

extrapetiolar: of stipules, positioned outside the petiole axil

extrastaminal: outside the stamens

extrorse: directed outward, as the dehiscence of an anther

falcate: sickle-shaped

fascicle: a cluster of flowers, leaves, etc., arising from the same point

febrifuge: an agent serving to reduce fever

ferruginous: rust-coloured

fertile (botany): capable of completing fertilization and producing seed; producing seed capable of germination; having functional sexual organs

fibre: any long, narrow cell of wood or bark other than vessel or parenchym elements

fibreboard: = hardboard

fibre pit: a pit in the cell wall of a fibre (see also pits)

fibro-granular: composed of or covered with fibrous to granular particles

fiddleback: resembling the shape of a fiddle; in wood anatomy: a wavy grain giving an undulating appearance to a smooth surface

filament: thread; the stalk supporting the anther

filiform: slender; threadlike

filler: a composition (as of powdered silica and oil) used to fill the pores and grain of wood

fimbriate: fringed

flabellate: fan-shaped, dilated in a wedge-shape, sometimes plaited (folded)

flat-sawn: = plain-sawn

flatulence: state marked by or affected by gases generated in the intestine

flush: a brief period of rapid shoot growth, with unfolding of the leaf primordia which had accumulated during the previous quiescent period

fluted (bole): with rounded grooves and folds

foliaceous: leaf-like

foliolate (2-, 3-, 4- etc.): with 2-, 3-, 4- leaflets

follicle: a dry, unicarpellate fruit, dehiscing by the ventral suture to which the seeds are attached

form factor (of bole): ratio of the estimated volume of the stem of a tree and the volume of a cylinder with a height equal to the total height of the tree and with a diameter equal to the diameter of the tree at breast height (1.3 m)

free: neither adhering nor united

frugivorous: feeding on fruit

fugacious: withering or falling off rapidly or early

full-cell process: a process to leave the maximum concentration of preservative in a piece of wood by the subsequent application of vacuum, pressure and again vacuum

fulvous: yellow, tawny

fungicide: an agent that destroys fungi or inhibits their growth

funicle: the stalk which attaches the ovule or seed to the placenta

funnelform: tubular with a spreading limb

fusiform: spindle-shaped; tapering towards each end from a swollen centre

gamopetalous: with united petals either throughout their length or at the base

gamosepalous: with united sepals either throughout their length or at the base

genetic erosion: the decline or loss of genetic variability

geniculate: abruptly bent so as to resemble the knee-joint

genus (plural genera): the smallest natural group containing distinct species

germplasm: the genetic material that provides the physical basis of heredity; also a collection of genotypes of an organism

girdling: cutting a girdle around the stem to kill the plant by interrupting the circulation of water and nutrients

glabrescent: becoming glabrous or nearly so

glandular: having or bearing secreting organs or glands

glaucous: pale bluish-green, or with a whitish bloom which rubs off

gley: a sticky clay layer formed below the surface of some waterlogged soils

glomerule: a condensed head of almost sessile flowers; a cluster of heads in a common involucre

glucoside: compound that is an acetal derivative of sugars and that yields glucose on hydrolysis

graft: a union of different individuals by apposition, the rooted plant being termed the stock, the portion inserted the scion

grafting: the process of inserting a scion, which consists of a piece of stem and two or more buds of the plant to be propagated, into another plant (rootstock) with the intention that it will unite and grow

grain (wood anatomy): the general direction or arrangement of the fibres; texture

granodiorite: granular intrusive igneous rock intermediate between granite and quartz diorite

granulose (granular): composed of or covered with grain-like minute particles

green wood: wood before drying, directly after harvesting

gum: a colloidal polysaccharide substance that is gelatinous when moist but hardens on drying; gum is exuded by plants or extracted from them

gum up: of a saw, when wood resin gets stuck between the saw teeth which hinders sawing

gynoecium: the female part of a flower, consisting, when complete, of one or more ovaries with their styles and stigmas

habit: external appearance or way of growth of a plant

habitat: the kind of locality in which a plant grows

haemorrhoid: a mass of dilated tortuous veins in swollen tissue situated near the anal sphincter

hardboard: board manufactured from fibres of ligno-cellulosic material
hardwood: the wood of an angiospermous tree as distinguished from that of a coniferous tree
head: a dense inflorescence of small crowded often stalkless flowers (a capitulum)
heart shake: a radial cleavage or split starting at the heart of a log, due to shrinkage through seasoning or old age
heartwood: wood from the inner portion of a tree in which the cells are dead and no longer engaged in sap conduction and food storage
heath forest: = kerangas
hemi-: prefix, half
hermaphrodite: bisexual; in flowers, with stamens and pistil in the same flower
heterocellular: having different types of cells
heterostylous: having styles of two or more distinct forms or of different lengths
hilum: the scar left on a seed indicating its point of attachment
hirsute: with rather coarse stiff hairs
hirtellous: minutely hirsute
hispid: covered with long rigid hairs or bristles
holocellulose: the total polysaccharide cellulose and hemicellulose fraction of wood
homomorphous: uniform in shape
homonym (botany): a name rejected because of an earlier application of the same name to another taxon
honeycombing (of wood): becoming pitted or checked upon drying
hoop-mark: a ring-shaped marking, often used to denote such a mark around a tree trunk
hybrid: the first generation offspring of a cross between two individuals of different species
hybridization: the crossing of individuals of different species
hypanthium: a cup-like receptacle usually derived from the fusion of the floral envelopes and androecium on which are seemingly borne the calyx, corolla and stamens
hypocotyl: the young stem below the cotyledons
hypoderm: the cell layer beneath the epidermis
hypogeal: below ground; in hypogeal germination the cotyledons remain below ground within the testa
hypsophyll: a reduced or modified leaf towards the upper end of a shoot
idioblast: a cell differing markedly in form and contents from other constituents of the same tissue, like crystalliferous cells, oil and mucilage cells
imbricate: overlapping like tiles; in a flower bud when one sepal or petal is wholly external and one wholly internal and the others overlapping at the edges only
imparipinnate: of leaves, pinnate with an unpaired terminal leaflet
indehiscent: not opening when ripe
indigenous: native to a particular area or region
indumentum: a covering, as of hairs, scales, etc.
induplicate: with the margins bent inwards and the external face of these edges applied to each other without twisting
inequilateral: unequal-sided
inferior: beneath, lower, below; an inferior ovary is one which is below the sepals, petals and stamens
inflorescence: the arrangement and mode of development of the flowers on the floral axis
infructescence: a ripened inflorescence in the fruiting stage
initial parenchyma: parenchyma forming a more or less continuous layer at the beginning of a growth ring
inner bark: the secondary phloem; the living part of the tissue outside the cambium
inoculation: grafting, more properly budding, a single bud only being inserted; transferring e.g. mycorrhiza or rhizobia in the growing medium to promote growth
insecticide: an agent that destroys insects
in situ: in the natural environment
integument: the envelope of an ovule
intercostal: between the veins of a leaf
interfloral: between the flowers
interlocked grain: a wood grain in which the fibres incline in one direction in a number of annual rings and in a reverse direction in succeeding rings
internode: the portion of the stem between two nodes
intervessel pit: see pits
intramarginal: of a vein, running near and parallel with the margin
intraspecific: occurring within a species or involving members of one species
intrastaminal: within the stamens
introrse: turned inward, towards the axis, as the dehiscence of an anther
involucre: a ring of bracts, surrounding several flowers or their supports
Janka hardness: the load required to embed a steel ball with a cross section of 100 mm^2 to half its diameter in the wood; Janka end hardness is determined on transverse sections, Janka side hardness is the average of tests on radial and

tangential surfaces

jaundice: a disease characterized by yellowish pigmentation of the skin, tissues, and body fluids caused by the deposition of bile pigments

joinery: articles constructed by joining pieces of wood

jugate: connected or yoked together; e.g. in leaves 1–n jugate: with 1–n pairs of leaflets

keel (carina): a ridge like the keel of a boat; the two anterior and united petals of a papilionaceous corolla; the principal vein of a sepal or glume

kerangas: heath forest, a type of tropical forest generally consisting of comparatively small trees with thin trunks (pole forest), often overlying a podsolic soil

kernel: the nucellus of an ovule or of a seed, that is, the whole body within the coats

kiln drying: see season

knee root: a tree root with an outgrowth

kraft pulp: = sulphate pulp

Kribs type heterogenous I: of wood rays, with the ray cells of the central or multiseriate part dissimilar to the vertically elongated ones (in tangential section) of the marginal or uniseriate part and the latter part as long as or longer than the first part

Kribs type heterogenous II: see type I but the marginal or uniseriate part shorter than the central or multiseriate part

Kribs type heterogenous III: of wood rays, with the ray cells of the central or multiseriate part dissimilar to the square and generally single marginal cell (in tangential section)

Kribs type homogeneous: of wood rays, with all ray cells similar and with their largest dimension radial as seen in radial section

labyrinthine seed: seed with the testa filling the crevices between the transverse lobes and folds of the cotyledons which adhere together closely

lacerate: irregularly cleft

laciniate: slashed, cut into narrow lobes

lamellate: made up of thin plates

lamina: see blade

laminate(d): consisting of plates or layers

lanceolate: lance-shaped; much longer than broad being widest at the base and tapering to the apex

lanose: woolly

lanuginose: woolly or cottony

lateral: on or at the side

laterite: a red soil that shows intensive weathering and chemical change and leaching away of bases and silica, leaving aluminium and iron oxides

latewood: the denser wood formed during the later stages of annual growth

latex: a juice, usually white and sometimes sticky, exuding from broken surfaces of some plants

laticifer: latex-bearing cells or vessels

laticiferous: latex-bearing

latosol: a leached red or yellow tropical soil

lax: loose, distant

laxative: having a tendency to loosen or relax; producing bowel movements and relieving constipation; a drug making the bowels loose and relieving constipation

leaching: of a soil, the removal of soluble and nutritive elements by a vertical, downward water movement

leaflet: one part of a compound leaf

lenticel: lenticular masses of loose cells protruding through fissures in the periderm on stems, fruits and roots; they usually arise beneath individual stomata and their main function is gaseous exchange

lenticellate: having lenticels

liberation thinning: cutting undesired trees to favour the growth of selected trees for a future harvest

lignin: a colloidal polymer of varying chemical structure used as secondary wall material in xylem vessels, tracheids and sclerenchyma fibres

ligulate: possessing an elongated, flattened, strap-shaped structure

limb: the expanded part of a tubular corolla, as distinct from the tube or throat; the lamina of a leaf or of a petal; the branch of a tree

linear: long and narrow with parallel sides

line planting: planting trees in parallel rows, generally at regularly spaced intervals, on land wholly or partially cleared, also used to denote enrichment planting by means of planting trees in lines

lingulate: tongue-shaped

lithosol: an azonal shallow soil consisting of imperfectly weathered rock fragments

lobed: of leaves: divided, but not to the base

locular: divided by internal partitions into compartments as in anthers and ovaries

locule: the cavity of an ovary or anther

loculicidal: dehiscent longitudinally, along the dorsal suture

log: a section cross cut from a tree or a branch of a tree. Round log: bark, branches and protuberances removed. Squared log: if a log has been sawn to an approximately rectangular cross-section

longitudinal: lengthwise

lozenge-aliform axial parenchyma: parenchyma surrounding or to one side of the vessel with lateral extensions forming a diamond-shaped outline

lumen (plural lumina): the space enclosed by the walls of a cell

Lyctus: see powder-post beetle

Malesia: the biogeographical region including Malaysia, Indonesia, the Philippines, Singapore, Brunei and Papua New Guinea

mangrove: a brackish-water coastal swamp of tropical and subtropical areas that is partly inundated by tidal flow

marginal parenchyma: parenchyma in bands at the margins of a growth ring

marine borer: a salt or brackish water mollusc (teredo), commonly called shipworm, damaging wood by producing tunnels with calcareous lining increasing rapidly in diameter from the surface inwards, or certain crustacea causing surface erosion

medial: belonging to the middle

membranous: thin and semi-transparent, like a fine membrane

meristem: undifferentiated tissue of the growing point whose cells are capable of dividing and developing into various organs and tissues

merous (4--, 5-- etc.): with 4, 5 etc. parts or numbers of sepals, petals etc.

mesocarp: the middle layer of the pericarp or fruit wall which is often fleshy or succulent

micropyle: a minute opening in the integument of an ovule through which the pollen tube penetrates

microsporophyll: a leaf-like organ bearing or subtending a sporangium which produces microspores

midrib: the main vein of a leaf which is a continuation of the petiole

modulus of elasticity: a measure of the rigidity of beams or long columns

modulus of rupture: a measure of the load-carrying capacity in bending until breaking occurs

moniliform: necklace-shaped

monochasium: a cymose inflorescence where a pattern of a single lateral branch arising below the terminal flower is repeated

monoclonal: belonging to one clone

monoecious: with unisexual flowers, but male and female flowers borne on the same plant

monopodial: of a primary axis which continues its original line of growth from the same apical meristem to produce successive lateral branches

monotypic: consisting of a single element, e.g. of a genus consisting of only one species

mordant: a compound that serves to fix a dye in or on a substance, e.g. a textile fibre; often a salt or hydroxide of chromium, aluminium or tin

morphogenetic: relating to the development of normal organic form

mortice: a hole or slot to receive a tenon of corresponding size

moulding: of wood or plywood, shaping by cutting and/or pressing into various contours

mucilage: a gelatinous substance that is similar to gum but that swells in water without dissolving and forms a slimy mass

mucous: secreting or containing a viscous or slimy matter

mucro: a sharp terminal point

mucronate: ending abruptly in a short stiff point

mucronulate: diminutive of mucronate

multiple (anatomy): a vessel arrangement where clusters of adjacent vessels are aligned parallel to the rays (radial multiple) or in a line oblique to the rays (oblique multiple)

multiseriate: arranged in several rows

muricate: rough, with short and hard tubercular excrescences

mycorrhiza: a symbiotic association of roots with a fungal mycelium which may form a layer outside the root (ectotrophic) or within the outer root tissue (endotrophic)

myrmecophilous: attracting or inhabiting ants

naturalized: introduced into a new area and established there, giving the impression of wild growth

nectar: a sweet fluid extruded from various parts of the plant (e.g. by the flower to attract pollinators)

nectarivorous: feeding on nectar

nectary: a group of modified subepidermal cells in flowers or leaves (extrafloral) secreting nectar

node: the point on the stem or branch at which a leaf or lateral is borne

nodule: a small knot or rounded body, often in roots of leguminous plants, where bacteria of the genus *Rhizobium* are active in the fixation of nitrogen from the air

nut: a one-seeded indehiscent fruit with a hard dry pericarp or shell

ob-: prefix, indicating inverse or opposite condition (obtriangular, obcordate, etc.)

oblanceolate: reverse of lanceolate

oblique: slanting; of unequal sides

oblong: longer than broad, with the sides parallel

or almost so
obovate: reverse of ovate
obovoid: a solid object which is obovate in section
obtuse: blunt or rounded at the end
ocrea: a tubular stipule or pair of opposite stipules so combined
ontogenetic: relating to or appearing during the development of an individual organism
open tank method: having timber absorb a preservative without applying any vacuum or pressure
operculum: a lid or cover which separates by a transverse line of division
opposite: of leaves and branches when two are borne at the same node on opposite sides of the stem
orbicular: flat with a more or less circular outline
organosol: an organic soil, i.e. an acid soil with over 30% organic matter, peaty soil in poorly drained situations
orthotropic: having a more or less vertical direction of growth
outcross: cross-pollination, usually by natural means, with plants differing in genetic constitution
outer bark: the periderm or rhytidome; the non-living layer of fibrous or corky tissue outside the cambium in woody plants which is shed or retained
oval (wood anatomy): broadly elliptical
ovary: that part of the pistil, usually the enlarged base, which contains the ovules and eventually becomes the fruit
ovate: egg-shaped in outline; a flat surface which is scarcely twice as long as broad with the widest portion below the middle
ovoid: a solid object which is egg-shaped (ovate) in section
ovule: the immature seeds in the ovary before fertilization
palmate: of leaflets, leaf-lobes or veins, with the different elements arising from the same point
palmatifid: palmately lobed
palynology: a branch of science studying pollen
panicle: an indeterminate branched racemose inflorescence
paniculate: resembling a panicle
pantropical: distributed throughout the tropics
papilionaceous flower: butterfly-like, pea-like flower, with standard, wings and keel
papillate: having minute nipple-like protuberances
papillose: covered with minute nipple-like protuberances
parang: a short sword, cleaver or machete
parasitic: deriving nourishment from some other organism
paratracheal: applied to wood-elements arranged about the vessels
parenchyma: tissue composed of more or less isodiametric cells, e.g. the pith and mesophyll
parietal: when ovules are attached to the inner surface of the walls of a one-celled syncarpous ovary
paripinnate: a pinnate leaf with all leaflets in pairs
particle board: board made from bonded particles of wood and/or other ligno-cellulosic material
partite (parted): cleft, but not quite to the base
patelliform: shaped like a small dish, circular and rimmed
pectinate: pinnately cleft with narrow segments set close like the teeth of a comb
pedicel: stalk of each individual flower of an inflorescence
pedicellate: furnished with a pedicel
peduncle: the stalk of an inflorescence or partial inflorescence
pedunculate: furnished with a peduncle
peeling: of a log, producing a continuous sheet of veneer by feeding a knife mounted parallel to the axis into a rotating log
pellucid: translucent
peltate: of a leaf, with the stalk attached to the lower surface, not at the edge
pendent, pendulous: drooping; hanging down from its support
pentagonal: with five angles
pentosan: any of various polysaccharides that yield monosaccharides containing five carbon atoms (pentoses) on hydrolysis; it functions as an inter-fibre bond in paper manufacture
perforation plate: the originally imperforate wall involved in the coalescence of two elements of a vessel
perianth: the floral leaves as a whole, including both sepals and petals if both are present
pericarp: the wall of the ripened ovary or fruit whose layers may be fused into one, or may be more or less divisible into exocarp, mesocarp and endocarp
persistent: remaining attached; not falling off
petal: a member of the inner series of perianth segments which are often brightly coloured
petiolate: having a petiole
petiole: the stalk of a leaf
petiolule: the stalk of a leaflet
phanerocotylar: of germination, condition in which

the (para)cotyledons become entirely exposed, free from the fruit wall and/or testa

phenotype: the physical or external appearance of an organism as distinguished from its genetic constitution (genotype); a group of organisms with similar physical or external make-up

phylloclade: a flattened branch assuming the form and funtion of foliage

phyllode: a petiole taking on the form and functions of a leaf

phyllotaxis: the arrangement of leaves or floral parts on an axis or stem

phytosanitary: of or relating to health or health measures of plants

piceoid pit: a crossfield pit in earlywood with a narrow, and often slightly extended aperture, as in *Picea*

picking up: of wood, the release of fibres, generally during and due to sawing, giving the surface a more of less woolly appearance

pickle: steep or soak in a solution for preservation, conditioning etc.

pilose: hairy with rather long soft hairs

pinhole borer: generally an ambrosia beetle damaging wood by a worm-hole of up to about 1.5 mm across which is generally darkly stained and without bore-dust

pinna (plural pinnae): a primary division or leaflet of a pinnate leaf

pinnate: arranged in pairs along each side of a common axis

pinnatifid: pinnately cleft

pistil: the female part of a flower (gynoecium) of one or more carpels, consisting, when complete, of one or more ovaries, styles and stigmas

pistillode: a sterile, often reduced pistil

pith: the soft core occurring in the structural centre of a log; the tissue, sometimes soft, in the centre of the stem of a non-woody dicotyledon

pits: recesses in the secondary wall of a cell, often in walls connecting two elements of a vessel (intervessel pits)

placenta: the part of the ovary to which the ovules are attached

placentation: the way in which the placentae are arranged in the ovary

plagiotropic: having an oblique or horizontal direction of growth

plain-sawn: of timber, converted so that the growth rings meet the face in any part at an angle of less than 45∞

planing: smoothing the timber surface

plano-convex: flat on one side and convex on the other

plicate: folded to and fro, like a fan

ploidy: degree or repetition of the basic number of chromosomes

plumose: featherlike with fine hairs

plumule: the primary bud of an embryo or germinating seed

plus tree: tree possessing specified qualities to a high degree

plywood: a structural material consisting of sheets of wood glued or cemented together with the grains of adjacent layers arranged at right angles or at a wide angle

pneumatophore: used of air vessels of any description; a root often functioning as a respiratory organ in a marsh plant

pod: a dry fruit composed of a single carpel and dehiscing by sutures, like in legumes

podzol: a zonal soil having an organic mat and a thin organic-mineral layer above a gray leached layer resting on a dark illuvial horizon

pole (tree): a young tree with a diameter of 10-30 cm at breast height

pollarding: cutting a tree back to the trunk to promote the growth of a dense head of foliage

pollen: spores or grains borne by the anthers containing the male element (gametophyte)

pollination: the transfer of pollen from the dehiscing anther to the receptive stigma

polyclonal: belonging to more than one clone

polyembryony: the production of two or more embryos within an ovule

polygamous: with unisexual and bisexual flowers in the same plant

polymorphic: polymorphous, with several or various forms; variable as to habit

polyploid: with more than two sets (genomes) of chromosomes in the somatic cells

poultice: a soft, usually heated and sometimes medicated mass spread on cloth and applied to sores or other lesions

powder-post beetle: a Lyctid or Bostrychid beetle damaging wood by characteristic round holes of about 1–3 mm in diameter with the wood reduced to flour-like dust

preservative: a liquid absorbed by timber to increase its durability

pressure treating method: = full-cell process

progeny: offspring

propagule: a part of a plant that becomes detached and grows into a new plant

prop root: aerial root

protuberance: projection, an extension beyond the normal surface

provenance: a collection of pollen, seed or propag-

ules from a certain restricted locality
pruning: cutting off the superfluous branches or shoots of a plant for better shaped or more fruitful growth
pseudocarp: false fruit, a fruit not derived solely from the ovary, but also from adnate parts
puberulent: covered with down or fine hairs
puberulous: minutely pubescent
pubescent: covered with soft short hairs
pulp: the soft fleshy part of the fruit; mechanically ground or chemically digested wood used in manufacturing paper and allied products
pulvinate: cushion-shaped
punctiform: in the form of a point or dot
pungent: bearing a sharp point; causing a sharp or irritating sensation
purgative: a medicine causing vigorous evacuation from the bowels
pustular, pustulate: with blister-like protrusions
pyrene: the stone of a drupe
pyriform: resembling a pear in shape
pyrogenous: produced by fire and heat
quadrangular: four-cornered or four-edged
quarter-sawn: of timber, converted so that the growth rings meet the face in any part at an angle of not less than 45°
raceme: an unbranched elongated indeterminate inflorescence with stalked flowers opening from the base upwards
racemose: raceme-like
rachis (plural rachides): the principal axis of an inflorescence or a compound leaf
radial: lengthwise, in a plane that passes through the pith; radiating, as from a centre (see tangential)
radial multiple: see multiple
radicle: the first root of an embryo or germinating seed
ramification: branching
ramified: branched
ramiflorous: flowering on the branches
raphid: a needle-shaped crystal occurring typically as one of a closely packed, sheaf-like bundle
rays (in wood): ribbons of parenchymatous tissue which are seen on a cross-section of timber as lighter coloured lines radiating from the pith outwards, and extending right up to the bark
receptacle: the flat, concave or convex part of the axis from which the parts of the flower arise
recurved: bent or curved downward or backward
reflexed: abruptly bent or turned downward or backward
reforestation: the replanting of a formerly forested area with forest trees
regosol: an azonal soil consisting chiefly of soft and imperfectly consolidated material
regular: of a radially symmetrical flower; actinomorphic
reniform: kidney-shaped
resaw: cut converted wood into smaller sections
resin: solid to soft semisolid amorphous fusible flammable substance obtained as exudate or as an extract of plants
reticulate: netted, as when the smallest veins of a leaf are connected together like the meshes of a net
retuse: with a shallow notch at a rounded apex
revolute: of leaves with the margins, rolled downwards towards the midrib
rheophyte: organism preferring or living in flowing water
rhizobia: bacteria of the genus *Rhizobium* capable of forming symbiotic nodules on the roots of leguminous plants and able to fix atmospheric nitrogen
rhombic: shaped like a rhomb, an equilateral oblique-angled figure
rhomboid (botany): quadrangular, diamond-shaped with the lateral angles obtuse
ring-porous: of wood, with vessels of the earlywood distinctly larger than those of the latewood and forming a well-defined zone or ring
riparian: frequently growing on the banks of streams or rivers
ripple mark: fine horizontal striations visible on tangential longitudinal surfaces of wood, due to the storied arrangement of rays or of axial elements or both
rip-sawn: of timber, sawn lengthwise, parallel to the edges
root-nodules: small dwellings on roots of leguminous and other plants, containing nitrogen-fixing bacteria (rhizobia)
rootstock: a stock for grafting, consisting of a root and part of the main axis
root sucker: a shoot originating from adventitious buds on the roots
rotary-cut: = peeled, see peeling
rotate: wheel-shaped; circular and flat
rotund: rounded in outline, somewhat orbicular, but tending towards oblong
rudimentary: of organs, imperfectly developed and non-functional
rufous: reddish
rugose: wrinkled
rugulose: somewhat wrinkled
ruminate (endosperm): having an irregular pattern of ridges and furrows, so as to appear

chewed, due to a dark inner layer of the seed-coat being folded into the paler endosperm

saccate: pouched

samara: an indehiscent winged fruit

sambal: a condiment made typically from hot peppers and various other ingredients

sanding: of wood, producing a smooth surface by means of an abrasive sheet, belt or drum

sapling: a young tree of more than 1.5 m tall and with a bole of less than 10 cm in diameter

saponin: a glycoside with soap properties

saprophytic: living upon dead organic matter such as humus

sapwood: the outer layers of wood adjacent to the bark which in the living tree contain living cells and reserve materials

sarcotesta: the fleshy outer seed-coat

scabrid, scabrous: rough to the touch

scalariform: having markings suggestive of a ladder

scale: a thin scarious body, often a degenerate leaf or a trichome of epidermal origin

scion: the plant being propagated vegetatively in grafting; the part of the plant above the graft union

sclerenchymatous: of tissue, composed of thick-walled cells

sclerotic: hardened, stony in texture

season (of timber): to reduce the moisture content of timber either by air drying (air season) or kiln drying (kiln season). Timber is fully seasoned when the moisture content has dropped to the equilibrium moisture content of the ambient climate

secondary venation: the collection of veins of a leaf blade branching off from the midrib in pinnately veined leaves, or from the main veins in palmately veined ones

section (botany): a taxonomic rank between the genus and the species accomodating a single or several related species

seed: the reproductive unit formed from a fertilized ovule, consisting of embryo and seed-coat, and, in some cases, also endosperm

seedling: the juvenile plant, grown from a seed, up to 1.5 m tall

seed orchard: a plantation of selected trees, isolated to reduce pollination from outside, cultivated for the production of seed

selective logging: a system with which only certain *a priori* selected timber groups are harvested from a forest

self-compatible: capable of fertilization and setting seed after self-pollination

self-pollination: pollination with pollen from the same flower or plant or from plants of the same clone

semi-: prefix, half; incompletely, e.g. semi-inferior

sepal: a member of the outer series of perianth segments

septate: divided by one or more partitions

septum (plural septa): a partition or cross-wall

seriate: serial, disposed in series of rows

sericeous: silky

serpentine: a rock consisting essentially of magnesium minerals and usually having a dull green colour and a mottled appearance

serrate: toothed like a saw, with regular pointed teeth pointing forwards

serrulate: serrate with minute teeth

sessile: without a stalk

shale: sedimentary rock formed by the consolidation of unaltered clay or silt

shear: a measure of the resistance of wood when the forces acting on it tend to make one part slide over another in the direction parallel to the grain

sheath cell: a ray cell located along the side of a broad ray (> 3-seriate) as viewed in tangential section and which is larger than the central cells

shrub: a woody plant which branches from the base, all branches being equivalent

silica body: globular or amorphous conglomerate of siliceous material, generally included in parenchymatous cells

siliceous: containing silica

simple (botany): not compound, as in leaves with a single blade

sinuate: with a deep wavy margin

slash: a cut or stroke along the stem of a tree to reveal exudates and colours of bark and sapwood

sliced veneer: a thin sheet of wood cut from a stationary block of wood by a knife mounted approximately parallel with and moving to and fro across the longitudinal axis of the block

softwood: the wood of a coniferous tree

spatulate: spoon-shaped

spherical: globular

spicate: spike-like

spike: a simple indeterminate inflorescence with sessile flowers along a single axis

spine: a short stiff straight sharp-pointed hard structure arising from the wood of a stem

spinescent: ending in a spine or sharp point

spiral: as though wound round an axis

spongy heart: situation where the wood of the pith of a bole is softened by saturation with water *spur (botany)*: a hollow and slender extension of some part of the flower, usually nectariferous; a small reproductive shoot

spur root: a root projecting from the base of the trunk

spur shoot: a short projecting branch of a tree

squamose: scaly

stain: discoloration or variation from natural colour due to fungi, chemical action or other causes

stamen: one of the male reproductive organs of a flower; a unit of the androecium

staminode: an abortive or rudimentary stamen without or with an imperfect anther

standard (flower part): the fifth, posterior or upper petal of a papilionaceous corolla

stellate: star-shaped, as of hairs with radiating branches

sterile: failing to complete fertilization and produce seed as a result of defective pollen or ovules; not producing seed capable of germination; lacking functional sexual organs (sterility)

stickering: using a stick or strip of wood (sticker) to separate the layers in a stack of wood to improve air circulation during drying

stigma: the portion of the pistil which receives the pollen

stilt roots: the oblique adventitious roots of the mangrove and similar forms

stipe: the stalk supporting a carpel or gynoecium

stipel: small secondary stipule at the base of a leaflet

stipitate: borne on a stipe or short stalk

stipule: a scale-like or leaf-like appendage at the base of a petiole

stoma (plural stomata): a breathing pore or aperture in the epidermis

stone: the hard endocarp of a drupe containing the seed or seeds

storied (anatomy): of cells, arranged in horizontal series as viewed on the tangential surface

stripling: seedling stripped of all but its terminal leaves and used as planting stock

strip planting: setting trees in two or more parallel lines in a long narrow area that has been wholly or partially cleared

stump: seedling with trimmed roots and shoot and used as planting stock; also the part of a tree remaining attached to the root after the trunk has been cut

style: the part of the pistil connecting the ovary with the stigma

styloid: of crystal, elongated, typically about four times as long as broad, with pointed or square ends

styptic: tending to check bleeding

sub-: prefix, somewhat or slightly (e.g. subacute), also below (e.g. subterranean) or less than, imperfectly

subfamily: a taxonomic rank between the family and the tribe denoting a part of a family

subspecies: a subdivision of a species, in rank between a variety and a species

subulate: awl-shaped

succulent: juicy, fleshy

sucker: a shoot usually originating from adventitious buds on the roots or basal stem parts, which does not fit in the architectural model, but is capable of repeating the model

sudorific: causing or inducing sweat

sulcate: grooved or furrowed

sulphate pulp: a chemical woodpulp obtained through application of a solution of sodium hydroxyde and sodium sulphate

superior (ovary): an ovary with the perianth inserted below or around its base, the ovary being attached at its base only

suture: the line or mark of splitting open

symbiosis: the intimate living together of two dissimilar organisms in a mutually benficial relationship

sympodial: of a stem in which the growing point either terminates in an inflorescence or dies, growth being continued by a new lateral growing point

syncarp: a multiple or fleshy aggregate fruit, including fruit produced from a more or less entire inflorescence (as in *Artocarpus*)

syncope: a temporary suspension of respiration and circulation due to cerebral ischaemia

tangential: lengthwise, in a plane at right angles to the radius but not passing through the pith (see radial)

tanniferous: containing tannin

taproot: the primary descending root, forming a direct continuation of the radicle

taungya system: an agroforestry method where a forest crop is raised in conjunction with a temporary agricultural crop

taxodioid pits: a crossfield pit in earlywood with a large, ovoid to circular, included aperture that is wider than the lateral space on either side between the aperture and the border

taxon (plural taxa): a term applied to any taxonomic unit irrespective of its classification level, e.g. variety, species, genus etc.

taxonomy: the study of principles and practice of classifying living organisms (systematics)

tension wood: reaction wood formed typically on the upper sides of branches and leaning or crooked stems with an abnormally high longitudinal shrinkage tending to cause distortion and splitting
tepal: a segment of a perianth, applied when no distinction between sepal and petals can be made
teredo: see marine borer
terete: cylindrical; circular in transverse section
terminal: borne at the end or apex
termite: ant-like organism damaging wood by characteristic irregular honeycombing or wide channels with dry bore-dust or dust cemented together
terrestrial: on or in the ground
tertiary venation: generally the collection of the smallest veins of a leaf blade
tesselate: marked with a fine chequered pattern, like a mosaic
testa: the outer coat of the seed
theca (plural thecae): a spore- or pollen-case
thinning: removing trees from immature stands in order to stimulate the growth of the remaining trees
throat: of a corolla, the orifice of a gamopetalous corolla
thyrse: a compound inflorescence composed of a panicle (indeterminate axis) with the secondary and ultimate axes cymose (determinate)
tile cell: a special type of apparently empty upright ray cell of approximately the same height as the procumbent ray cells and occurring in indeterminate horizontal series usually interspersed among the procumbent cells
tissue culture: a body of tissue growing in a culture medium outside the organism
tomentose: densely covered with short soft hairs
tomentulose: slightly tomentose
tomentum: pubescence
tonic: medicinal preparation believed to have the power of restoring normal activity
torus: = receptacle
tracheid: an imperforate wood cell with bordered pits to congeneric elements
transverse: of tertiary veins, connecting the secondary veins, not necessarily in a perpendicular way
traumatic duct: canal formed in response to injury, generally irregular in outline
tree: a perennial woody plant with a single evident trunk
tribe (plural tribae): a taxonomic rank between the family and the genus
trichome: any hair, bristle or scale-like outgrowth of the epidermis
trifoliolate: with three leaflets
trigonous: three-angled
truncate: cut off more or less squarely at the end
trunk: the main stem of a tree apart from its limbs and roots
tuberculate: covered with warty protuberances
tungsten carbide: a heavy and very hard type of metal
turbinate: top-shaped
turnery: articles made by the process of turning
turning: of wood, shaping, especially in a rounded form, by applying a cutting tool while revolving in a lathe
tylosis (plural tyloses): an outgrowth of a parenchyma cell through a pit cavity in a vessel wall
ultrabasic: of soil, very low in silica and rich in ferromagnesian minerals as in e.g. serpentine soils
umbel: an indeterminate, often flat-topped inflorescence whose divergent peduncles (rays) and pedicels arise from a common point; in a compound umbel each ray itself bears an umbellule
umbellule: see umbel
umbo: a protuberance on the swollen top of the scale of a coniferous female cone or on the top of a fruit
umbonate: provided with an umbo
undulate: wavy, said for instance of a leaf margin if the waves run in a plane at right angles to the plane of the leaf blade
unilateral: one-sided
unilocular: one-celled
uniseriate: in one horizontal row or series
unisexual: of one sex, having stamens or pistils only
urceolate: urn-shaped
vacuum-pressure method (or system): = full-cell process
valvate: of perianth segments with their edges in contact, but not overlapping in the bud
valve: one of the parts produced by a dehiscing capsule
variety: botanical variety which is a subdivision of a species; an agricultural or horticultural variety is referred to as a cultivar
vascular strand: a bundle of specialized cells (vessels), consisting of xylem and phloem, sometimes with a strip of cambium
vasicentric: with parenchyma round the vessel
vein: a strand of vascular tissue in a flat organ, such as a leaf
velutinous: = velvety

velvety: with a coating of fine soft hairs; the same as tomentose but denser so that the surface resembles (and feels like) velvet
venation: the arrangement of the veins in a leaf
veneer: a thin sheet of wood
ventral: faces central axis (adaxial), opposed to dorsal
vermiculite: lightweight highly water-absorbent material, usually resulting from expansion of the granules of mica at high temperature
vermifuge: a drug serving to destroy or expel parasitic worms of the intestine
verrucose: warty
verticil: whorl
verticillate: in a whorl with several elements arising at the same node
vesicant: an agent that induces blistering
vesicular: bladder-like
vessel-parenchyma pit: pit in the wall connecting a parenchyma cell and a vessel element
vessel-ray pit: pit in the wall connecting a ray cell and a vessel element
vestigial: small and imperfectly developed
vestured pit: an intervessel pit with the pit cavity and/or aperture wholly or partially lined with projections from the secondary cell wall
viability: ability to live, grow and develop
vitreous: transparent, glassy
warp: distortion of a piece of sawn timber usually occurring during seasoning
warty: covered with firm roundish excrescences
water-logged: flooded with water, generally for a period of at least a few weeks
wayang: an Indonesian dramatic representation of mythological events in a puppet shadow play
weatherboard: board forming the exposed surface of outside walls of frame buildings
whorl: arrangement with more than two organs of the same kind arising at the same level
wildling: a seedling taken from natural regeneration to serve as planting stock
wing: any membraneous expansion attached to an organ; a lateral petal of a papilionaceous corolla
winged-aliform axial parenchyma: parenchyma surrounding or to one side of the vessel with the lateral extensions being elongated and narrow
Wolman salt: aqueous wood preservative of fluoride-phenol-chrome composition, with or without the addition of insecticidal and fire-resistant chemicals
wood-cement board: = wood-wool board
wood-wool board: a panel material in which wood shavings or shredded waste paper is bonded with inorganic cement
woolly: referring to an indumentum, clothed with long and tortuous or matted hairs
zygomorphic: irregular and divisible into equal halves in one plane only

Sources of illustrations

Acacia leucophloea: Photograph taken by R.H. M.J. Lemmens (tree habit); Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 5 (flowering branch); Nielsen, I., 1981. Leguminosae (Fabaceae) Mimosoideae. In: Aubréville, A. & Leroy, J.F. (Editors): Flore du Cambodge du Laos et du Vietnam. Fasc. 19. Muséum National d'Histoire Naturelle, Paris. p. 45, Pl. 6 (pod). Redrawn and adapted by Achmad Satiri Nurhaman.

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Cryptocarya ferrea: Photograph taken by R.H.M.J. Lemmens (tree habit); Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 212 (twig with leaf and inflorescence, infructescence); Lecomte, H., 1914. Lauracées. In: Gagnepain, F. (Editor): Flore générale de l'Indo-Chine. Vol. 5. Masson et Cie, Paris. p. 147, Fig. 13 (flower, stamen with basal glands). Redrawn and adapted by Iskak Syamsudin.

Cryptocarya nitens: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 214 (tree habit, twig with leaf and inflorescence, infructescence). Redrawn and adapted by Iskak Syamsudin.

Cryptocarya tomentosa: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 215 (habit of young tree, twig with leaf and young inflorescence, twig with infructescence). Redrawn and adapted by Iskak Syamsudin.

Dacrycarpus imbricatus: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 586 (tree habit); Keng, H. 1983. Coniferae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. 2nd edition. Vol. 1. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Kuala Lumpur. p. 50, Fig. 4 (twig with seed cones, pollen cone, seed cone). Redrawn and adapted by Achmad Satiri Nurhaman.

Dacrydium elatum: Gaussen, H., 1974. Les Gymnospermes actuelles et fossiles. Chapitre 20. Les Coniferales 12. Les Podocarpacées autres que Podocarpus ss. Travaux du Laboratoire Forestier de Toulouse. Tom. 2, Etudes dendrologiques. Vol. 1, part. II-3. p. 11, Pl. 36 (tree habit); Keng, H., 1983. Coniferae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. 2nd edition. Vol. 1. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Kuala Lumpur. p. 45, Fig. 1 (young twig); Ridley, H.N., 1925. The flora of the Malay Peninsula. Vol. 5. L. Reeve & Co., London. p. 279, Fig. 227 (mature twig with seeds, top of twig with seed). Redrawn and adapted by Iskak Syamsudin.

Dillenia excelsa: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 4 (tree habit, flowering twig, dehisced fruit). Redrawn and adapted by Iskak Syamsudin.

Dillenia obovata: Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd edition. Vol. 1. The Malayan Nature Society, Kuala Lumpur. p. 229, Pl. 54 (tree habit); Kochummen, K.M., 1972. Dilleniaceae. In: Whitmore, T.C. (Editor): Tree of flora of Malaya. 2nd edition. Vol. 1. Longman Malaysia SDN. Berhad, Kuala Lumpur. p. 189, Fig. 2 (leaf); Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 1 (flowering twig). Redrawn and adapted by Iskak Syamsudin.

Dillenia papuana: Hoogland, R.D., 1951. Dilleniaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 4. Noordhoff-Kolff N.V., Djakarta. p. 155, Fig. 8 (fruiting twig, winged petiole of young leaf, inflorescence, seed with aril). Redrawn and adapted by Iskak Syamsudin.

Dillenia reticulata: Foxworthy, F.W., 1927. Commercial timber trees of the Malay Peninsula. Malayan Forest Records No 3. Forest Department, Kuala Lumpur. Photographs opposite p. 148 and 149 (tree habit, twig with leaves, flowering branchlet). Redrawn and adapted by Iskak Syamsudin.

Diospyros celebica: Pandjaitan, F.H. & Dali, J., 1971. Hasil survey ebony, Ampibabo (Sulawesi Tengah) [Results of a survey on ebony, Ampibabo (Central Sulawesi)]. Lembaga Penelitian Hutan, Bogor. Fig. 5 (tree habit); Bakhuizen van den Brink, R.C., 1955. Revisio Ebenacearum Malayensium. Contributions à l'étude de la flore des Indes Néerlandaises XXXIII. Bulletin du Jardin Botanique de Buitenzorg Série III, 15(5): Pl. 43 (flower, fruiting calyx, lateral and dorsal view of seed); Forest Botany Division, 1972. List of tree species of Southeast Sulawesi and surroundings. Report No 151. Forest Research Insititute, Bogor (fruiting twig). Redrawn and adapted by Iskak Syamsudin.

Diospyros ferrea: Bakhuizen van den Brink, R.C., 1955. Revisio Ebenacearum Malayensium. Contributions à l'étude de la flore des Indes Néerlandaises XXXIII. Bulletin du Jardin Botanique de Buitenzorg Série III, 15(5): Pl. 1 (fruiting twig, flower, fruit). Redrawn and adapted by Iskak Syamsudin.

Diospyros philippinensis: Photograph taken by R.H.M.J. Lemmens (habit of young tree); Bakhuizen van den Brink, R.C., 1955. Revisio Ebenacearum Malayensium. Contributions à l'étude de la flore des Indes Néerlandaises XXXIII. Bulletin du Jardin Botanique de Buitenzorg Série III, 15(5): Pl. 43 (flowering twig, flower, fruit, fruiting calyx). Redrawn and adapted by Iskak Syamsudin.

Diospyros pilosanthera: Photograph taken by R.H.M.J. Lemmens (tree habit); Bakhuizen van den Brink, R.C., 1955. Revisio Ebenacearum Malayensium. Contributions à l'étude de la flore des Indes Néerlandaises XXXIII. Bulletin du Jardin Botanique de Buitenzorg Série III, 15(5): Pl. 52 (flowering twig, flower, branchlet with fruits, lateral and dorsal view of seed). Redrawn and adapted by Iskak Syamsudin.

Diospyros sumatrana: Bakhuizen van den Brink, R.C., 1955. Revisio Ebenacearum Malayensium.

Contributions à l'étude de la flore des Indes Néerlandaises XXXIII. Bulletin du Jardin Botanique de Buitenzorg Série III, 15(5): Pl. 43 (flowering twig, flower, flower bud, fruiting twig, fruits). Redrawn and adapted by Iskak Syamsudin.

Dracontomelon dao: Hou, D., 1978. Anacadiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 8. Sijthoff & Noordhoff International Publishers, Alphen aan den Rijn. p. 471, Fig. 31 (tree habit); Kraemer, J.H., 1951. Trees of the western Pacific region. Tri-State Offset Company, Cincinnatti. p. 194, Fig. 68 (branchlet with leaf); Brown, W.H., 1954. Useful plants of the Philippines. Vol. 2. Bureau of Printing, Manila. p. 335, Fig. 161 (flowering twig, flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Duabanga grandiflora: Troup, R.S., 1921. The silviculture of Indian trees. Vol. 2. Clarendon Press, Oxford. Fig. 229 (habit of young tree); Whitmore, T.C., 1983. Sonneratiaceae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. 2nd edition. Vol. 1. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Kuala Lumpur. p. 443, Fig. 1 (twig with old flowers); Vu Van Cuong, 1965. Sonneratiaceae. In: Tardieu-Blot, M.-L. (Editor): Flore du Cambodge du Laos et du Vietnam. Fasc. 4. Muséum National d'Histoire Naturelle, Paris. p. 205, Pl. 11 (inflorescence); Geesink, R., 1970. Duabanga taylorii Jayaweera (Sonneratiaceae), a putative hybrid. Blumea 18: p. 455, Fig. 1 (fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Durio carinatus: Kostermans, A.J.G.H., 1958. The genus Durio Adans. (Bombac.). Reinwardtia 4: p. 136, 137, 138, Fig. 23, 24, 25 (twig with leaves, inflorescence, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Durio dulcis: Kostermans, A.J.G.H., 1958. The genus Durio Adans. (Bombac.). Reinwardtia 4: p. 126, Fig. 13 (twig with leaves, inflorescence, part of branch with infructescence). Redrawn and adapted by Achmad Satiri Nurhaman.

Durio testudinarum: Kostermans, A.J.G.H., 1958. The genus Durio Adans. (Bombac.). Reinwardtia 4: p. 144, Fig. 31 (twig with leaves, flower, base of trunk with fruits, opened fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Dyera costulata: Photograph taken by R.H.M.J. Lemmens (tree habit); Whitmore, T.C., 1983. Apocynaceae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. 2nd edition. Vol. 2. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Kuala Lumpur. p. 14, Fig. 2 (twig with leaves); Cockburn, P.F., 1976. Trees of Sabah. Vol. 1. Sabah Forest Records No 10. Forest Department Sabah, Sandakan. p. 14, Fig. 1 (fruit, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Elmerrillia tsiampacca: Nooteboom, H.P., 1988. Magnoliaceae. In: van Steenis, C.G.G.J. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Ser. 1, Vol. 10. Kluwer Academic Publishers, Boston, Dordrecht, London. p. 597, Fig. 10 (flowering twig, twig with young infructescence). Redrawn and adapted by Iskak Syamsudin.

Fagraea fragrans: Photograph taken by R.H.M.J. Lemmens (tree habit); Leenhouts, P.W., 1962. Loganiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 6. Wolters-Noordhoff Publishing, Groningen. p. 306, Fig. 6 (twig with flowers and fruits); Koorders, S.H. & Valeton, Th., 1914. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 332 (flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Fagraea racemosa: Koorders, S.H. & Valeton, Th., 1914. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 331 (tree habit, corolla with stamens, fruit); Leenhouts, P.W., 1962. Loganiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 6. Wolters-Noordhoff Publishing, Groningen. p. 310, Fig. 9 (flowering twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Falcatifolium falciforme: de Laubenfels, D.J., 1988. Coniferales. In: van Steenis, C.G.G.J. & de Wilde, W.J.J.O (Editors): Flora Malesiana. Ser. 1, Vol. 10. Kluwer Academic Publishers, Dordrecht, Boston, London. p. 373, Fig. 22 (twig with male cone); Pilger, R., 1903. Taxaceae. In: Engler, A. (Editor): Das Pflanzenreich IV, 5, heft 18. Wilhelm Engelmann, Leipzig. p. 47, Fig. 4D, I, L (twig with young seed-bearing structure, young seed-bearing structure, mature seed). Redrawn and adapted by Iskak Syamsudin.

Gluta malayana: Hou, D., 1978. Anacardiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 8. Sijthoff & Noordhoff International Publishers, Alphen aan den Rijn. p. 455, Fig. 19 (tree habit); Kochummen, K.M., 1989. Anacardiaceae. In: Ng, F.S.P. (Editor): Tree flora of Malaya. 2nd edition. Vol. 4. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Petaling Jaya. p. 27, Fig. 4 (leaf, fruit). Redrawn and adapted by Iskak Syamsudin.

Gluta renghas: Photograph taken by R.H.M.J. Lemmens (tree habit); Prawira, S.A., 1975. Pengenalan jenis-jenis pohon ekspor, serie ke VII. [An introduction to export timber tree species, 7th series] Laporan No 214. Lembaga Penelitian Hutan, Bogor (flowering twig); Engler, A., 1883. Anacardiaceae. In: De Candolle, A. & De Candolle, C. (Editors): Monographiae Phanerogamarum. Vol. IV. G. Masson, Paris. Tab. VI (flower, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Gluta wallichii: Photograph taken by R.H.M.J. Lemmens (tree habit); Ridley, H.N., 1922. The flora of the Malay Peninsula. Vol. 1. L. Reeve & Co., London. p. 529, Fig. 52 (flower); Kessler, P.J.A. & Sidiyasa, K., 1994. Trees of the Balikpapan-Samarinda area, East Kalimantan, Indonesia. Tropenbos Series 7. The Tropenbos Foundation, Wageningen. p. 247, Fig. 5 (fruiting twig). Redrawn and adapted by Iskak Syamsudin.

Gymnacranthera bancana: Schouten, R., 1986. Revision of the genus Gymnacranthera (Myristicaceae). Blumea 31: p. 464, Fig. 3 (twig with leaves, twig with male inflorescence, sectioned male flower, branchlet with infructescence, sectioned fruit with seed and aril). Redrawn and adapted by Achmad Satiri Nurhaman.

Hevea brasiliensis: Photograph taken by R.H.M.J. Lemmens (tree habit); Van den Abeele, M. & Vandenput, R., 1951. De voornaamste cultures van Belgisch-Congo. 2nd edition. Ministerie van Koloniën, Directie voor Landbouw, Veeteelt en Kolonisatie, Brussel. p. 363, Fig. 204 (flowering twig, fruit). Redrawn and adapted by Iskak Syamsudin.

Homalium grandiflorum: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 341 (fruiting twig, flower, fruits). Redrawn and adapted by Iskak Syamsudin.

Homalium tomentosum: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 340 (tree habit, twig with leaves, twig with inflorescence, young fruit); Lescot, M., 1970. Flacourtiaceae. In: Aubréville, A. & Leroy, J.F. (Editors): Flore du Cambodge, du Laos et du Vietnam. Fasc. 11. Muséum National d'Histoire Naturelle, Paris. p. 87, Fig. 9.3 (flower). Redrawn and adapted by Iskak Syamsudin.

Kokoona ovatolanceolata: Hou, D., 1962. Celastraceae – I. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 6. Wolters-Noordhoff Publishing, Groningen. p. 259, Fig. 8 (flowering twig, flower bud, sectioned flower, opened fruit, seed). Redrawn and adapted by Iskak Syamsudin.

Koordersiodendron pinnatum: Hou, D., 1978. Anacardiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 8. Sijthoff & Noordhoff International Publishers, Alphen aan den Rijn. p. 487, Fig. 41 (flower with 1 petal removed), p. 488, Fig. 42 (tree habit); Kraemer, J.H., 1951. Trees of the western Pacific region. Tri-State Offset Company, Cincinnatti. p. 196, Fig. 69 (flowering twig, branchlet with fruits). Redrawn and adapted by Iskak Syamsudin.

Libocedrus papuana: Kalkman, C. & Vink, W., 1970. Botanical exploration in the Doma Peaks region, New Guinea. Blumea 18: p. 105, photo 3 (habit of young tree); Lauterbach, C., 1913. Beiträge zur Flora von Papuasien II. Neue Pinaceae Papuasiens. Botanische Jahrbücher, Systematik 50: p. 53, Fig. 2 (twig with leaves, pollen cone, seed-bearing structure, seed). Redrawn and adapted by Iskak Syamsudin.

Lithocarpus elegans: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 42 (tree habit); Cockburn, P.F., 1976. Trees of Sabah. Vol. 1. Sabah Forest Records No 10. Forest Department Sabah, Sandakan. p. 98, Fig. 19 (leaf); Camus, A., 1948. Les chênes. Atlas Tome III. Encyclopédie Economique de Silviculture 8. Paul Lechevalier, Paris. Pl. 482 (infructescence). Redrawn and adapted by Iskak Syamsudin.

Lithocarpus javensis: Soepadmo, E., 1972. Fagaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 7. Noordhoff International Publishing, Leiden. p. 326, Fig. 18 (tree habit); Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 46 (leaf, branchlet with inflorescence, branchlet with fruits). Redrawn and adapted by Achmad Satiri Nurhaman.

Lithocarpus rassa: Cockburn, P.F., 1976. Trees of Sabah. Vol. 1. Sabah Forest Records No 10. Forest Department Sabah, Sandakan. p. 112, Pl. 7 (trunk base); Camus, A., 1948. Les chênes. Atlas Tome III. Encyclopédie Economique de Silviculture 8. Paul Lechevalier, Paris. Pl. 400 (fruiting twig), Pl. 404 (infructescence). Redrawn and adapted by Iskak Syamsudin.

Lithocarpus sundaicus: Kraemer, J.H., 1951. Trees of the western Pacific region. Tri-State

Offset Company, Cincinnatti. p. 52, Fig. 11 (flowering twig, infructescence). Redrawn and adapted by Achmad Satiri Nurhaman.

Litsea angulata: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 224 (tree habit, flowering twig, infructescence). Redrawn and adapted by Iskak Syamsudin.

Litsea castanea: Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd edition. Vol. 1. The Malayan Nature Society, Kuala Lumpur. Pl. 73 (tree habit); Kochummen, K.M., 1989. Lauraceae. In: Ng, F.S.P. (Editor): Tree flora of Malaya. Vol. 4. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Petaling Jaya. p. 153, Fig. 9 (fruiting twig). Redrawn and adapted by Iskak Syamsudin.

Litsea monopetala: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 231 (flowering twig, umbellule of flowers, branchlet with leaf and infructescence). Redrawn and adapted by Iskak Syamsudin.

Litsea resinosa: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 236 (tree habit, fruiting twig, branchlet with fruits). Redrawn and adapted by Iskak Syamsudin.

Mangifera caesia: Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd edition. Vol. 1. The Malayan Nature Society, Kuala Lumpur. p. 116, Fig. 22, Pl. 7 (tree habit, flower); Kochummen, K.M., 1989. Anacardiaceae. In: Ng, F.S.P. (Editor): Tree flora of Malaya. Vol. 4. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Petaling Jaya. p. 34, Fig. 5 (leaf); Kostermans, A.J.G.H. & Bompard, J.-M., 1993. The mangoes. Their botany, nomenclature, horticulture and utilization. Academic Press, London. Pl. 42 (halved fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Mangifera foetida: Hou, D., 1978. Anacardiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 8. Sijthoff & Noordhoff International Publishers, Alphen aan den Rijn. p. 435, Fig. 10 (tree habit), redrawn and adapted by Achmad Satiri Nurhaman; original drawing by Achmad Satiri Nurhaman (flowering twig, fruit).

Mangifera laurina: Original drawing by Achmad Satiri Nurhaman (flowering twig, fruit).

Mangifera odorata: Original drawing by Achmad Satiri Nurhaman (flowering twig, fruit).

Mesua beccariana: Kostermans, A.J.G.H., 1956. New and critical Malaysian plants IV. Reinwardtia 4: p. 6, Fig. 3 (flowering twig), redrawn and adapted by Iskak Syamsudin; original drawing by Iskak Syamsudin (fruit).

Mesua ferrea: Photograph taken by R.H.M.J. Lemmens (tree habit); Engler, A., 1893. Guttiferae. In: Engler, A. & Prantl, K. (Editors): Die natürlichen Pflanzenfamilien III, 6. Wilhelm Engelmann, Leipzig. p. 219, Fig. 103 (flower); Whitmore, T.C., 1983. Guttiferae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. 2nd edition. Vol. 2. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Kuala Lumpur. p. 233, Fig. 9 (fruiting twig). Redrawn and adapted by Iskak Syamsudin.

Myristica fatua: Sinclair, J., 1968. Flora Malesianae Precursores - XLII. The genus Myristica in Malesia and outside Malesia. Gardens' Bulletin Singapore 23: p. 270, Fig. 30 (twig with male flowers, female flower, dehisced fruit showing seed and aril); de Wilde, W.J.J.O., 1990. Conspectus of Myristica (Myristicaceae) indigenous in the Moluccas. Blumea 35: p. 240, Fig. 1(3) (sectioned male flower). Redrawn and adapted by Iskak Syamsudin.

Myristica hollrungii: Photograph taken by R.H.M.J. Lemmens (tree habit); Sinclair, J., 1968. Flora Malesianae Precursores - XLII. The genus Myristica in Malesia and outside Malesia. Gardens' Bulletin Singapore 23: p. 406, 407, Fig. 69 (male flower, androecium, female flower, pistil, fruiting twig, seed with aril). Redrawn and adapted by Achmad Satiri Nurhaman.

Myristica maingayi: Sinclair, J., 1958. A revision of the Malayan Myristicaceae. Gardens' Bulletin Singapore 16: p. 349, Fig. 24 (twig with female flowers, female flower, sectioned female flower, fruits, seed with aril). Redrawn and adapted by Achmad Satiri Nurhaman.

Nageia wallichiana: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 588 (tree habit, twig with pollen cones, twig with mature seed). Redrawn and adapted by Iskak Syamsudin.

Nothofagus grandis: Soepadmo, E., 1972. Fagaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 7. Noordhoff International Publishing, Leiden, p. 284, Fig. 3 (tree habit), p. 293, Fig. 9 (male inflorescence, mature cupule, nut); van Steenis, C.G.G.J., 1953. Results of the Archbold expeditions, Papuan Nothofagus. Journal of the Arnold Arboretum 34: p. 364, Fig. 17 (twig with leaves). Redrawn and adapted by Achmad Satiri Nurhaman.

Nothofagus rubra: van Steenis, C.G.G.J., 1953. Results of the Archbold expeditions, Papuan Nothofagus. Journal of the Arnold Arboretum 34: p. 369–371, Fig. 20, 21, 22 (twig with leaves, stipule, male inflorescence, female flower enclosed by cupule, mature cupule). Redrawn and adapted by Achmad Satiri Nurhaman.

Ochanostachys amentacea: Foxworthy, F.W., 1927. Commercial timber trees of the Malay Peninsula. Malayan Forest Records No 3. Forest Department, Kuala Lumpur. Pl. opposite p. 119 (tree habit); Sleumer, H., 1984. Olacaceae. In: van Steenis, C.G.G.J. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Ser. 1, Vol. 10. Kluwer Academic Publishers, Dordrecht, Boston, London. p. 13, Fig. 5 (branchlet with inflorescence); Ridley, H.N., 1922. The flora of the Malay Peninsula. Vol. 1. L. Reeve & Co., London. p. 422, Fig. 42 (flower); Kessler, P.J.A. & Sidiyasa, K., 1994. Trees of the Balikpapan-Samarinda area, East Kalimantan, Indonesia. Tropenbos Series 7. The Tropenbos Foundation, Wageningen. p. 398, Fig. 149 (fruiting twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Octomeles sumatrana: van Steenis, C.G.G.J., 1953. Datiscaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 4. Noordhoff-Kolff N.V., Djakarta. p. 384, Fig. 3 (tree habit); Cockburn, P.F., 1976. Trees of Sabah. Vol. 1. Sabah Forest Records No 10. Forest Department Sabah, Sandakan. p. 25, Fig. 13 (twig with female inflorescence, dehisced fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Parishia paucijuga: Photograph taken by R.H. M.J. Lemmens (tree habit); Hou, D., 1978. Anacardiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 8. Sijthoff & Noordhoff International Publishers, Alphen aan den Rijn. p. 542, Fig. 68 (flowering twig, opened female flower, male flower, opened male flower, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Pentace excelsa: Kochummen, K.M., 1983. Tiliaceae. In: Whitmore, T.C. (Editor): Tree flora of Malaya. 2nd edition. Vol. 2. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Kuala Lumpur. p. 405, Fig. 3 (fruiting twig, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Pentace triptera: Phengklai, C., 1986. Study in Thai flora, Tiliaceae. Thai Forest Bulletin (Botany) 16: p. 73, Fig. 33 (flowering twig, fruit); Ridley, H.N., 1922. The flora of the Malay Peninsula. Vol. 1. L. Reeve & Co., London. p. 294, Fig. 28 (flower, pistil). Redrawn and adapted by Achmad Satiri Nurhaman.

Pentaspadon motleyi: Photograph taken by R.H. M.J. Lemmens (tree habit); Prawira, S.A., 1979. Pengenalan jenis-jenis pohon ekspor, serie ke IX [An introduction to export timber tree species, 9th series]. Laporan No 303. Lembaga Penelitian Hutan, Bogor. p. 25 (flowering twig, branchlet with fruits). Redrawn and adapted by Iskak Syamsudin.

Phyllocladus hypophyllus: de Laubenfels, D.J., 1988. Coniferales. In: van Steenis, C.G.G.J. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Ser. 1, Vol. 10. Kluwer Academic Publishers, Dordrecht, Boston, London. p. 358, 359, Fig. 7, 8 (twig with male cones, male cone, twig with female cones, phylloclade with femal cones, seeds). Redrawn and adapted by Iskak Syamsudin.

Podocarpus neriifolius: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 588 (habit of young tree, twig with male inflorescences, twig with seeds, mature seed with receptacle). Redrawn and adapted by Iskak Syamsudin.

Podocarpus rumphii: Gaussen, H., 1976. Les Gymnospermes actuelles et fossiles. Chapitre 21: Les Coniferales 13. Le genre Podocarpus. Travaux du Laboratoire Forestier de Toulouse. Tom. 2, Etudes dendrologiques. Vol. 1. part. II-3. p. 158, Fig. 804 (habit of young tree, twig with male inflorescences, male inflorescence). Redrawn and adapted by Iskak Syamsudin.

Prumnopitys amara: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 590, 591 (tree habit, twig with pollen cones, part of a pollen cone, twig with seeds). Redrawn and adapted by Iskak Syamsudin.

Pterocymbium tinctorium: Photograph taken by R.H.M.J. Lemmens (tree habit); de Guzman, E.D., Umali, R.M. & Sotalbo, E.D., 1986. Guide to Philippine flora and fauna. Vol. 3: Dipterocarps, non-dipterocarps. Natural Resources Management Center, Ministry of Natural Resources & University of the Philippines, Quezon City and Los Baños. p. 156, Fig. 69 (twig with leaves); Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 80 (sectioned female flower, fruit). Redrawn and adapted by Iskak Syamsudin.

Quercus gemelliflora: Photograph taken by R.H.

M.J. Lemmens (tree habit); Soepadmo, E., 1968. A revision of the genus Quercus L. subgen. Cyclobalanopsis (Oersted) Schneider in Malesia. Gardens' Bulletin Singapore 22: p. 417, Fig. 15 (fruiting branch, fruit). Redrawn and adapted by Iskak Syamsudin.

Quercus lineata: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 58 (tree habit); Soepadmo, E., 1972. Fagaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 7. Noordhoff International Publishing, Leiden. p. 397, Fig. 34 (twig with male inflorescences, male flower, twig with female flowers, female flower enclosed by cupule, fruit). Redrawn and adapted by Iskak Syamsudin.

Santiria apiculata: Leenhouts, P.W., Kalkman, C. & Lam, H.J., 1956. Burseraceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 5. Noordhoff-Kolff N.V., Djakarta. p. 235, Fig. 13 (flowering twig, opened male flower, opened female flower); Lam, H.J., 1932. Beiträge zur Morphologie der Burseraceae, insbesondere der Canarieae. Annales du Jardin Botanique de Buitenzorg 42: Tab. 14, Fig. 107F (fruit). Redrawn and adapted by Iskak Syamsudin.

Santiria rubiginosa: Leenhouts, P.W., Kalkman, C. & Lam, H.J., 1956. Burseraceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 5. Noordhoff-Kolff N.V., Djakarta p. 237, Fig. 14 (tree habit); Engler, A., 1931. Burseraceae. In: Engler, A. & Prantl, K. (Editors): Die natürlichen Pflanzenfamilien. 2nd edition. Band 19A. Wilhelm Engelmann, Leipzig. p. 453, Fig. 217 (flowering twig); Lam, H.J., 1932. The Burseraceae of the Malay Archipelago and Peninsula. Bulletin du Jardin Botanique de Buitenzorg, Série III, Vol. 12: p. 397, Pl. VII, Fig. 37 (sectioned male flower, sectioned female flower); Lam, H.J., 1932. Beiträge zur Morphologie der Burseraceae, insbesondere der Canarieae. Annales du Jardin Botanique de Buitenzorg 42: Tab. 14, Fig. 107B (fruit). Redrawn and adapted by Iskak Syamsudin.

Sterculia foetida: Photograph taken by R.H.M.J. Lemmens (tree habit); Kraemer, J.H., 1951. Trees of the western Pacific region. Tri-State Offset Company, Cincinnatti. p. 242, Fig. 88 (flowering twig, fruit, follicle in longitudinal section). Redrawn and adapted by Achmad Satiri Nurhaman.

Sterculia macrophylla: Photographs taken by R.H.M.J. Lemmens (habit of young tree, habit of mature tree); Kraemer, J.H., 1951. Trees of the western Pacific region. Tri-State Offset Company, Cincinnatti. p. 247, Fig. 89 (seedling, flowering twig, branchlet with fruits). Redrawn and adapted by Achmad Satiri Nurhaman.

Sterculia oblongata: Photograph taken by R.H. M.J. Lemmens (tree habit); Koorders, S.H. & Valeton, Th., 1914. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 414 (flowering twig, female flower, opened female flower); Cockburn, P.F., 1976. Trees of Sabah. Vol. 1. Sabah Forest Records No 10. Forest Department Sabah, Sandakan. p. 242, Fig. 52 (fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Swintonia floribunda: Tardieu-Blot, M.-L., 1962. Anacardiacées. In: Tardieu-Blot, M.-L. (Editor): Flore du Cambodge, du Laos et du Vietnam. Fasc. 2. Muséum National d'Histoire Naturelle, Paris. p. 109, Pl. IV (flowering twig, flower, stamens and pistil); Prawira, S.A., 1980. Pengenalan jenis-jenis pohon ekspor, serie ke XI [An introduction to export timber tree species, 11th series]. Laporan No 350. Lembaga Penelitian Hutan, Bogor. p. 46 (fruit). Redrawn and adapted by Iskak Syamsudin.

Swintonia minutalata: Hou, D., 1978. Anacardiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 8. Sijthoff & Noordhoff International Publishers, Alphen aan den Rijn. p. 441, Fig. 13 (flowering twig, flower, fruit). Redrawn and adapted by Iskak Syamsudin.

Syzygium buettnerianum: Hyland, B.P.M., 1983. A revision of Syzygium and allied genera (Myrtaceae) in Australia. Australian Journal of Botany, Supplementary Series No 9: p. 65, Fig. 19 (flowering twig, flower bud, sectioned flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Syzygium claviflorum: Hyland, B.P.M., 1983. A revision of Syzygium and allied genera (Myrtaceae) in Australia. Australian Journal of Botany, Supplementary Series No 9: p. 25, Fig. 8 (twig with flower buds, flower bud, sectioned flower, fruit). Redrawn and adapted by Iskak Syamsudin.

Syzygium grande: Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd edition. Vol. 2. The Malayan Nature Society, Kuala Lumpur. Pl. 182, Fig. 180 (tree habit, fruit, cross section of fruit); original drawings provided by Noorma Wati Haron (flowering twig, fruiting twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Syzygium napiforme: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 489 (tree habit, flower, fruiting twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Syzygium nervosum: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 503 (twig with old flowers, opening bud, flower, infructescence). Redrawn and adapted by Iskak Syamsudin.

Syzygium polyanthum: Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd edition. Vol. 1. The Malayan Nature Society, Kuala Lumpur. Pl. 184 (tree habit); Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 470 (twig with leaves, branchlet with inflorescence, flower, fruit). Redrawn and adapted by Iskak Syamsudin.

Syzygium pyrifolium: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 451 (tree habit, flowering twig, flower). Redrawn and adapted by Iskak Syamsudin.

Syzygium rostratum: Koorders, S.H. & Valeton, Th., 1915. Atlas der Baumarten von Java. Vol. 3. P.W.M. Trap, Leiden. Fig. 494 (tree habit, flowering twig, flower, fruit). Redrawn and adapted by Iskak Syamsudin.

Syzygium sayeri: Hyland, B.P.M., 1983. A revision of Syzygium and allied genera (Myrtaceae) in Australia. Australian Journal of Botany, Supplementary Series No 9: p. 120, Fig. 38 (twig with leaves, flowering twig, flower bud, sectioned flower). Redrawn and adapted by Iskak Syamsudin.

Terminalia brassii: Coode, M.J.E., 1978. Combretaceae. In: Womersley, J.S. (Editor): Handbooks of the flora of Papua New Guinea. Vol. 1. Melbourne University Press, Carlton. p. 66, fig. 25 (flowering twig, infructescence). Redrawn and adapted by P. Verheij-Hayes.

Terminalia catappa: Photograph taken by R.H. M.J. Lemmens (habit of leafless and flowering tree); Berhaut, J., 1974. Flore illustrée du Sénégal. Vol. 2. Ministère du Développement Rural, Direction des Eaux et Forêts, Dakar. p. 398 (flowering twig, branchlet with fruits); Lecompte, O., 1969. Combretaceae. In: Tardieu-Blot, M.-L. (Editor): Flore du Cambodge, du Laos et du Vietnam. Fasc. 10. Muséum National d'Histoire Naturelle, Paris. p. 69, Pl. 7 (flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Terminalia copelandii: Exell, A.W., 1954. Combretaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 4. Noordhoff-Kolff N.V., Djakarta. p. 580, Fig. 27 (tree habit); Coode, M.J.E., 1978. Combretaceae. In: Womersley, J.S. (Editor): Handbooks of the flora of Papua New Guinea. Vol. 1. Melbourne University Press, Carlton. p. 78, Fig. 32 (flowering twig); Cockburn, P.F., 1976. Trees of Sabah. Vol. 1. Sabah Forest Record No 10. Forest Department Sabah, Sandakan. p. 67, Fig. 12 (fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Terminalia microcarpa: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 74 (tree habit, inflorescence, flower, fruiting twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Terminalia superba: Groulez, J. & Wood, P.J., 1985. Terminalia superba, a monograph. Commonwealth Forestry Institute, University of Oxford & Centre Technique Forestier Tropical, Nogent-sur-Marne. p. 14, Fig. 10 (tree habit); Berhaut, J., 1974. Flore illustrée du Sénégal. Vol. 2. Ministère du Développement Rural, Direction des Eaux et Forêts, Dakar. p. 414 (inflorescence); Voorhoeve, A.G., 1965. Liberian high forest trees. Pudoc, Wageningen. p. 87, Fig. 7 (flower, fruiting twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Toona sureni: Koorders, S.H. & Valeton, Th., 1913. Atlas der Baumarten von Java. Vol. 1. P.W.M. Trap, Leiden. Fig. 168 (tree habit); Mabberley, D.J. & Pannell, C.M., 1989. Meliaceae. In: Ng, F.S.P. (Editor): Tree flora of Malaya. Vol. 4. Malayan Forest Records No 26. Longman Malaysia SDN. Berhad, Petaling Jaya. p. 257, Fig. 11 (flowering twig, sectioned flower, infructescence, seed). Redrawn and adapted by Iskak Syamsudin.

Triomma malaccensis: Leenhouts, P.W., Kalkman, C. & Lam, H.J., 1956. Burseraceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Ser. 1, Vol. 5. Noordhoff-Kolff N.V., Djakarta. p. 212, Fig. 2C (fruit), p. 219, Fig. 7 (tree habit), Fig. 8 (sectioned male flower, female flower); Cockburn, P.F., 1976. Trees of Sabah. Vol. 1. Sabah Forest Records No 10. Forest Department Sabah, Sandakan. p. 50, Fig. 9 (flowering twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Vitex cofassus: Henderson, C.P. & Hancock, I.R., 1989. A guide to the useful plants of Solomon Islands. Research Department, Ministry of Agriculture and Lands, Honiara. p. 189, Fig. 69 (tree habit); Fundter, J.M. & Wisse, J.H., 1977. 40 belangrijke houtsoorten uit Indonesisch Nieuw Guinea (Irian Jaya) met de anatomische en technische kenmerken. Mededelingen Landbouwhogeschool Wageningen 77-9: p. 208 (flowering twig, flower in front view and side view, infructescence). Redrawn and adapted by Iskak Syamsudin.

Vitex pinnata: Koorders, S.H. & Valeton, Th., 1914. Atlas der Baumarten von Java. Vol. 2. P.W.M. Trap, Leiden. Fig. 294, 295 (tree habit, leaf, flower, fruiting twig). Redrawn and adapted by Iskak Syamsudin.

Wrightia pubescens: Ngan, P.T., 1965. A revision of the genus Wrightia (Apocynaceae). Annals of the Missouri Botanical Garden 52: p. 151, Fig. 9 (flowering twig, sectioned flower); Koorders, S.H. & Valeton, Th., 1916. Atlas der Baumarten von Java. Vol. 4. P.W.M. Trap, Leiden. Fig. 627 (fruit, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Sources of photographs

Acacia mangium: photographs by J. Ilic
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Azadirachta excelsa: photographs by S. Noshiro
Beilschmiedia lucidula: photographs by S. Noshiro
Bischofia javanica: transverse section photograph by E. Wheeler, radial and tangential section photographs by R.W. den Outer
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Canarium luzonicum: photographs by R.B. Miller
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Wrightia laevis: photographs by S. Sudo

Index of scientific plant names

Page numbers printed in bold refer to main treatment.

Index of vernacular plant names

Page numbers printed in bold refer to main treatment. For transcriptions of Vietnamese names, see at the end of the index.

Transcriptions of Vietnamese characters

[aa] = â	[ar] = ả	[ax] = ã	[ej] = ẹ	[oo] = ô	[ow] = ơ	[uj] = ụ	[uwx] = ữ
[aaf] = ầ	[as] = á	[ee] = ê	[er] = ẻ	[oof] = ồ	[owf] = ờ	[ur] = ủ	[ux] = ũ
[aaj] = ậ	[aw] = ă	[eef] = ề	[es] = é	[ooj] = ộ	[ooj] = ợ	[us] = ú	
[aar] = ẩ	[awf] = ằ	[eej] = ệ	[ex] = ẽ	[oor] = ổ	[owr] = ở	[uw] = ư	
[aas] = ấ	[awj] = ặ	[eer] = ể	[if] = ì	[oos] = ố	[ows] = ớ	[uwf] = ừ	
[aax] = ẫ	[awr] = ẳ	[ees] = ế	[is] = í	[oox] = ỗ	[owx] = ỡ	[uwj] = ự	
[af] = à	[aws] = ắ	[eex] = ễ	[of] = ò	[or] = ỏ	[ox] = õ	[uwr] = ử	
[aj] = ạ	[awx] = ẵ	[ef] = è	[oj] = ọ	[os] = ó	[uf] = ù	[uws] = ứ	

The Prosea Foundation
(Plant Resources of South-East Asia)

Name, location, legal status and structure

- Prosea is a Foundation under Indonesian law, with an international charter, domiciled in Bogor. It is an autonomous, non-profit, international agency, governed by a Board of Trustees. It seeks linkage with existing regional and international organizations;
- Prosea is an international programme focusing on the documentation of information on plant resources of South-East Asia;
- Prosea consists of a Network Office at Bogor (Indonesia) coordinating 6 Country Offices in South-East Asia, and a Publication Office in Wageningen (the Netherlands).

Participating institutions

- Forest Research Institute of Malaysia (FRIM), Karung Berkunci 201, Jalan FRI Kepong, 52109 Kuala Lumpur, Malaysia;
- Indonesian Institute of Sciences (LIPI), Widya Graha, Jalan Gatot Subroto 10, Jakarta 12710, Indonesia;
- Institute of Ecology & Biological Resources (IEBR), Nghia Do, Tu Liem, Hanoi, Vietnam;
- Papua New Guinea University of Technology (UNITECH), Private Mail Bag, Lae, Papua New Guinea;
- Philippine Council for Agriculture, Forestry and Natural Resources Research & Development (PCARRD), Los Baños, Laguna, the Philippines;
- Thailand Institute of Scientific and Technological Research (TISTR), 196 Phahonyothin Road, Chatuchak, Bangkok 10900, Thailand;
- Wageningen Agricultural University (WAU), Costerweg 50, 6701 BH Wageningen, the Netherlands.

Objectives

- to document and make available the existing wealth of information on the plant resources of South-East Asia for education, extension work, research and industry;
- to make operational a computerized data bank on the plant resources of South-East Asia;
- to publish the results in the form of an illustrated, multi-volume handbook in English;
- to promote the dissemination of the information gathered.

Target groups

- those professionally concerned with plant resources in South-East Asia and working in education, extension work, research and commercial production (direct users);
- those in South-East Asia depending directly on plant resources, obtaining relevant information through extension (indirect users).

Activities

- the establishment and operation of data bases;
- the publication of books;
- the sponsorship, support and organization of training courses;
- research into topics relevant to Prosea's purpose;
- the publication and dissemination of reports and the research results.

Implementation

The programme period has been tentatively divided into 3 phases:
- preliminary phase (1985–1986): publication of 'Plant Resources of South-East Asia, Proposal for a Handbook' (1986);
- preparatory phase (1987–1990): establishing cooperation with South-East Asia through internationalization, documentation, consultation and publication; reaching agreement on the scientific, organizational and financial structure of Prosea;
- implementation phase (1991–2000): compiling, editing and publishing of the handbook; making operational the computerized data bank with the texts and additional information; promoting the dissemination of the information obtained.

Documentation

A documentation system has been developed for information storage and retrieval called SAPRIS (South-East Asian Plant Resources Information System). It consists of 6 data bases:
- BASELIST: primarily a checklist of more than 6200 plant species;
- CATALOG: references to secondary literature;
- PREPHASE: references to literature from South-East Asia;
- ORGANYM: references to institutions and their research activities;
- PERSONYM: references to specialists;
- TEXTFILE: all Prosea publications and additional information.

Publication

The handbook in blue cover (hardbound) is distributed by Backhuys Publishers, Leiden (formerly by Pudoc, Wageningen). The handbook in green cover (paperback) is distributed in two price-classes: a low-price paperback, distributed by Prosea South-East Asia for all developing countries; a medium-price paperback, distributed by Backhuys Publishers, Leiden, for developed countries (becoming available two years after publication of the hardbound edition). The bibliographies are distributed by Prosea South-East Asia.

The handbook
- No 1. Pulses. L.J.G. van der Maesen and Sadikin Somaatmadja (Editors). Pudoc, Wageningen. 1989/ESCAP CGPRT Centre, Bogor. 1990 (out of print)/Prosea, Bogor. 1992.
- No 2. Edible fruits and nuts. E.W.M. Verheij and R.E. Coronel (Editors). Pudoc, Wageningen. 1991/Prosea, Bogor. 1992.
- No 3. Dye and tannin-producing plants. R.H.M.J. Lemmens and N. Wulijarni-Soetjipto (Editors). Pudoc, Wageningen. 1991/Prosea, Bogor. 1992 (out of print)/ Prosea, Bogor. 1994.
- No 4. Forages. L. 't Mannetje and R.M. Jones (Editors). Pudoc, Wageningen. 1992/Prosea, Bogor. 1992.
- No 5(1). Timber trees. Major commercial timbers. I. Soerianegara and R.H.M.J. Lemmens (Editors). Pudoc, Wageningen. 1993/Prosea, Bogor. 1994.
- No 5(2). Timber trees. Minor commercial timbers. R.H.M.J. Lemmens, I. Soerianegara and Wong Wing Chong (Editors). Backhuys Publishers, Leiden. 1995/Prosea, Bogor. 1995.
- No 5(3). Timber trees. Lesser-known timbers. M.S.M. Sosef, L.T. Hong and I. Soerianegara (Editors). (expected publication date 1997).
- No 6. Rattans. J. Dransfield and N. Manokaran (Editors). Pudoc, Wageningen. 1993/Prosea, Bogor. 1994.
- No 7. Bamboos. S. Dransfield and E.A. Widjaja (Editors). Backhuys Publishers, Leiden. 1995/Prosea, Bogor. 1995.
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- No 12. Medicinal and poisonous plants.
- No 13. Spices.
- No 14. Vegetable oils and fats.
- No 15. Cryptogams. W.F. Prud'homme van Reine and M.A. Rifai (Editors). (expected publication date 1996).
- No 16. Stimulants.
- No 17. Fibre plants.
- No 18. Plants producing exudates.
- No 19. Essential-oil plants.
- No 20. Ornamental plants.

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geningen. 1993.
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- Bibliography 5(1): Timber trees: Major commercial timbers. Edition 1. Part 1 and part 2. Sarkat Danimihardja and Soedarsono Riswan (Editors). Prosea, Bogor/Pudoc, Wageningen. 1994.

Miscellaneous
- A Selection. E. Westphal and P.C.M. Jansen (Editors). Pudoc, Wageningen. 1989/Prosea, Bogor. 1993.
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- Proceedings of the First Prosea International Symposium, May 22–25, 1989. Jakarta, Indonesia. J.S. Siemonsma and N. Wulijarni-Soetjipto (Editors). Pudoc, Wageningen. 1989. (out of print).

In brief, Prosea is

- an international programme, focused on plant resources of South-East Asia;
- interdisciplinary, covering the fields of agriculture, forestry, horticulture and botany;
- a research programme, making knowledge available for education and extension;
- ecologically focused on promoting plant resources for sustainable tropical land-use systems;
- committed to conservation of biodiversity;
- committed to rural development through diversification of resources and application of farmers' knowledge.

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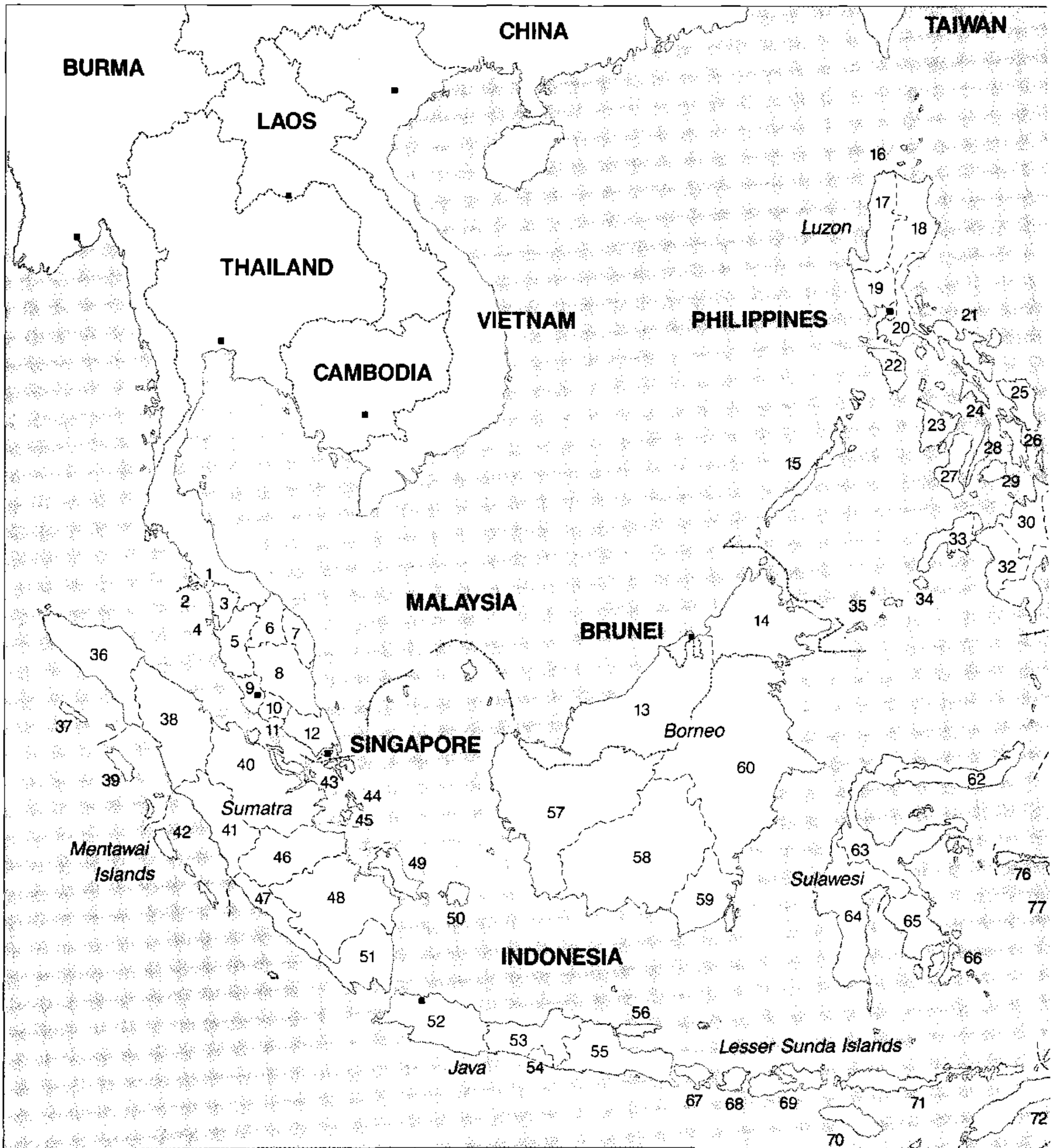
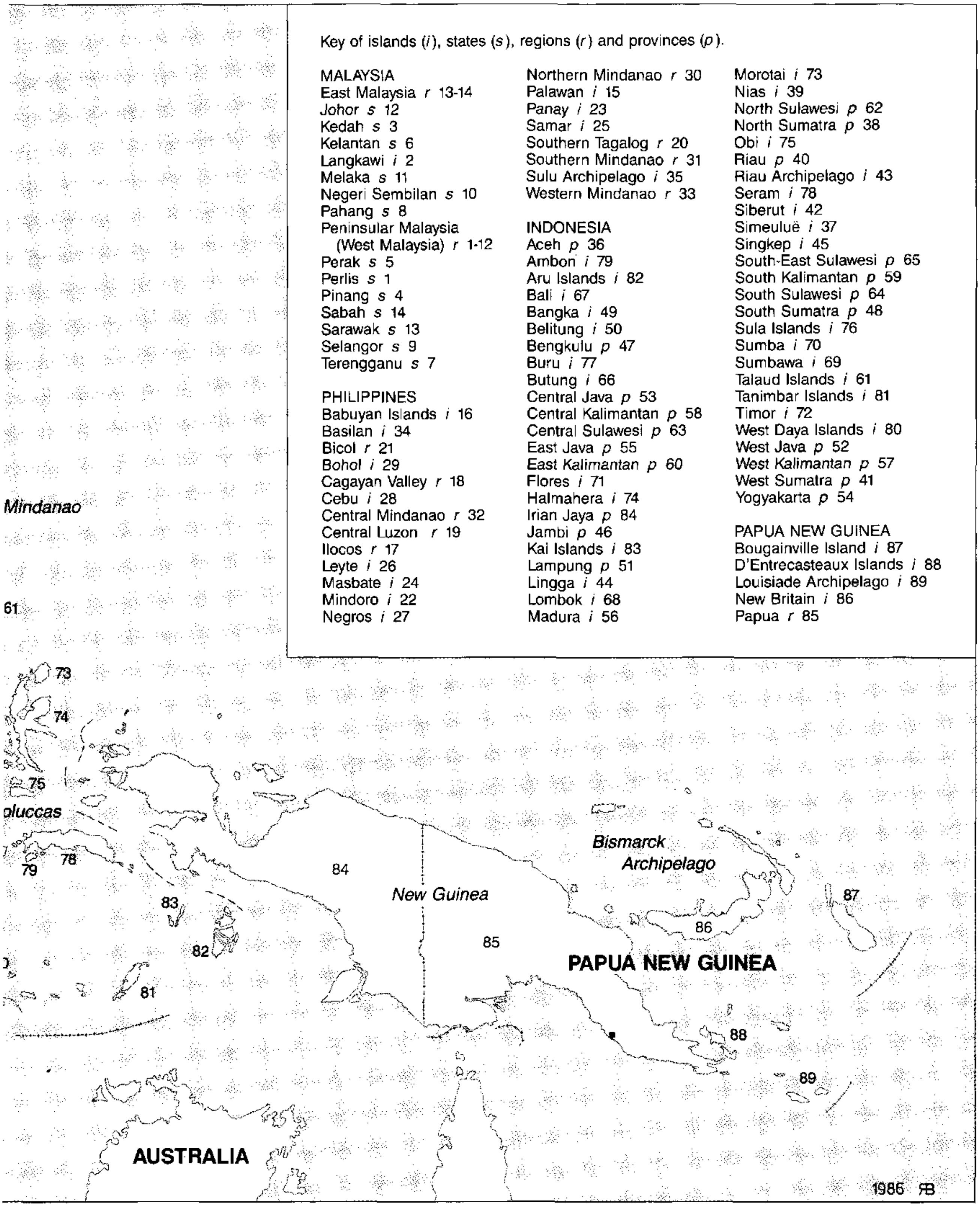


MAP OF SOUTH-EAST ASIA FOR PROSEA

Names of countries in capital letters and islands in lower case; numbers refer to the key.



Key of islands (*i*), states (*s*), regions (*r*) and provinces (*p*).

MALAYSIA
East Malaysia *r* 13-14
Johor *s* 12
Kedah *s* 3
Kelantan *s* 6
Langkawi *i* 2
Melaka *s* 11
Negeri Sembilan *s* 10
Pahang *s* 8
Peninsular Malaysia
(West Malaysia) *r* 1-12
Perak *s* 5
Perlis *s* 1
Pinang *s* 4
Sabah *s* 14
Sarawak *s* 13
Selangor *s* 9
Terengganu *s* 7

PHILIPPINES
Babuyan Islands *i* 16
Basilan *i* 34
Bicol *r* 21
Bohol *i* 29
Cagayan Valley *r* 18
Cebu *i* 28
Central Mindanao *r* 32
Central Luzon *r* 19
Ilocos *r* 17
Leyte *i* 26
Masbate *i* 24
Mindoro *i* 22
Negros *i* 27
Northern Mindanao *r* 30
Palawan *i* 15
Panay *i* 23
Samar *i* 25
Southern Tagalog *r* 20
Southern Mindanao *r* 31
Sulu Archipelago *i* 35
Western Mindanao *r* 33

INDONESIA
Aceh *p* 36
Ambon *i* 79
Aru Islands *i* 82
Bali *i* 67
Bangka *i* 49
Belitung *i* 50
Bengkulu *p* 47
Buru *i* 77
Butung *i* 66
Central Java *p* 53
Central Kalimantan *p* 58
Central Sulawesi *p* 63
East Java *p* 55
East Kalimantan *p* 60
Flores *i* 71
Halmahera *i* 74
Irian Jaya *p* 84
Jambi *p* 46
Kai Islands *i* 83
Lampung *p* 51
Lingga *i* 44
Lombok *i* 68
Madura *i* 56
Morotai *i* 73
Nias *i* 39
North Sulawesi *p* 62
North Sumatra *p* 38
Obi *i* 75
Riau *p* 40
Riau Archipelago *i* 43
Seram *i* 78
Siberut *i* 42
Simeuluë *i* 37
Singkep *i* 45
South-East Sulawesi *p* 65
South Kalimantan *p* 59
South Sulawesi *p* 64
South Sumatra *p* 48
Sula Islands *i* 76
Sumba *i* 70
Sumbawa *i* 69
Talaud Islands *i* 61
Tanimbar Islands *i* 81
Timor *i* 72
West Daya Islands *i* 80
West Java *p* 52
West Kalimantan *p* 57
West Sumatra *p* 41
Yogyakarta *p* 54

PAPUA NEW GUINEA
Bougainville Island *i* 87
D'Entrecasteaux Islands *i* 88
Louisiade Archipelago *i* 89
New Britain *i* 86
Papua *r* 85