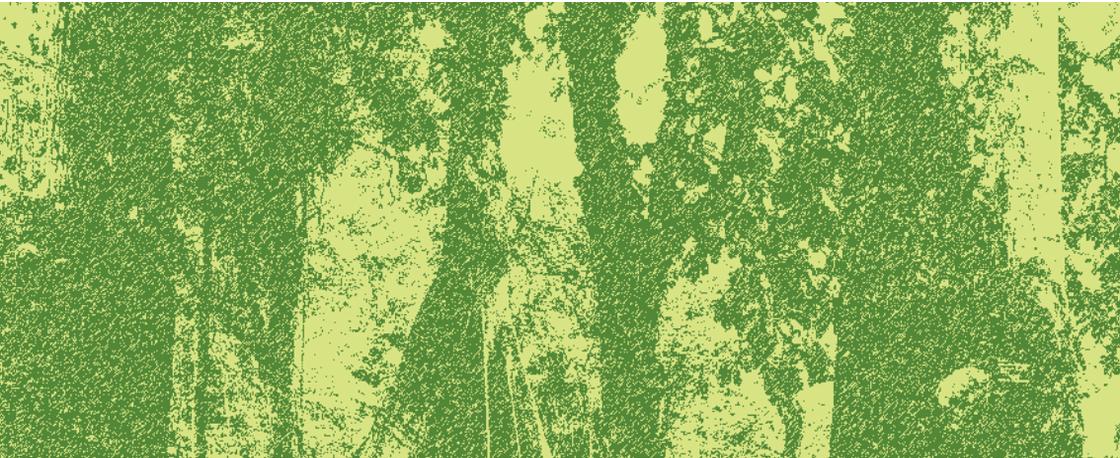


Tropical trees, of Indonesia

- A Field Guide to Tropical Trees -

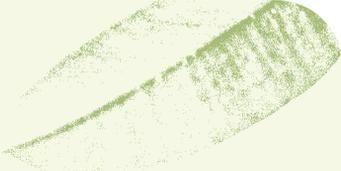


Moon HK, Ujang SI, Park SY, Park CH, Yi JS



KOREA FOREST
RESEARCH INSTITUTE

Preface



The vast green forests are our greatest natural resource. To meet the target of further plantations, a master plan for overseas forest resources was developed in 2007 by Korea Forest Service (KFS). The KFS is continuing its efforts to expand overseas plantations to 1 million ha by 2050, so as to meet the domestic demand for timber. Since the main objective of overseas forest resources development is to secure stable timber supply so most development plans are towards commercial forests, plantations to earn carbon credits and bio-energy.

In an attempt to meet those goals, KFS and 'Ministry of Forestry, Indonesia' signed a MOU for 'Afforestation and A/R Clean Development Mechanism (CDM) Investment Cooperation' to establish the artificial forestations (500,000ha) in rainforest areas of Indonesia. KFS had earlier conducted a Korea International Cooperation Agency (KOICA) project entitled 'Seed Sources and Nursery Technology Development (SSNTDP)' in Indonesia in 2007.

To follow up the research for the evaluation and utilization of the massive rainforest resources collected during SSNTDP project, the 1st phase research collaboration (2008-2010) was started between Korea Forest Research Institute (KFRI) and Forest Research and Development Agency (FORDA) of Indonesia, for rainforest afforestation and wasted area restoration, and the 2nd phase collaboration (2011-2015) is now in progress.

As one of the fruitful results from 1st phase research collaboration, this book has come out. The book is published to provide the readers to fundamental information regarding the genetic resources of tropical trees growing in Indonesia. Although Indonesia has countless varieties of trees, this book contains information regarding the principal commercial species on 36 families and 86 species of tropical trees.

I wish to thank and formally acknowledge the KFRI researchers and other authors who have dedicated themselves in publishing this book despite difficult circumstances. With the publication of this book, I hope the book will serve an invaluable role in understanding of tropical trees, tropical forest management, and its utilization.

Director General **Dr. Koo Gil Bon**

발간사

드넓게 펼쳐진 방대한 푸른 숲은 우리의 가장 큰 자원입니다. 산림청은 우리나라의 미래 산림 자원을 확보하기 위해 1993년부터 해외조림을 시작하여 2007년 수립한 해외조림 기본계획을 통해 2050년까지 1백만 헥타르에 이르는 방대한 토지에 해외조림을 실시할 계획에 있습니다. 해외조림 사업은 21세기 화두로 떠오르고 있는 탄소배출권을 확보하고 안정적인 목재공급원을 확보하는데 그 중요성이 있다고 하겠습니다.

이러한 노력의 일환으로 산림청과 인도네시아 산림부는 2006년 '조림투자외 A/R CDM사업'의 양자간 양해각서를 체결하고 인도네시아에 50만 헥타르 인공조림을 실시하기로 협의하고, 한국국제협력단(KOICA)과 인도네시아에 '종자공급과 양묘기술 개발사업(Seed Sources and Nursery Technology Development Project; SSNTDP)'을 추진한 바 있습니다. SSNTDP 사업의 후속으로 국립산림과학원은 인도네시아 산림부 산하 연구개발청과 국제공동연구를 수행하였고 그 1단계 공동연구의 결과물로 본 서를 발간하게 되었습니다.

이 책은 인도네시아에서 자생하는 다양한 수목 중 우리에게 다소 생소하지만 산업적으로 가치가 있는 36속 86여종의 열대수종들을 소개하고 있습니다. 책에서는 각 수종들의 지리적 분포, 특성, 번식방법과 함께 이용방안 등을 소개하고 있으며, 독자들의 이해를 돕기 위해 저자들이 인도네시아에서 직접 촬영한 사진들을 되도록 많이 포함시키려고 노력하였습니다.

이 책은 국내에서 처음으로 발간되는 열대수종 전문서로 앞으로 해외조림을 위해 인도네시아 등 열대지역에 진출할 국내기업들과 현지관계자들이 열대수종을 이해하고 이용하는데 큰 도움이 되리라 생각합니다.

끝으로 본 책이 발간되기까지 노고를 아끼지 않은 국립산림과학원 관계자들과 저자 분들의 노고에 깊은 감사를 드립니다.

국립산림과학원 원장

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FAMILY **ANACARDIACEAE**



Tropical trees of Indonesia

01. *Dracontomelon dao* (Blanco) Merr. & Rolfe

Dracontomelon dao is a member of Anacardiaceae family. The vernacular names of this species are; Indonesia: dahu (general), sengkuang (Kalimnatan), 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: kakh, sang-kuan (Peninsular), phrachao ha phra ong (Chiang Mai). The synonyms of this species are: *Dracontomelon mangiferum* Blume (1850), *Dracontomelon sylvestre* Blume (1850), *Dracontomelon puberulum* Miq. (1861), *Dracontomelon edule* (Blanco) Skeels (1912). Detailed descriptions of *Dracontomelon dao* are as follows:



a. Distribution

D. dao has the largest area of distribution; India, Burma (Myanmar), Thailand, Cambodia, southern China, throughout the Malesian area toward the Solomon Islands.

b. Observation

A large tree up to 45m tall, bole branchless for up to 20m, up to 100cm in diameter, with narrow buttresses up to 6m high, bark surface irregularly scaly, grayish-brown with brown or greenish patches, inner bark pink to red; leaf rachis 6-25cm long, leaflets 9-19, alternate to opposite, 4.5-20cm x 2-7cm, glabrous or sometimes pubescent below, with hairy domatia; flowers 7-10mm long, in penicles of up to 50cm long, disk puberulous; fruit globose, 5-celled. *D. dao* occurs in primary or secondary evergreen to semideciduous 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 1,000m altitude. The density of the wood is 370-790 kg/m³ at 15% moisture content.

c. Growth and development

Young trees of *D. dao* reach a height of 3-4m after 2 years and 6.5m 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 appears. However, *D. dao* is also reported to bear flowers almost throughout the year.

D. 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.

d. Ecology

Dracontomelon species occur scattered in primary or secondary, evergreen or semi-deciduous (monsoon) forest at low altitude, rarely at 500-1,000m 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 1,800-2,900mm. The species are found on well drained to poorly drained soils, mainly on alluvial flats and in swampy areas.

e. Propagation and planting

The species propagate 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 flesh 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 flesh seed of *D. dao* is reported to germination takes 28-67 days. Seedlings can be planted out without problems. In trial plantations in Java where direct sowing had been practiced, 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 spacing of 1m x 3m. When clearing land for shifting cultivation, trees may be retained for their fruit production.

Basal trunk



f. Silviculture and management

In the Philippines stands of natural forest have been encountered with 8-10 trees per ha over 20m tall. In the Bismarck Archipelago (Papua New Guinea), *D. dao* may contribute up to 7% of the total volume of commercial standing timber (trees over 50cm in diameter) with an average of 30 m³/ha.

D. dao regenerates easily in abandoned agricultural plots. The canopy of plantation of *D. dao* planted at 1m x 3m 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.

g. Uses

D. dao is the main source of dao timber. The tree is planted as an ornamental in roadside plantings. The fruit is edible but considered inferior and eaten mostly by children; 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).

FAMILY **ANNOCACEAE**



Tropical trees of Indonesia

02. *Cananga odorata* (Lam.) Hook. F. & Thoms.

Cananga odorata is a species of Annonaceae family. The vernacular names of this species are; *canang odorant* (French); chiráng, irang (Palau); derangerang, derangirang (Nauru); ilahnglahng, ilanlang (Kosrae); ilang-ilang, alang-ilang (Guam, CNMI); ilangilang, lengileng, alangilang, pur-n-wai, pwurenwai, seir en wai (Pohnpei); ilanilan (Marshall Islands); lanalana (Hawai'i); makosoi, mokohoi, makasui, mokosoi (Fiji); mohokoi (Tonga); moso'oi (Samoa); moto'i (Society Islands); moto'oi, mata'oi, mato'oi (Cook Islands, Niue, Tahiti); motoi (Marquesas–Nukuhiva, Niue); mutui (Marquesas–Fatuiva); pwalang (Puluwat Atoll); pwanang, pwuur, pwalang (Chuuk); sa'o (Solomon Islands: Kwara'ae); ylang ylang, perfume tree, cananga (English). Detailed descriptions of *Cananga odorata* are as follows:



a. Origin and geographic distribution

Distribution common throughout Polynesia, Micronesia, and Melanesia; also present throughout its native Indo-Malayan region, and now distributed pantropically.

Native range

Ylang-ylang is native to Indo-Malaysia and has been widely introduced by Polynesians, Micronesians, and early European explorers into many islands in the Pacific, where in some places it has become naturalized (e.g., Samoa).

Current distribution

There is a degree of uncertainty concerning the antiquity of ylang-ylang in Polynesia. Whistler (1991) noted that the species was probably present in Samoa in pre-European times, but because the Cook expeditions did not visit Samoa, and the species was not collected in western Polynesia until 1839, its status is not clear. Thaman et al. (1994) consider the species to be an aboriginal introduction into Polynesia. Thaman (1993) also suggested that the species is possibly native to the Solomon Islands and the Caroline Islands. However, Fosberg et al. (1979) stated that the species is a European introduction into various places in Micronesia. Moreover, the species is not listed for Yap State, but it is found on the other high islands of Micronesia. According to Merlin et al. (1992), this species is recently introduced to Pohnpei, occurring with early European contact, and is also believed to be recently (European) introduced to Nauru and the Mariana islands. It was introduced

into Guam from the Philippines. The species is also classified as a recent introduction in New Caledonia. It has also been introduced to tropical America (e.g., Costa Rica). In the Pacific, ylang-ylang is now found in the Mariana Islands (Saipan, Rota, Guam), Nauru, Caroline Islands (Palau, Koror, Faraulep, Chuuk, Pohnpei, Puluwat Atoll), Fiji, Tonga, Samoa, New Caledonia (rare), Hawai'i (rare), Cook Islands, Marquesas Islands, and many other small islands.

b. Uses

In the Pacific, this species has multiple uses. The wood is often used for canoe parts, small canoes, furniture, fuelwood, and cordage. More importantly, the fragrant flowers are used to scent coconut oil and in making lei and warmwars.

Medicinal

The bark is used in Tonga and Samoa to treat stomach ailments and sometimes as a laxative. In Java, the dried flowers are used against malaria, and the fresh flowers are pounded into a paste to treat asthma. A distillate of the flowers is said to have medicinal value by herbalists and aromatherapists. Aromatherapists claim that oil is useful for depression, distressed breathing, high blood pressure, anxiety, aphrodisiac, etc.

Flavoring/spice

The distilled oils are sometimes used to flavor beverages and foods.

Timber

The timber is pinkish, yellowish to light gray, non-



Flower

Fruits

Basal trunk

durable, and vulnerable to termite attack. The wood is coarse textured and straight grained. In Tonga and Samoa it is used for general construction and canoe making. The timber is used for furniture in Cook Islands. The wood is also used for lathe turnings, boxes and crates, clogs/wooden shoes, and fishnet floats.

Fuelwood

The wood is occasionally used for fuelwood.

Craft wood/tools

It is a minor wood for tool handles.

Canoe/boat/raft making

The wood is employed in canoe making in Samoa and Tonga.

Rope/cordage/string

The bark has very minor use for cordage. In Sulawesi, the bark is beaten to make coarse rope.

Body ornamentation/garlands

The tree is a very important source of flowers in Micronesia and Polynesia. The very heavily scented flowers are used for garlands, head dresses and other personal adornment.

Cosmetic/soap/perfume

The primary commercial product is the distilled oil

for the perfume industry, much of which is shipped to France. Ylang-ylang oil is said to be the basis for Chanel #5 and perfumes by Guerlain. Ylang-ylang is often used as a scent for coconut oil in the Pacific islands. The special name of potea is reserved for this scented oil in Tonga. When used in moderation, the oil is non-toxic and non-irritant. However, the oil is an allergen and has been removed from some cosmetics. During the mid-1900s, ylang-ylang was used in a popular hair pomade manufactured in Hawaii. Cananga oil mixed with coconut oil is called Macassar oil and used for hair dressing in Southeast Asia.

Ceremonial/religious importance

The tree has minor ceremonial importance. While the plant may be a recent introduction to Tonga, ylang-ylang (mohokoi) is categorized there as a culturally important or sacred plant (akau kakala), along with other sacred or culturally important indigenous plants.

c. Descriptions

Flowers

It flowers throughout the year in axillary, umbellate hanging clusters of 4–12 flowers. The flower has three sepals and six petals up to 8cm (2.4in) long. The petals are twisted when young, then limp and drooping when mature. Flowers are very fragrant, greenish yellow at first, then turning a

deep yellow/yellow brown when mature. Merlin et al. (1993) stated that on Kosrae this plant flowers at the same time as other fruit or nut trees, e.g., breadfruit, pandanus, mango, and Tahitian chestnut (*Inocarpus fagifer*). In Madagascar, the trees flower year-round, but mainly during the rainy season from November to March.

Leaves

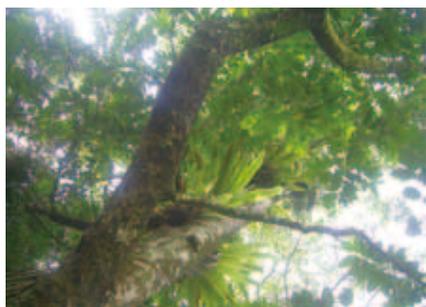
Leaves are dark green, up to 20cm (8in) in length, alternate, simple, entire, elliptic-oblong, slightly pubescent, and with a prominent midrib and drip tip. As with most members of this family, the leaves are arranged mainly along a plane.

Fruits

Greenish black in color, 1.5–2.5cm in length, containing 6–12 stalked fruitlets, fleshy, olive-like, and borne in axillary clusters. There are 6–12 small, pale brown, flattened ovoid seeds in each fruit.

d. Growth and development

Ylang-ylang is classified as a fast grower, more than 2m per year in its early years. It is a spontaneous species in secondary forest fallows.



e. Propagation and planting

Ylang-ylang is commonly propagated by seed. It can also be propagated by cuttings, with varying degrees of success. Direct-seeding in the field is also commonly practiced, which avoids damage to ylang-ylang's long taproot. Another method is to collect small seedlings (10–20cm, 4–8in) from under trees in the wild, and grow them out in bags for 2–3 months prior to outplanting.

f. Silviculture and management

The major commercial product is ylang-ylang oil, which has been produced in the Philippines since the early 1,900s. The Comoro Islands and Madagascar are major producers of this oil. In the Pacific islands, the tree is mainly grown for flowers to be used in garlands and other personal adornment. Leis from ylang-ylang are commonly sold in Samoa in the marketplace and by children outside dances and night clubs.

Spacing

Typical spacing in a commercial ylang-ylang plantation is 6m x 6m. Closer spacing may result in overcrowding and reduced productivity on lower limbs due to shading.

Management objectives and design considerations

To allow for ease of harvesting the flowers, the tree is topped at 3m after 2–3 years of growth. This allows for plenty of light to reach the branches



Leaf

that droop naturally or are tied down to pegs in the ground. After first opening, the flowers have no fragrance. Most fragrance develops 15–20 days after opening, when the flower has turned from green to yellow. Flowers are best collected in the early morning hours before much of the fragrance dissipates.

Spacing/density of species

The plantation was laid out on a 4m x 4m spacing. However, by the end of the project (3 years) it was obvious that the trees were spaced too closely (branches of adjoining trees were intertwined). Since the project was abandoned, no action was taken and the plantation was allowed to revert to secondary forest. Local farmers were less enthusiastic about planting new trees, with most converting their plantations to secondary forest, topping the existing wild ylang-ylang trees, and planting yam under the other tree species, which they ringbarked. They also interplanted banana in their plantations.

g. Diseases and pests

Little is known about pests and diseases of ylang-ylang and none are currently reported from the Pacific islands. Reported problems include stem borers, flower-eating beetles, and insects that cause leaves to wilt.

h. Yield

Topped trees of cv. group ylang-ylang rarely produce more than 20kg of flowers per year. The flowers yield about 1–2% distilled volatile oil. In Madagascar, mainly at Nosy Bé, 500 ha produced 800,000kg of flowers which yielded 20,000kg of essential oil per year. In the Comoro Islands, 1ha produced 900–1,500kg flowers equivalent to 18–30kg oil distillate.



FAMILY **APOCYNACEAE**



Tropical trees of Indonesia

03. *Alstonia scholaris* (L.) R.Br.

Alstonia scholaris belongs to the family of Apocynaceae. The synonyms of this species are *Echites scholaris* L., *Tabernaemontana alternifolia* Burm and *Echites pala* Ham. The vernacular names of *Alstonia scholaris* are; white cheesewood, milk wood pine, blackboard tree (En). Brunei: pulai lilin. Indonesia: pulai (general), pule (Java), rite (Ambon). Malaysia: pulai (Peninsular). Papua New Guinea: white cheesewood, milky pine. Philippines: dita (general), dalipaoen. Burma: lettok. Laos: tinpet. Thailand: sattaban, teenpet (central), hassaban (Kanchanaburi). Vietnam: c[aa]y m[of] cua, c[aa]y s[uwx]a. Detailed descriptions of *Alstonia scholaris* are as follows:



a. Origin and geographic distribution

Alstonia consists of about 40 species and are found in a continuous belt in the paleotropics. *Alstonia scholaris* is the most widely distributed species in the genus, found from Sri Lanka and India through mainland South-East Asia and Southern China, throughout Malesia, to northern Australia, the Bismarck Archipelago and the Solomon Islands.

b. Uses

Due to its weakness, pulai is not recommended for structural purposes. It is suitable for boxes, crates, coffins, drawing boards, picture frames, matches, shuttering, interior trim, furniture components, prahus, foundry patterns, and handicraft such as wooden shoes, toys, puppets and masks. A latex which contains alkaloids and important used in traditional medicine can be tapped only from the bark of Pulai (not from the bark of hard alstonia). *A. scholaris* is the most important source of pulai timber. The wood yields a good quality pulp. In Java the wood was formerly used for school blackboards. The latex can be used to clean wounds, or when mixed with oil, to treat earache and is often used in traditional medicine. It also provides a good quality chewing gum. The tree is also planted as an ornamental.

c. Observation

Leaves on a 0–2cm long petiole, usually in whorls of 3, 10–30cm long, oblong-lanceolate, shortly acuminate to obtuse and with about 15 pairs of secondary veins; calyx and corolla white tomentose

outside; follicles glabrous. Often common in rain forest up to 450m altitude. The density of the wood is 600–800 kg/m³ at 15% moisture content.

d. Descriptions

A medium-sized to fairly large tree of up to 40m tall, bole cylindrical, in older trees massively fluted, up to 125cm in diameter, with stout buttresses 6m tall which spread out at the base for up to 2m, outer bark brown or yellowish white, smooth but coming off evenly in small papery flakes, with horizontally enlarged lenticels and hoops, inner bark yellow to brown, usually tinged yellowish, with copious white latex, leaves petiole, elliptical.

e. Wood anatomy

Macroscopic character:

Sapwood very wide, not well defined from the yellowish, cream-white or straw-coloured to pale yellow-brown heartwood. Texture moderately fine to moderately coarse, wood with an attractive figure in species with higher density.

Microscopic character:

Growth rings not evident, sometimes vaguely indicated, particularly in species with denser wood, due to zones of thicker-walled fibres. Vessel diffuse, few (2–3mm²) to numerous (more than 20mm²). Tangential diameter ranging from 70–220µm, generally with maximum tangential diameter of 150–220µm in the pulai group and less than 120µm in the hard alstonia group (*A. spectabilis*). Fibres 1,200–1,760µm long.



Leaf



Seeds

f. Growth development

Seedlings are vigorous and hardy, and young trees demand full light in order to grow vigorously. Under favorable condition they are undoubtedly fast growers, although no data are available on growth rates. Young trees of most species have a pagoda – like crown with a monopodial appearance. The growth of branches is intermittent. The trees are often deciduous at irregular intervals, they do not flower at every leaf-change, but only after marked periods of dry weather. Pollination is by insects, when flowering, trees are often surrounded by butterflies and bees. The fruit open on the tree and the seeds, which have a tuft of silky hairs at each end, are dispersed by wind.

g. Ecology

Species of *Alstonia* grow in both primary and secondary lowland evergreen to deciduous rain forest. They grow on humus-rich clayey soils but also on sandy or even limestone soil and in places which are periodically inundated and carry swamp or peat swamp forest, to comparatively dry areas with savanna woodlands. The species are found from sea-level to up to 1,000m altitude, and in the area of distribution the annual number of dry month ranges from 0–3.

h. Propagation and planting

A. scholaris can be propagated by seed. The weight of 1,000 seeds is about 1.5-2g. the germination rate of fresh seeds is high, nearly 100%. Seeds can be stored in closed tins for 2 months, maintaining a germination rate of 90%. *A. scholaris* has been grafted. Cleft grafting and inverted T-grafting have been found to be most appropriate.

i. Silviculture and management

Natural regeneration of *Alstonia* is often scarce, and seedlings are found scattered or in group, particularly in open places at forest edges and in secondary forest. Regeneration can be enhanced by enrichment planting using the strip system, but sufficient opening of the canopy is essential for optimal growth of the seedlings. There is hardly any experience with silviculture of *Alstonia*.

j. Harvesting

In most countries of South-east Asia, *Alstonia* is harvested selectively from natural forest, with diameter limit of 40cm, 50cm, or 60cm. Pulai logs float easily in water when freshly cut, but they tend to become waterlogged and to sink after some week. The logs are very susceptible, to insect and fungal attack and should be dried quickly or treated with preservatives after felling.

k. Genetic resources

Most *Alstonia* species are common and widely distributed, although they are found scattered, and do not seem immediately liable to genetic erosion, largely because they often easily invade severely disturbed places. However, stands are heavily depleted locally as a result of deforestation caused by logging and shifting cultivation and the remaining stands need protection.

Basal trunk



04. *Alstonia spectabilis* R.Br.

Alstonia spectabilis belongs to the family of Apocinaceae. The synonyms of this species are *Alstonia villosa* Blume (1826), *Alstonia subsessilis* Miq (1868), and *Alstonia longissima* F.v. Mueller (1877). The trade group of this species is Hard alstonia: (*Alstonia spectabilis* and *A. macrophylla* are include in group of hard alstonia, medium-heavy hard wood). The other groups is Pulai (lightweight hard wood, such as *A. scholaris*, *A. pneumatophora*, and *A. spatulata*) and the vernacular names of *Alstonia* are hard milkwood (En), Indonesia: legarang (Java), pole (Timor), oli (Papua). Papua New Guinea: hard alstonia. Detailed descriptions of *Alstonia spectabilis* are as follows:



a. Origin and geographic distribution

Alstonia consist of about 40 species and are found in a continuous belt in the paleotropics. It ranges from tropical West Africa to the Marquesas in the far eastern Pacific and from Himalayas in the north to New South Wales in the south. Two species are native to tropical Africa, 4 to Australia, about 15 to the Pacific region, 12 to the Malesian region and the rest are found in continental Asia. *A. scholaris* is the most widespread species and distributed from India and Srilanka through Indo-China (including southern China) towards Malesia, south to the Solomon Islands. Distribution of *A. spectabilis* is in Java, Borneo, the Philippines, Sulawesi, the Moluccas, New Guinea, and northern Australia.

b. Uses

Due to its weakness, pulai is not recommended for structural purposes. It is suitable for boxes, crates, coffins, drawing boards, picture frames, matches, shuttering, interior trim, furniture components, prahus, foundry patterns, and handicraft such as wooden shoes, toys, puppets and masks. Hard *alstonia*, being stronger than pulai, can be applied for medium and sometimes even for heavy constructional work, railway, sleepers and boarding. When properly protected against the weather and fungal and insect attacks, it can

be used for house building; it has been used for beams, rafters and joists. A latex which contains important alkaloids to be used in traditional medicine can be tapped only from the bark of Pulai (not from the bark of hard *alstonia*). The wood of *A. spectabilis* is used as hard *alstonia* and is suitable for building houses and bridges, it is also used for household implements.

c. Observation

A medium-size to fairly large tree of up to 50m tall, bole up to 60cm in diameter, leaves on a 0–2cm long petiole, usually in whorls of 3, 10-30cm long, oblong-lanceolate, shortly acuminate to obtuse and with about 15 pairs of secondary veins; calyx and corolla white tomentose outside; follicles glabrous. Often common in rain forest up to 450m altitude. The density of the wood is 600-800 kg/m³ at 15% moisture content.

d. Properties

Hard *Alstonia* is a moderately heavy hard wood. The heartwood is yellowish-white to pale yellowish-brown and not distinctly demarcated from the sapwood. Texture moderately fine. This timber is much harder and much stronger than pulai.

e. Descriptions

Shrubs or small to large, evergreen or rarely deciduous, laticiferous trees of up to 50m tall, bole



Seedling

Adaxial leaf

straight, generally coarsely fluted at the base and up to 125cm in diameter, bark surface generally tessellated with small scales or shallowly fissured, appearing smooth at a distance, variable in colour. Leaves verticillate (or some time opposite) in verticils of 2-8, simple, entire with very variable shape. With or without intrapetiolar stipules. Fruit composed of 2 follicles. Seed with endosperm, thin, flattened, some times winged. Seedling with epigeal, erect hypocotyl, cotyledons leaf-such as, thin, oblong or ovate-oblong.

f. Growth development

Seedlings are vigorous and hardy, and young trees demand full light in order to grow vigorously. Under favorable condition they are undoubtedly fast growers, although no data are available on growth rates. Young trees of most species have a pagoda – such as crown with a monopodial appearance. The growth of branches is intermittent. The trees are often deciduous at irregular intervals, they do not flower at every leaf-change, but only after marked periods of dry weather. Pollination is by insects, when flowering, trees are often surrounded by butterflies and bees. The fruit open on the tree and the seeds, which have a tuft of silky hairs at each end, are dispersed by wind.

g. Ecology

The species grow in both primary and-secondary lowland evergreen to deciduous rain forest. They are found on humus-rich clayey soils but also on sandy or even limestone soil and in places which are periodically inundated and carry swamp or peat swamp forest, to comparatively dry areas with savanna woodlands. The species are found from sea-level to up to 1,000m altitude, and in the area of distribution the annual number of dry month ranges from 0–3.

h. Propagation and planting

Seeds are difficult to collect, as the fruits open while still on the trees. The weight of 1,000 seeds is about 1.5-2g. The germination rate of fresh seed is high, nearly 100%. Seed can be stored in closed tins for 2 months, maintaining a germination rate of 90%. Seeds germinate in 2-8 weeks after sowing. In Indonesia, seedlings are planted into the field when they are 15-25cm tall, with spacing of 1m x 2m and interplanted with *Leucaena leucocephala* (Lamk) de Wit.



Abaxial leaf

Trunk

i. Silviculture and management

Natural regeneration of *Alstonia* is often scarce, and seedlings are found scattered or in group, particularly in open places at forest edges and in secondary forest. Regeneration can be enhanced by enrichment planting using the strip system, but sufficient opening of the canopy is essential for optimal growth of the seedlings. There is hardly any experience with silviculture of *Alstonia*.

j. Harvesting

In most countries of South-east Asia, *Alstonia* is harvested selectively from natural forest, with diameter limit of 40cm, 50cm, or 60cm. Pulai logs float easily in water when freshly cut, but they tend to become waterlogged and to sink after some weeks. The logs are very susceptible, to insect and fungal attack and should be dried quickly or treated with preservatives after felling.

k. Genetic resources

Most *Alstonia* species are common and widely distributed, although they are found scattered, and do not seem immediately liable to genetic erosion, largely because they often easily invade severely disturbed places. However, stands are heavily depleted locally as a result of deforestation caused by logging and shifting cultivation and the remaining stands need protection.



05. *Cerbera odollam* Gaertn.

Cerbera odollam is a member of Apocynaceae family. The vernacular names of this species are; Malaysia: bintan (Peninsular). Thailand: sang la (peninsular). Detailed descriptions of *Cerbera odollam* are as follows:





Flowers

Leaves

Fruit

a. Origin and geographic distribution

Cerbera comprises 7 species. Distribution of *Cerbera odollam* is from Sri Lanka and India towards Burma (Myanmar), Indo-China and Thailand, throughout the Malesian area towards Melanesia.

b. Uses

The wood of *Cerbera* is used for mouldings, interior trim, fruit cases, core veneer, match splints, shuttering, clogs, plain furniture and carving. The wood of *Cerbera manghas* yields a good charcoal. *C. manghas* and *C. odollam* are well-known for their poisonous seeds. The seeds contain an oil which has been used for making candles.

c. Properties

Cerbera yields a lightweight to medium-weight timber with a density of 320-610 kg/m³ at 15% moisture content. Heartwood white to pale yellow-brown. Texture fine and uneven because of the banded parenchyma.

d. Descriptions

Evergreen shrubs or small to medium-sized trees up to 30m tall, bole up to 90cm in diameter, not buttressed, bark surface irregularly scaly or warty. Seedling with hypogeal germination. The flowers

are pollinated by insects. The fruits are dispersed by water and are quite commonly washed up on the shores.

e. Ecology

Cerbera species are generally associated with water and grows along rivers or streams, in swamp forest and behind mangroves, but may also be found in shrubby, savanna or in secondary forest edges. Some species, like *C. manghas* and *C. odollam*, are common elements of mangrove swamp and tidal river banks and may root in muddy locations but also in sandy coastal soils. Most species grow at low altitude in primary lowland rain forest, but some may ascend up to 2,000m altitude.

f. Propagation

Cerbera can be propagated by seed.

Seedling



06. *Dyera costulata* (Miq.) Hook.f.

Dyera costulata is a member of Apocynaceae family. The synonyms of this species are *Albizia moluccana* Miq. (1855) and *Albizia falcataria* (L.) Fosberg (1965). The vernacular names of this species are; Brunei: Puah. Indonesia: jeungjing (general), sengan laut (Java). Malaysia: batai, kayu machis. Papua New Guinea; white albazia. Philippines: Moluccan sau, falcate. The local name of this species is jelutung. Detailed descriptions of *Dyera costulata* are as follows:





Leaf (adaxial & abxial side)

a. Origin and geographic distribution

The area of natural distribution is Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo and intervening islands. It is mainly found in primary lowland rain forest on planes or smaller hills at altitudes up to 300m altitude, occasionally up to 800m. Typically it grows in heavy rainfall areas on soil with good drainage e.g., on ridges or alluvial soil and lateritic clay soil but not in swamp forest (site of related *D. polyphylla*). It 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'. Distribution of the species has declined as a result of tapping for latex and felling for timber and in some places it is reported to be threatened.

b. Uses

Wood is a yellow, light weight hard wood with no distinction between heartwood and sapwood. The texture is fine and straight, and the surface is glossy. It is considered easy to dry and saw even though it contains latex. The wood is easy to work, nail, screw, paint, and varnish. It has a number of speciality uses such as plywood, pulp and paper, pencils, picture frames, wood containers, furniture, blackboard, toys, handles, partitioning, match boxes and wood carving. The roots are used as a substitute for cork and the latex is used in the manufacture of chewing gum, in paints, as priming for concrete, or for sizing paper.

c. Descriptions

Large deciduous tree with straight bole, up to 50-60m, occasionally up to 80m tall, with diameter up to 3m and a clear bole up to 15-30m without buttresses. Bark surface is dark grey, smooth, with small square scales; inner bark thick, with milky latex. The leaves are usually shed once a year. Leaves in whorls, glabrous, 12-25cm long and 6-11cm wide. Flowers are small and white, glabrous, in 5-18cm long panicles.

d. Propagation and planting

Sowing and germination:

Fully mature seeds germinate well, 80-90%. Seeds extracted from immature pods have lower viability and take longer time to germinate. Germination is epigeal, i.e. the cotyledons appear above ground.

The seeds are sown in a mixture of peat or soil and sand (1:1) in shady conditions. It is recommended to sow them in a seedbed with a light cover of sand. The seedlings can be transplanted after the first pair of leaves has emerged.

Vegetative propagation:

Propagated by rooted cuttings e.g., from wildlings. The cuttings should be 0.5-1.5cm in diameter and 30-40cm in length. They should be soaked in rooting hormone such as Rootone-F prior to planting in a mixture of peat and sand (1:1). The cutting bed should be covered with transparent material (e.g., plastic) under shady conditions. By this method, 30% of rooted cuttings are ready for planting after 3 months.

Bark



Basal trunk



FAMILY **ARAUCARIACEAE**



Tropical trees of Indonesia

07. *Agathis dammara* (Lambert) Rich.

Agathis dammara is one of the species of Araucariaceae family. The synonyms of this species are; *Agathis loranthifolia* Salisb (1807), *Agathis celebica* (Koord.) Warb. (1900), and *Agathis hamii* Meijer Drees (1940). The vernacular names are: Indonesia: dammar raja (general), kisi (Buru), salo (Ternate), Philippines: dayungan (Samar). Detailed descriptions of *Agathis dammara* are as follows:





Leaves

Fruits

Seeds

a. Origin and geographic distribution

The Philippines (Palawan and Samar), Sulawesi and the Moluccas; planted on a fairly large scale in Java.

b. Uses

The wood is used as kauri. *A. dammara* is an important source of copal resin.

c. Observation

A very large tree of up to 65m tall; adult leaves elliptical. The density of the wood is 380-660 kg/m³ at 15% moisture content.

d. Properties

Kauri is a light weight softwood. The heartwood is pale yellow to straw-coloured,

e. Descriptions

Medium-size to very large monoecious but strongly dichogamous trees up to 60m tall. Bole straight and cylindrical, up to 200-400cm in diameter. Crown monopodial, usually eventually sympodial.

f. Wood anatomy

Macroscopic character:

Sapwood not distinct from the heartwood, whitish,

heartwood pale yellow-brown, straw-coloured or buff, sometimes with a pinkish tinge. Texture very fine and even. Growth rings barely distinguishable.

Microscopic character:

Tracheids irregularly polygonal, rounded to square in cross section, radial diameter approximately 50µm (up to 70µm in the early wood).

g. Ecology

Agathis is the conifer genus par excellence of lowland tropical rain forest. It grows from sea-level up to 2,000(-2,400)m altitude with an annual rainfall between 2,000 and 4,000mm which is well distributed over the year.

h. Growth and development

Seedlings need shade and show slow growth during the first years. Afterwards, when released from competition with weeds, growth is rapid. Annual volume increment may be 20-30 m³/ha.

i. Propagation and planting

Natural regeneration may occur under shade near mother trees, but seedlings are often rare. They seem able to establish in secondary vegetation. Naturally established seedlings in plantations can be used as planting stock. Artificial regeneration is



Leaf

mainly by sowing. Seed supply is limited by the very rapid decline in viability and the high costs of collecting seed from species whose cones disintegrate. Close planting in Java 3m x 3m, encourages the formation of long branchless boles.

j. Silviculture and management

Commercial plantations should be on gentle slopes on well drained soils with good aeration. Extensive clearing, often accompanied by burning, is required to prepare the sites. In the sapling period, opening in the canopy are needed for further successful growth. In plantation of *A. dammara* in Java (with initial spacing of 3m x 3m), the first thinning is often at the age of 6 years, and then every 3 years until then the age of 20 years and every 5 years afterwards. Young trees seem to be sensitive to competition from the grass and also to over growing by vines, so young plantation must be weeded.

k. Diseases and pests

The rust *Aecidium* may infest seedlings in nurseries and young trees in the field. The symptoms are reddish-brown raised lesions on the leaf surface. The disease may slow down growth. Fungi of *Gloeosporium* are reported to infest young seedlings in seed-beds.

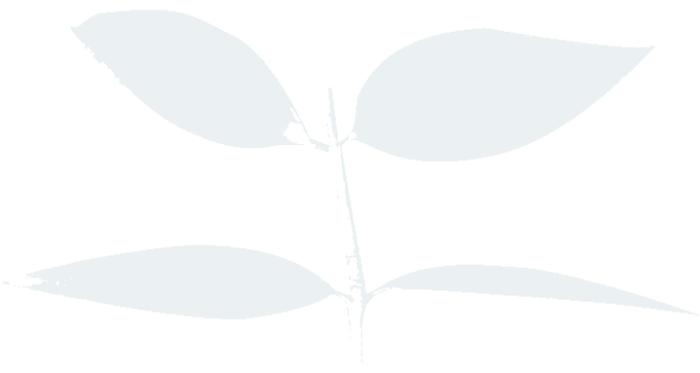
l. Harvesting

In natural stands, trees with a diameter of more than 50cm or 60cm are usually harvested for timber.

m. Yield

The annual wood production of kauri planted in java in a pulpwood rotation of 30 years is reported as 23-32 m³/ha, and in a plantation for veneer production in a 50-years rotation of 22-28 m³/ha. Total yield of timber after 40 years 570 m³/ha.

Basal trunk



08. *Agathis robusta* (Moore) Bailey

Agathis robusta is a member of Araucariaceae family. The synonym of *Agathis robusta* is *Agathis palmerstonii* (F. v. Mueller) Bailey (1891). The vernacular name of this species is smooth-barked kauri (En). Detailed descriptions of *Agathis robusta* are as follows:



a. Trade groups

Kauri: lightweight softwood, e.g., *Agathis borneensis* Warb., *A. dammara* (Lambert) Rich., *A. labillardieri* Warb.

b. Origin and geographic distribution

Agathis is the most tropical genus of the *Coniferae*. Opinions differ on the number of species. Some authorities recognize 21 species, 11 of which occur in the Malesian area. Others, applying a broader species concept, distinguish 13 species, with only 4 occurring in the Malesian area. The natural distribution of the genus is from Peninsular Malaysia, Sumatra, Borneo, Sulawesi, the Philippines, the Moluccas, New Guinea and New Britain toward western Australia, the Solomon Islands, New Caledonia, Vanuatu, Fiji and northern New Zealand. There are centres of diversity in western North Queensland and New Caledonia. If a narrow species concept is adopted, a third centre can be recognized in Borneo. It has been hypothesized that *Agathis* invaded the Malesian Archipelago and the Melanesian island from two Gondwanic centres, northern Queensland and New Caledonia, and the speciation has subsequently occurred. The oldest fossil records date from the Upper Cretaceous of New Zealand and the Jurassic of Australia. *Agathis* is cultivated as a plantation tree and used in enrichment planting and reforestation in various areas within the natural



Trunk

range, especially in Irian Jaya. Outside the natural range, it has been planted in Java, India, Mauritius, tropical Africa, South Africa and Central America.

c. Observations

A large tree up to 48m tall; adult leaves ovate, 9.5cm x 2.6cm, acute to rounded at the apex, tapering into a 3-10mm long petiole; mature pollen cones 4-8.5cm x 0.7-0.9cm, microsporophylls with a sharply angled apex with 3 lateral faces; mature seed cones oval to elongated, 9-15cm x 8-10cm, seed bracts rounded obtriangular-ovate, with a large projection on one side and a smaller one near the base on the other; seed with a prominent, acute projection on one upper corner and a wing on the other. *A. robusta* is locally common in recently disturbed places and occurs on a variety of soil up to 900m altitude. The density of the wood is about 475 kg/m³ at 15% moisture content.

d. Growth and development

Seedlings need shade and show slow growth during the first year. Afterwards, when released

from competition with herbs, growth is rapid, as in most typical primary rain forest trees. For *A. labillardieri*, height growth of trees amounts to 0.5-1.5m annually, depending on soil characteristic and competition. Diameter increment can easily exceed 1cm annually. Annual volume increment may be 20-30 m³/ha. Maximum age is known as several hundred years.

Young trees have a cone-shaped taproot and thin horizontal lateral roots. In order trees most of the lateral grow vertically from the taproot and sometimes reach a depth of 12m. Horizontal laterals grow just below the soil surface and may cover an extensive area. The root system is sensitive to lack of oxygen and the trees do not tolerate water logging.

Kauri is reputed to be a self-pruning tree, but open-grown trees of some species and provenances retain their low branches for some time. In general, the stem form is good. In plantations in Java *A. dammara* starts to produce cones at the age of 15 years, but viable seeds are usually not produced before 25 years. Viable seeds can be collected from February to April and from August to October. Mature trees may produce 200-300 cones and approximately 1kg of seed per year.

Many *Agathis* species produce seed cones well before pollen cones appear, promoting cross-fertilization. The seed cones usually carried for only

short distances by wind, and they often germinate in large numbers near the parent tree. Pollination is done by wind.

e. Ecology

Agathis is the conifer genus par excellence of lowland tropical rain forest. Within the Malesian area kauri occurs in lowland or lower montane tropical rain forest except for some populations in Peninsular Malaysia which thrive in upper montane rain forest. It occurs from sea-level up to 2,000(-2,400)m altitude. In Malesia, kauri is confined to regions with an annual rainfall between 2,000 and 4,000mm which is well distributed over the year. On Palawas (the Philippines) several small populations thrive in a climate with a more marked dry period. Kauri occurs on a diversity soils and in a wide variety of habitats. It has been found in places as divergent as heath forest, on ultrabasics, limestone and in peat-swamp-forest. Kauri occurs as a solitary tree as well as a dominant and main or even sole canopy tree in Malesia large stands are restricted to azonal soils. Natural stands on sand ridges in swamp forest in Kalimantan contain 1-2.6 m³/ha of standing timber; *A. borneensis* is there associated with ramin (*Gonystylus bancanus* (Miq.) Kurz). Kauri is generally least successful in species-rich forest and as a rule does not tolerate stagnant water.



Leaves

f. Propagation and planting

Natural regeneration may occur under shade near mother trees, but seedlings are often rare. They seem able to establish in secondary vegetation. Naturally established seedlings in plantations can be used as planting stock. The shade tolerance of several species allows them to be managed under a selective felling system, always maintaining a good forest cover, which is important on erosion-prone soils on steep hills.

Artificial regeneration is mainly by sowing. Seed supply is limited by the very rapid decline in viability and the high costs of collecting seed from species whose cone disintegrated. In Indonesia and Papua New Guinea cones are collected when they have ripened and become blackish-green. It is not easy to collect female cones, as they are produced mainly in the upper parts of the crown at the ends of branches. It is not recommended to collect fallen seeds. The weight of 1,000 dry seeds is about 200g. Seeds must be sown as soon as possible, because the viability drops rapidly, from 90-100% initially to zero after some weeks. Germination starts 6 days after sowing, 80% of the seedlings emerge within 10 days. Storage time can be extended by quick drying without heating, and storage at temperatures below 0°C. Air dried seeds have a germination rate of 40-50% after 14 days, but this drops to zero after about 9 weeks. After soaking for 24 hours, seeds are directly sown on seed-beds,

and covered thinly with soil. Seedlings prefer shade and will survive open planting only if the roots are minimally damaged and soil is moist. Plants are more resistant to exposure when more than a year old.

Potting stock at least 15cm high, but preferably larger as small stock high mortality, is used for planting. The best nursery seedlings for transplanting are those of 1-1.5 years old and 25-60cm tall. If the taproot is bent sharply when transplanting, the plant dies. Mycorrhizal association is easily formed with ubiquitous soil fungi. When planted in open terrain, e.g., under taungya systems, with food crops between the rows of kauri for 1-2 years, a shade plant, e.g., *Leucaena leucocephala* (Lamk) de Wit, should be sown in advance to provide the necessary shade. Planting during the dormant stage of terminal buds is preferable, and transpiration is reduced by clipping side shoots.

Trees for tapping are planted at a wide spacing of about 10m x 5m close planting, in Java 3m x 3m, encourages the formation of long branchless boles. In Papua New Guinea a spacing of 6m x 6m is often practiced to make unmerchantable thinnings redundant; the self-pruning ability of the trees makes wide spacing possible.

Vegetative propagation, to overcome lack of

seed, has proved successful, e.g., root suckers from seedlings in the nursery, and by stem and leaf cuttings assisted by auxin applications stem cuttings should preferably be taken from young plants or low branches of young trees. Cuttings taken from plagiotropic branches can only be used for seed-orchard trees. Root suckers can be produced several times from potted seedlings and are considered to be the most successful material for vegetative propagation. *A. robusta* has been propagated successfully by in vitro culture in Australia, using stem segment with 3-5 leaf axils, excised from the upper portion of the main stem of 2-year-old seedlings. The success rate of rooting was, however, only 5-20% on a medium of half-strength Murashige and Skoog inorganic salts plus growth regulators.

g. Silviculture and management

Commercial plantations should be on gentle slopes on well drained soils with good aeration. Extensive clearing, often accompanied by burning, is required to prepare the sites. Initially it is preferable to retain some overhead from shade trees, but in the sapling period, openings in the canopy are needed for further successful growth. In plantations of *A. dammara* in Java (with initial spacing of 3m x 3m), the first thinning is often at the age of 6 years, and then every 3 years until the age of 20 years, and every 5 years afterwards. In Papua New Guinea, an

extremely heavy thinning and tending of the upper canopy, leaving only trees of commercial value, is implemented around the age of 10 years. Selective felling, with a diameter limit, often benefits the natural regeneration of kauri.

Young trees seem to be sensitive to competition from grass and also to overgrowing by vines, so young plantations must be weeded. The usual rotation for plywood production is 20 years in Java, but a longer rotation is needed for timber production.

h. Uses

The wood is used as kauri. The wood of kauri is used as a general purpose softwood, and has many uses. It is excellent for joinery, boat building (especially masts), construction under cover, household utensils, paneling, turnery, mouldings, packaging and foundry pattern making. More specific purposes are drawing broads and ruler, matches, matchboxes, pencils, furniture, battery separators, piano parts and artificial limbs. As the timber is odourless it was formerly used for containers such as tea chests and butter boxes. It makes a good peeled veneer with an attractive colour and figure for decorative plywood paneling. Wood-wool boards are manufactured from kauri wood. Kauri is very suitable for the manufacture of wrapping, writing and printing paper and rayon-





Tree

Bark

grade pulp. The wood is also suitable for the manufacture of charcoal and activated carbon.

The inner bark of kauri exudes a translucent or clear white resin which is called 'copal' or 'Manila copal'. This resin used to be an important component of varnish and was used in the manufacture of linoleum. There is still a steady demand in the export market for specialized uses such as in varnishes for labels of food tins and photographic colour prints, reflector paint, as a component of paint for lines on road and for fluxes. Local demand is still high and applications of the resin for varnish, incense, torches, illumination, for making patent leather, sealing wax, as a liniment and as an unguent to prevent the attacks of leeches have been reported. Kauri is also used in reforestation projects. Trees are tapped for resin which is also dug up at the base of trees.

i. Diseases and pests

The rust *Aecidium* may infest seedlings in nurseries and young trees in the field. The symptoms are reddish-brown raised lesions on the leaf surface. The disease may slow down growth. Fungi of *Gloeosporium* are reported to infest young seedlings in seed-beds. Pink disease caused by *Corticium salmonicolor* may damage twigs, branches and finally whole trees. Several fungal diseases are associated with waterlogging. Diseases reported of kauri in the Philippines are seedling dieback caused by *Colletotrichum gloeosporoides*, seedling leaf blight caused by *Phoma* sp., seedling dry rot caused by *Fusarium solani*, and butt and heart rot caused by *Fomes* and *Ganoderma* spp.

In Papua New Guinea a seed-eating moth (*Agathiphaga*) is widespread and may severely damage seeds. The termite *Coptotermes eliseae* sometimes attacks trees in Papua New Guinea. Parrots and cockatoos feed on the cones of *Agathis* tree in New Guinea, and wild pigs and squirrels may destroy young plantations.

FAMILY **BURSERACEAE**



Tropical trees of Indonesia

09. *Canarium asperum* Benth.

Canarium asperum is a member of Burseraceae family. The vernacular names of this species are: Indonesia; damar jahat (Sulawesi), damar hitam (Ambon), kessi (Sumbawa). Philippines: pagsahingin (Filipino), sulusalungan (Bisaya), anteng (Iloko). The synonyms of this species are: *Canarium villosum* Benth. & Hook.f. ex Fernandez-Villar (1880), *Canarium zollingeri* Engl. (1883), and *Canarium unifolium* Merr. (1921). The trade groups of this species are: Kedondong: lightweight to medium-weight hardwood, e.g., *Canarium hirsutum* Wild., *C. indicum* L., *C. littorale* Blume, *C. luzonicum* (Blume) A. Gray. Kedondong is the standard name for all timber of the family *Burseraceae*, hence addition to *Canarium* timber also including the timber of *Dacryodes*, *Garuga*, *Protium*, *Santiria*, *Scutinanthus*, and *Triomma*. Detailed descriptions of *Canarium asperum* are as follows:



a. Origin and geographic distribution

Canarium consist of about 80 species and distributed in the Old World tropics, from tropical Africa to tropical Asia, northern Asia Australia and the Pasific. The main center of diversity lies in the Malesian are where most species occur in the moister parts, hence in Peninsular Malaysia, Sumatra and Borneo in the west and New Guinea in the east.

The trees grow in the Pilippines, Borneo, Sulawesi, the Lesser Sunda Islands (including Bawean and Kangean Islands), the Moluccas, New Guinea and the Solomon Islands.

b. Observation

A medium-sized to fairly large tree up to 35m tall, bole straight, cylindrical, branchless for up to 16m, up to 100cm in diameter, with prominent buttresses, bark surface pale grey; stipules sub-persistent to caduceus, 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 12-15 pairs of secondary veins; in florescence spicate to narrowly paniculate; flowers 3-7mm long, stamens 6; fruit aoid to subglobose, circular to slightly trigonous in cross section, 9-14mm x 4-11mm, 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. (synonym: *Canarium clementis* Merr.,

Canarium leyntense 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/m³ at 15% moisture content.

c. Seed descriptions

Seed with palmatifid to-3 foliolate and variously folded cotyledons.

d. Growth and development

An average annual diameter increment of a small *C. asperum* tree in secondary forest of 1.9cm has been recorded. They may grow to a height of 2m 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. 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.

e. Ecology

Species of *Canarium* are mainly canopy trees of primary lowland evergreen rain forest, although some species are found up to 1,800m altitude. They also occur in monsoon or more open forest, or in secondary forest, where some species may be locally abundant.

f. Propagation and planting

Canarium can be propagated by seed and seedlings may be prepared as stumps before planting. Vegetative methods of propagation are practiced for the fruit species, e.g., budding and grafting techniques are used for *C. ovatum*. One kg contains 200-1,350 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 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 40cm long and with a diameter of 1-2.5cm 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 9m) in the Solomon Islands, and *C. ovatum* is planted in the Philippines at a spacing of 12-15m (45-70 trees/ha).

g. Silviculture and management

Canarium trees generally grow scattered and the fruits are often collected for their stone, natural regeneration is scarce.

h. Uses

The wood is used as kedondong. The timber, being part of kedondong trade group, is use 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 use for outdoor construction because it is nondurable and divicult 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 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.

i. Diseases and pests

Anthracnose of young seedlings has been observed in *C. ovatum*, but this is easy controlled by fungicides.



10. *Ceiba pentandra* (L.) Gaertn.

Ceiba pentandra is a species member of Bombacaceae family. The local name of this species is kapuk. Detailed descriptions of *Ceiba pentandra* are as follows:





Leaves



Fruits

a. Origin and geographic distribution

Native to Mexico, Central America and the Caribbean, northern South America, and (as the variety *Ceiba pentandra* var. *guineensis*) to tropical west Africa.

b. Uses

The fiber is light, very buoyant, resilient, highly flammable and resistant to water. The process of harvesting and separating the fiber is labor-intensive and manual. It cannot be spun but is used as an alternative to down as filling in mattresses, pillows, upholstery, teddy bears, zarfs and for insulation. It was previously much used in life jackets and similar devices. The fiber has been

largely replaced by man-made materials. The seeds produce oil used locally in soap and that can be used as fertilizer.

c. Descriptions

The tree grows to 60-70m tall and has a very substantial trunk up to 3m in diameter with buttresses. The trunk and many of the larger branches are densely crowded with very large, robust simple thorns. The leaves are compound of 5 to 9 leaflets, each up to 20cm and palm like. Adult trees produce several hundred 15cm seed pods. The pods contain seeds surrounded by a fluffy, yellowish fiber that is a mix of lignin and cellulose.

d. Propagation

C. pentandra can be propagated by seeds.

e. Silviculture and management

Seedlings need full sun or party shade, and also organic rich soil. *C. pentandra* should be plant in frost free locations. It is also can be used in landscaping as a specimen tree.

Basal trunk



11. *Ochroma bicolor* Rowlee

Ochroma bicolor is a member of Bombacaceae family. The local name of this species is balsa. Detailed descriptions of *Ochroma bicolor* are as follows:



a. Origin and geographic distribution

Ochroma is a monotypic genus occurring in tropical Central and South America from southern Mexico to Bolivia.

b. Uses

The extremely light-weight wood of *Ochroma* is used for buoys, life-jackets and life-belts, surf boards, aircraft construction, toys, model making, entomology mounting boards, core stock in sandwich construction, surgical splints, packaging of fragile articles and as insulation for heat, vibration, sound and formerly also for electricity. The kapok from the fruits is suitable for filling pillows and mattresses. Ropes have been made from the fibrous bark. The tree is sometimes planted as an ornamental or to provide shade expediently.

c. Properties

Ochroma is an extremely light-weight hard wood with a density of 90-310 kg/m³ at 12% moisture content.

d. Descriptions

Deciduous or evergreen, medium-sized or rarely large trees up to 30(-50)m tall; bole straight, usually short, cylindrical, up to 100(-180)cm in diameter, with short buttresses in older trees; bark surface smooth, grey white mottled. Leaves arranged spirally, angular-lobate, palmately veined; stipuled present.

e. Wood anatomy

Macroscopic character:

Heartwood white to grey-white, sometimes with a pinkish tinge near the heart in older trees, not clearly demarcated from sapwood. Grain straight, texture coarse and even. The wood very soft and very weak but with a good strength to weight ratio.

Microscopic character:

Growth ring indistinct. Both sapwood and heartwood are permeable to impregnation, the retention of preservative by the pressure heating method is about 560 kg/m³ for sapwood and about 334 kg/m³ for heartwood.

Leaf

Flower buds and fruit



f. Ecology

O. pyramidale is a typical pioneer, colonizing clearings. It grows gregariously with a preference for alluvial flats, on rich, well-drained or volcanic soils up to 1,000m altitude. In natural conditions it prevails under an annual temperature of 22-27°C. It can tolerate a dry season of up to 4 months, but only if the relative humidity does not normally drop below 75%.

g. Growth and development

The mean annual increment in trials in Indonesia was 2.0-6.6cm in diameter and 1.2–3.3m in height.

h. Propagation and planting

O. bicolor can be propagated by seed. The very fine seed (112,000-150,000 dry seeds/kg) should be collected from standing trees and can be stored for several years in jute bags or in closed receptacles. Freshly collected seed has only 10% germination. Seeds contain an impervious test, which must be ruptured by heat (boiling water, fire) before they will germinate. Under natural conditions forest clearance exposes the soil to the sun and this triggers germination of the seeds.

i. Silviculture and management

Thinning is comparatively heavy and aims at creating enough growing space for the trees to allow for rapid growth.

j. Yield

A mean annual volume increment of 17-30 m³/ha can generally be expected, although 69 m³/ha and 90 m³/ha has been achieved in Indonesia in 8 and 6 years old plantations, respectively and 50 m³/ha is commonly accepted as realistic.



Seeds



Basal trunk



FAMILY
CLUSIACEAE



Tropical trees of Indonesia

12. *Callophyllum soulattri* Burm.f.

Callophyllum soulattri is a member of Clusiaceae family. The vernacular names of this species are; Indonesia: sulatri, slatri, malang-malang. Malaysia: bintangor labu, bintangor lanchar, mintak. Philippines: bitanghol-sibat, pamintaogon, gigabi. Thailand: tanghon baiyai. Vietnam: c[loof]ng tr[aws]ng. Detailed descriptions of *Callophyllum soulattri* are as follows:





Flower buds

Fruits

Bark

a. Origin and geographic distribution

Vietnam, Cambodia, the Andaman Islands, Thailand, throughout Malesia towards the Solomon Islands and northern Australia.

b. Uses

The timber is used for masts and spars and in house construction throughout the area of distribution. In many places it is considered as one of the biggest bintangors. The latex may be used to poison dogs. The bark, root and latex are used in local medicine. The fruits are edible but sour. The tree is sometimes planted as a shade or ornamental.

c. Descriptions

Evergreen trees, rarely shrubs, up to 40(-60)m tall, with sticky latex either clear or opaque and white, cream or yellow; bole often straight and cylindrical, but occasionally twisted, up to 100(-240)cm in diameter; buttresses usually absent, rarely small, some species with stilt or loop roots; outer bark often with characteristic diamond to boat shapes fissures becoming confluent with age, smooth, often with a yellowish or ochre tint, inner bark usually thick, soft, firm, fibrous and laminated, pink to red, darkening to brownish on exposure.

Seedlings with crypto-cotylar germination (cotyledons remaining enclosed in stone) and short epicotyl; seedlings leaves opposite, sometimes first two pairs of leaves pseudo-verticillate or lowest pairs of seedling leaves small and soon falling off.

d. Propagation and planting

C. soulattri can be propagated by seed. Natural regeneration usually occurs near the mother tree. Seedlings grown in nurseries require shade.

e. Silviculture and management

The selective cutting system and removal of undesirable trees can enhance the natural regenerations of bintangor.

Seedling



FAMILY **COMBRETACEAE**



Tropical trees of Indonesia

13. *Terminalia catapa* L.

Terminalia catapa is a member of Combretaceae family. The synonyms of this species are: *Terminalia moluccana* Lamk (1783), *Terminalia procera* Roxb. (1832), *Terminalia mauritiana* Blanco (1845). The local names of this species are: Indonesia: ketapang. Malaysia: jelawai ketapang, telisai. Papua New Guinea: reddish-brown terminalia. Philippines: talisai, almendras, dalinsi. Cambodia: châmbâk barang, kapang, pareang prang. Laos: hu kwang, sômz moox dông, 'hou kouang. Burma: badan. Thailand: hukwang. Detailed descriptions of *Terminalia catapa* are as follows:





Tree

a. Origin and geographic distribution

Native to India through Indo-China and Thailand, throughout the Malesian area, to northern Australia and Polynesia.

b. Uses

The wood is used 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 contains an oil which is used medicinally as a substitute for true almond oil. The trees are very commonly applied as shade trees in gardens and along roads.

c. Observation

A medium sized evergreen or briefly deciduous tree up to 25(-40)m tall, bole up to 150cm in diameter, often with buttresses up to 3m high, bark surface shallowly fissured and slightly flaky. The density of this species is 450-720 kg/m³ at 12% moisture content.

d. Properties

Terminalia yield a light weight to medium-weight hard wood. The colour of the heartwood is variable.

The colour groupings are: brown, pale brown, red-brown, pale-yellow, and yellow-brown.

e. Descriptions

A medium-sized evergreen or briefly deciduous tree up to 25(-40)m tall, bole up to 150cm in diameter, often with buttresses up to 3m 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. *T. catappa* grows along sandy and rocky beaches or on tidal river banks, and is a typical element of *Barringtonia* formations.

f. Wood anatomy

Macroscopic character:

Heartwood pale brown, reddish brown, or yellowish brown to brown. Texture moderately fine to moderately coarse. Growth rings generally not distinct, sometimes fairly distinct to distinct.

Microscopic character:

Tangential diameter usually 150-300µm.

g. Ecology

Generally occur as elements of the canopy layer, sometimes of the subcanopy layer. 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



Flowers

Leaves

forest, and even in dry mixed dipterocarp forest. *Terminalia* is mostly found at low altitudes but few individual species may ascend up to 2,000 m altitude. The climate ranges from everwet to seasonal.

j. Growth and development

Terminalia catapa has a leaf-exchanging habit, the old leaves senesce at the same time that the new ones flush.

i. Propagation and planting

Terminalia can be propagated by seeds including direct sowing, by cuttings, grafting, and wildings. Insects and other animals readily and severely attack seed, 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 about 500 seeds. *T. catapa* seed remains viable for a long time and its fruits may be transported over long distances by sea water.

j. Silviculture and management

Weeding is necessary during the first 3-4 years after planting. Most species, with the apparent exception *T. catapa*, have good to extremely good self pruning capacity. Because of the wide spreading branches, the trees need much space. Coppicing ability is good for a number of *Terminalia* species planted in Africa and India.

k. Diseases and pests

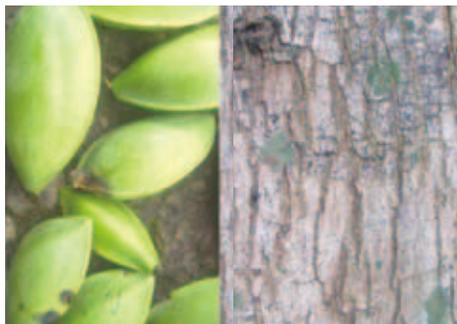
In the Solomon island, *T. brasii* and *T. calamansanai* are attacked by the larva of a cerambycid borer.

l. Yield

The mean annual volume increment of a trial plantation of *Terminalia bellirica* in Java planted at 1m x 6m was 6 m³/ha.

Fruits

Bark



FAMILY **DILLENIACEAE**



Tropical trees of Indonesia

14. *Dillenia pteropoda*

Dillenia pteropoda is a member of Dilleniaceae family. The trade groups of this species are: 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. reticulate* King. The vernacular names of this species are; Simpoh. Brunei: simpor. Indonesia : simpur. Phillipines: katmon (general). Burma (Myanmar): zinbyum, mai-masan. Cambodia: 'san. Thailand: san, masan. Vietnam: s[oo]. Detailed descriptions of *Dillenia pteropoda* are as follows:



a. Origin and geographic distribution

Dillenia consist of about 60 species and distributed from Madagascar and the Seychelles, north to the Himalayas and southern China, throughout South-East Asia and east to the Fiji Island 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 eastern Java, the Lesser Sunda Islands and southern Sulawesi for *D. pentagyna*.

b. Uses

Timber is suitable for general construction, posts, beams, joists, rafters, doors, window frames and sills, stairs, flooring, ceilings, decorative wall paneling, furniture, mouldings, frames and bottom boards of boats, vans, fancy boxes, package, pallets, structural grade plywood and slice 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 is suitable for all medium-heavy construction and also for sleepers and pilings. It is used to be used for

dunnage as substitute for keruing (*Dipterocarpus spp.*). Several species yield a good quality charcoal. The bark yields an extract which has astringent properties and a red dye. The bark has also been used medicinally against boils.

c. Descriptions

Fruits consisting of several follicles and enclosed by the enlarged fleshy sepals (apseudocarp), 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.

d. Growth and development

The seedling has a weak taproot and its function is soon taken over by adventitious roots from the hypocotyls and stem which may later develop into prominent stilt roots in mature trees. Saplings do not branch out for a long time and have larger leaves than mature trees. The apical bud is protected by the base of an unexpanded leaf.

Mean annual diameter increment of over 0.8cm have been reported for *D. grandifolia*, but other species grow slower, e.g., about 0.3cm/year in diameter for *D. obovata* and *D. ovata*.



Leaves



Basal trunk

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 abscide (a 'leaf-exchanging' species).

The arillate seeds of simpho 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*).

e. Ecology

The trees are found in lowland and hill dipterocarp forest, swamp to semi-swamp forest and old secondary forest, generally below 1,000m altitude, but some species occur up to 2,000m (e.g., *D. Montana* Diels in Papua New Guinea). *D. pentagyna* is confined to regions with a distinct dry period.

Tree



f. Propagation and planting

The seed weight is only reported for *D. pentagyna*. 1kg 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 and varies with the species. Planting stock can also be produced from wildings.

g. Silviculture and management

Most *Dillenia* species are referred to as long-lived pioneer or late secondary species. Natural regeneration is generally sufficient in natural forest and simpho can compete successfully with fast growing secondary forest species. 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 simpho may be regarded as a weed in silvicultural operations, because of their heavy crowns. Some species coppice freely.

FAMILY **DIPTEROCARPACEAE**



Tropical trees of Indonesia

15. *Dryobalanops aromatica* Gaertner f.

Dryobalanops aromatica is a member of Dipterocarpaceae family. The synonyms of this species are *Dryobalanops sumatrensis* (J.F. Gmelin) Kosterm and *Dryobalanops camphora* Colebr. The vernacular names are; Brunei: kapur anggi, kapur peringgi, Indonesia: kapur singkel, kapurun, pokok kapur baru (Sumatra), Malaysia: kapur (Peninsular), kapur biasa (Sabah), kapur peringgi (Serawak). Detailed descriptions of *Dryobalanops aromatica* are as follows:





Leaf(adaxial and abaxial side)

a. Origin and geographic distribution

Dryobalanops consists of 7 species and is confined to Peninsular Malaysia, Sumatra, Borneo.

b. Uses

This species represents the most important source of kapur timber as well as of camphor in Peninsular and Sumatra. The bark is used locally for walls and floors of houses and for baskets.

c. Descriptions

A very large tree up to 60(-67)m tall. With a straight and cylindrical bole. Branchless for up to 40m.

d. Ecology

Kapur are often found gregariously as a canopy tree in lowland dipterocarp forest and mixed peat-swamp forest. The trees often grow on hillsides, ridges or near streams, up to 800m altitude.

e. Growth and development

Kapur trees are evergreen, and flowering of trees in certain areas is more or less concurrent. They may be expected to attain a diameter of about 65cm in 60 years. Often the trees start to flower at the age of about 20 years.

f. Propagation and planting

The seed weight is about 10g. Seed germinate rapidly, after 1-2 weeks. Germination in the nurseries is usually good and simultaneous. Seedlings at least 30cm tall from nurseries or from natural regeneration are used for enrichment planting.

g. Silviculture and management

Kapur is suitable for management under the selective logging system. Where kapur trees are abundant, it is not difficult to convert the forest into a practically pure stand in a single rotation.

h. Diseases and pests

Brown pinhead spot caused by *Colletotrichum gloeosporioides* is reported as a leaf disease.

Bark

Basal trunk



16. *Hopea mengarawan* Miq.

Hopea mengarawan is a member of Dipterocarpaceae family. The vernacular names of this species are: damar mata kucing, merawan benar (Sumatra, Kalimantan), chengal bulu (Sumatra). Detailed descriptions of *Hopea mengarawan* are as follows:





Leaf (adaxial and abaxial side)

a. Origin and geographic distribution

Peninsular Malaysia, Sumatra, Belitung, Bangka, and Borneo.

b. Uses

An important source of merawan timber. It produces a dammar which is considered of good quality.

c. Observation

A medium-sized to large tree of up to 40(-60)m tall, bole branchless for up to 25m.

d. Descriptions

Small to fairly large, occasionally large. Seedlings with epigeal germination.

e. Ecology

Merawan is found from sea-level to 1,650m altitude.

f. Growth and development

The growth of seedlings is enhanced by inoculation with ectomycorrhizal fungi. Growth rates of tree are very considerable between species. Maximum diameter is 60cm at the age of 40 years.

g. Propagation and planting

It is recommended to begin collection of seeds as soon as the seed wings start turning brown. In Indonesia seedlings planted in the field when they reach 30-40cm high.

h. Silviculture and management

In a 30 years old plantation in Indonesia trees of *H. mengarawan* planted at a density of 600 trees/ha produced 760,000 seedlings/ha.

i. Diseases and pests

Seed of *Hopea* reported to be attacked by the weevil *Nanophyes shoreae*.

j. Yield

Yields are usually not high. Stands with 10-13 trees over 40cm in diameter per ha occur only very locally.

Bark



17. *Hopea odorata* Roxb.

Hopea odorata is a member of Dipterocarpaceae family. Detailed descriptions of *Hopea odorata* are as follows:





Leaf (adaxial & abxial side)

Bark

a. Origin and geographic distribution

Bangladesh, Burma, Laos, southern Vietnam, Cambodia, Thailand, the Andaman Islands and northern Peninsular Malaysia.

b. Uses

The wood is suitable for rollers in the textile industry, piles, and bridge construction and as an alternative to maple for shoe and boot lasts. *H. odorata* is sometimes used as shade tree. The bark has a high tannin content, and is suitable for tanning leather; it also produces an inferior quality dammar (rock dammar). The dammar is medicinally applied to sores and wounds.

c. Descriptions

A medium-sized to large tree of up to 45m tall, bole straight, cylindrical, branchless for up to 25m, with a diameter of up to 120cm and prominent buttresses, bark surface scaly, dark brown, outer bark rather thick, inner bark dull yellow, tinged green at the cambium, sapwood resinous; young

parts sparsely pale buff puberulent; leaves ovate lanceolate.

Merawan is found from sea-level to 1,650m altitude.

d. Growth and development

The growth of seedlings is enhanced by inoculation with ectomycorrhizal fungi. Growth rates of tree are very considerably between species. Maximum diameter is 60cm at the age of 40 years.

e. Propagation and planting

There are problems with seed storage, therefore, vegetative propagation with cuttings is often used. The weight of 1,000 seeds of *H. odorata* is about 130g. Merawan seeds exhibit no dormancy and germinate quickly after maturation. Seeds of *H. odorata* dried at 35°C to 33% moisture content could be kept viable for 1-2 months at 15°C, maintaining a germination rate of over 60%.

About 1,400–2,200 fruits per kg, with 2,500–5,300 seeds per kg. Immediately after collection



germination is fast and the rate is almost 100%. Fruits stored, even under optimal conditions lose their viability fast. It is recommended to collect directly from the tree by climbing or by shaking the fruiting branches over tarpaulins on the ground. Fruits collected from the forest floor have often low viability or are already damaged by insects. Keep the fruits in loosely folded bags or baskets and keep them out of the sun. The wings of the fruits should be removed by hand before storage. In general it is recommended to keep the period between fruit collecting and sowing short, with a maximum of 3 days.

f. Silviculture and management

The young plants need full overhead light and the shade crop should be cut back periodically to ensure it does not overtop the tree. Weeding, occasional watering and loosening of the soil around the plants is recommended in the nursery.

g. Diseases and pests

Seed of *Hopea* is reported to be attacked by the weevil *Nanophyes shoreae*.

h. Yield

Yield are usually not high. Stands with 10-13 trees over 40cm in diameter per ha are only found very locally.

Seeds



18. *Shorea leprosula* Miq.

Shorea leprosula is a member of Dipterocarpaceae family. The local name of *Shorea leprosula* are Meranti Merah, Meranti Tembaga (Indonesia), Pelepak Kontoi (Kalimantan), Merkuyang (Sumatera). Detailed descriptions of *Shorea leprosula* are as follows:





Leaf (adaxial & abaxial side)

Seed

Bark

a. Origin and geographic distribution

Borneo, Sumatera, Bangka, Balitung, Peninsular Malaysia, Thailand.

b. Uses

S. leprosula is one of the commonest light red meranti timbers. A resin called “damar daging” is found between the roots and is used in tradisional medicine. The bark is used for tanning. Construction material, floor board, container.

c. Descriptions

Evergreen big tree up to 50m tall, large crown, *oblong* or hemispherical, open. *S. leprosula* is common on well drained or swampy sites on clay soils below 700m altitude.

d. Propagation and planting

Planting can be done by seeds, natural regeneration (wildlings)/ bare root planting and by vegetative propagation (shoot cutting).

e. Silviculture and management

Strip cutting-artificial/natural regeneration, lowland Dipterocarp forest below 700m a.s.l., lower hill slopes and valleys, a strong light demander.

f. Disease and pest

Fusarium fungi may kill seedlings.

g. Harvesting

Logs float in water and can be transported by river. This commonly practiced in Borneo.



Tree

Natural seed germination and seedlings



19. *Shorea selanica* (DC) Blume

Shorea selanica is a member of Dipterocarpaceae family. The local names of this species are Kayu Bapa (Maluku), and Meranti Bapa (Indonesia). Detailed descriptions of *Shorea selanica* are as follows:





Leaf (adaxial & abaxial side)

Bark

a. Origin and geographic distribution

South Western Moluccas.

b. Uses

Mast, board, boat materials, house buildings.

c. Descriptions

A large tree up to 60m tall, crown rather dense to dense, rather pale yellow from below, symmetrical, branches spreading, young branches sometimes hanging at ends.

S. selanica is often the dominant species in the lowland forest on well-drained soils in the south – western Moluccas up to 150m altitude.

d. Propagation and planting

Planting can be done by seeds, natural regeneration (wildling)/bare root planting and by vegetative propagation (shoot cutting).

e. Silviculture and management

Strip cutting-artificial/natural regeneration.

Tree

Seedlings



FAMILY **EBENACEAE**



Tropical trees of Indonesia

20. *Diospyros celebica* Bakh.

Diospyros celebica is a member of Ebenaceae family. The synonyms of this species: *Sirium myrtifolium* L., *Santalum ovatum* R. Br., *Santalum myrtifolium* (L) Roxb. Vernacular/common name: Trade name ebony used for all dark-wood *Diospyros* species throughout the tropics. Ebony is thus locally used for different local species. Other local names for *D. celebica* in Indonesia are Kayu Hitam, Toe (Donggala, Poso and Manado), Limara (Luwu), Sora (Malili), and Ayu Maitong (Parigi). Detailed descriptions of *Diospyros celebica* are as follows:



a. Origin and geographic distribution

Diospyros celebica Bakh. is endemic to the eastern part of Indonesia, found naturally in Sulawesi and possibly the Maluku. In Sulawesi it grows particularly in North Sulawesi (Minahasa, Bolaang Mongondow), Central Sulawesi (Parigi, Poso, Donggala, Toli-toli, Kolonodale, and Luwuk), and South Sulawesi (Maros, Barru, Luwu, and Mamuju). *D. celebica* grows naturally in the humid area with a distinct seasonality, in rain forest and monsoon forest. It is found from lowland to 540m asl. The optimal rainfall range from 2,000-2,500mm/year and temperature between 22 and 28°C. *D. celebica* grows on various soil types, both calcareous soil, clay and shallow stony soil. It prefers relatively nutrient rich soil and is sensitive to water-logging.

b. Uses

D. celebica is used for round wood; building poles; sawn or hewn building timbers; for light construction; carpentry/joinery; engineering structures; bridges; containers; boxes; woodware; industrial and domestic woodware; tool handles; brushes; cutlery; toys; musical instruments; sports equipment; wood carvings; turnery; wood based materials; laminated wood; laminated veneer lumber.

c. Observation

A medium-sized to fairly large tree up to 40m tall, bole branchless for 10-26m, up to 150cm in diameter, which buttresses up to 4m high. Bark surface scaly, black. Leaves linear-elliptical, 12-35cm x 2.5-7cm.

d. Properties

Black and streaked ebony are heavy, hard, and strong woods. The heartwood is dark brown or black and may have reddish stripes, sometime with pale green. The density is 640-1,270 kg/m³ at 15% moisture content.

e. Descriptions

D. celebica is a medium to large size tree up to 40m tall and 150cm in diameter, with buttresses up to 4m high. The species is endemic to Sulawesi where it grows in lowland forest up to 550m altitude.

f. Wood anatomy

Macroscopic character:

Heartwood black or black with pale yellow streaks (*D. blancoi*). Texture fine, Growth rings usually indistinct.

Microscopic character:

Tangential diameter is 80-190µm, perforation simple.

g. Ecology

Most ebony species are found in primary or rarely secondary lowland to hill evergreen rain forest up to 900m altitude. Grows in variety of soil.

h. Fruit and seed descriptions

Fruit

Berry, oval or egg-formed, 3.5-5cm long, 2.5-3cm diameter. Mature fruit yellowish dark green with brown spots, and silky hairs. Each fruit contain 3-11 seeds.



Leaf



Seedling

Seed

Mature seed is brownish black, long rounded. Mean weight of one seed is 0.5-2g. There are about 800-1,100 seed in one kilogram. Healthy seed of ebony is marked by the colour, blackish brown, sinking when put in water, radicle brownish yellow, and not furrowed.

Flowering and fruiting habit

Ebony starts flowering and fruiting at age 5-7 years. Flowering season normally in March-May and fruit become ripen in September-November with some local variation: In South Sulawesi flowering season starts in January-March and fruit become ripen in July-September; in Mamuju and Luwu flowering season is in March-May and fruit ripen in September-November; the same phenology is found in Poso and Donggala, Central Sulawesi. Development from flower to fruit takes about 6 months.

i. Growth and development

Most *Diospyros* species have epigeal germination. The growth of young plants is slow and in plantation trial of *D. celebica* under teak in Java the young trees were 30-100cm tall after 2 years and 40-190cm at the age of 4 years. The mean annual height increment was 90cm during the first 10 years, then it decreased, whereas the mean annual diameter increment was 1.5cm during the first 20 years then decreasing to 0.5cm. All *Diospyros*

species are characterized by the architectural growth model of Massart. Trees of ebony may already start to bear flower and fruit at the age of 5-7 years.

j. Propagation and planting

D. celebica can be propagated both vegetatively (stump) and generatively (seeds or wildlings).

Fruit harvesting

Fruits are collected from the tree by climbing or are collected on nets so that they will not drop to the forest floor. Collection from the forest floor is avoided because seeds quickly deteriorate, e.g., attacked by the fungus *Penicillium clavariaeformis*.

Processing and handling

A short after-ripening for about 24 hours eases removal of the fruit pulp. After extraction, seeds are rinsed using clean water to remove the remaining flesh. High pressure water eases extraction.

Storage and viability

The seeds are desiccation sensitive and recalcitrant; they rapidly lose viability and cannot be successfully stored for long periods. Seed tests in Indonesia showed that fresh seed sown one day after collection had a germination percentage of about 85% with germination length 17-65 days. Seeds dried for 3 days did not germinate. Seed rate

which were not dried but stored in wet charcoal powder maintained a germination of 70% after 12 days storage prior to sowing; after 20 days storage germination potential was reduced to 28%. Another simple storage technique for ebony seeds is by keeping them in the wet gunny bags at high humidity (80-90% humidity) so that seed will not dry out. Using this technique, germination percentage was maintained to 50-60% after 2-3 weeks.

Dormancy and pretreatment

As all fleshy fruits, the pulp contains germination inhibitors. These are removed by normal extraction, and the seeds do not exhibit any other type of dormancy.

Sowing and germination

Ebony is a semi-tolerant species, hence it needs shading during early growth in the nursery. Sowing media for ebony uses soil and fine sand (3:1). Seed is planted horizontally or vertically with radicle end down, with a sowing depth of 1-1½ times the thickness of seed. Distance between seeds is 3-5cm. Seeds are very sensitive to desiccation during germination and must be regularly watered during germination and nursery period. Normally the seed will germinate after one week. Germination is hypogeal. Seedlings of ebonies have long hypocotyl and heavy and big cotyledon, which are easily damaged during mechanical handling.

k. Silviculture and management

It grows in humid as well as markedly seasonal climatic areas, and on a range of soils such as latosols, calcareous soils and podzols. It is shade-tolerant. Stand establishment was done using stump plants; natural regeneration; and planting stock.

l. Diseases and pests

No serious diseases or pests attack *D. celebica* plantations. Seed from fallen fruits is frequently infested by the fungus *Penicillioptis clavariaeformis*, which is specific to ebony seed.

m. Harvesting

Before 1972 the diameter limit for *D. celebica* in Indonesia was 55-60cm.

n. Yield

In trial plantation in java the mean annual increment of *Diospyros celebica* is 6 m³/ha.



FAMILY **EUPHORBIACEAE**



Tropical trees of Indonesia

21. *Aleurites moluccana* (L.) Willd.

The synonyms of *Aleurites moluccana* are: *Albizia moluccana* Miq. (1855) and *Albizia falcata* (L.) Fosberg (1965). The vernacular names of this species are: Brunei: Puah. Indonesia: jeungjing (general), sengan laut (Java). Malaysia: batai, kayu machis. Papua New Guinea; white albazia. Philippines: Moluccan sau, falcate. The local name of this species is kemiri. Detailed descriptions of *Aleurites moluccana* are as follows:



a. Origin and geographic distribution

Malaysia, Polinesia, Malay Peninsula, Philippines and South Seas Islands

b. Uses

Seed yields 57–80 percent of inedible, semi-drying oil, containing oleostearic acid. Oil, quicker drying than linseed oil, is used as a wood preservative, for varnishes and paint oil, as an illuminant, for soap making, waterproofing paper, rubber substitutes and insulating material. The oil is purgative and sometimes used like castor oil. The irritant oil is rubbed on scalp as a hair stimulant. In Sumatra, pounded seeds, burned with charcoal, are applied around the navel for soreness. In Java, the bark is used for bloody diarrhea or dysentery. Bark juice with coconut milk is used for sprue. Malaysians apply boiled leaves to the temples for headache.

c. Descriptions

Medium to large sized tree, up to 60 ft tall, ornamental, with widespreading or pendulous branches; leaves simple, variable in shape, young leaves large, up to 12" long, palmate, shining, while leaves on mature trees are ovate, entire, and acuminate, whitish above when young, becoming green with age, with rusty stellate pubescence

beneath when young, and perisiting on veins. Small flowers in rusty-pubescent paniced cymes, dingy white or creamy. Fruit an indehiscent drupe, roundish, 2" or more in diameter, with thick rough hard shell making up 64–68 percent of fruit, difficult to separate from kernels; containing 1 or 2 seeds.

d. Propagation and planting

Propagation of *A. moluccana* is easily done by seed. Although the seed can take up to 3–4 months to germinate, they are large and quickly grow into strong, stout seedlings ready for field planting. This species also can be propagated by cuttings, but this is uncommon and may not yields a plant that grows as vigorously as seedlings.

e. Silviculture and management

This species can grow well even on relatively poor sites, provided ample soils moistures is available, particularly during establishment. It regrows very well after severe pruning, although it has a tendency to die after two or more prunings in quick succession.

After germination, plants are ready to be transplanted into the field after about 3 – 4 months. Seedlings are ready to plant when they reach about 25cm in height and 12mm in diameter.

Flowers



Leaf



Fruits



Bark



Trunk



FAMILY **FABACEAE**



Tropical trees of Indonesia

22. *Acacia mangium*

Acacia mangium belongs to the family of Fabaceae. Common names are Black Wattle, Hickory Wattle and Mangium. The trade group of this species is Wattle; medium – weight hard-wood, e.g., *Acacia auriculiformis* A. Cunn. Ex Benth, *A. catechu* (L.f.). Wild and the vernacular names of this species are: Wattle, brown salwood, acacia(En). Acacie (Fr). Indonesia; akasia (general). Detailed descriptions of *Acacia mangium* are as follows:



a. Origin and geographic distribution

Acacia is a large genus with over 1,300 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 are found native or naturalized. Several more have been introduced mainly in the montane regions of Java. Most of the timber-producing species are found in Papua New Guinea.

b. Uses

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

c. 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 from *A. mangium* timber are exported from peninsular Malaysia and Sabah, for instance to Taiwan.

d. Observation

A medium-sized to fairly large tree up to 35(-39) m tall, bole branchless for up to 21m, up to 90cm 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, 7-15cm x 0.6-3.5cm, 4-12 times longer than wide, with 3-7 major longitudinal veins, secondary veins not anastomosing; flowers in spikes, 5-merous, corolla 1.5-1.9mm long; pod straight but often twisted when old, up to 8cm x (1-)2cm, 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 15-60m altitude in New Guinea, but up to 1,000m in Australia. The density of the wood is 645-720 kg/m³ at 12% moisture content.

e. Properties

Wattle is a medium-weight hard wood. The heartwood is pale olive-brown, grey-brown to pink, darkening to reddish-brown or dark-red, and often attractively streaked. The sap wood is yellowish-white, cream or straw-coloured and distinctly demarcated from the heartwood. Heartwood formation varies significantly with provenance. Such as the wood from wattle plantations has the inherent potential disadvantage of small diameter, knottiness, low density, and 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-



Flowers

Leaf

) 560-1,000 kg/m³ at 15% moisture content. The grain is straight to shallowly interlocked, texture fine to medium an even.

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 semi chemical process, and the pulp was readily bleached to brightness levels acceptable for use in fine papers.

f. Descriptions

Armed or unarmed lianas, shrubs or small to fairly large trees up to 35(-39)m tall; bole branchless for up to 21m, up to 100cm in diameter, not buttressed; bark surface (of timber tress) 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.

g. Wood anatomy

Macroscopic characters:

Heartwood pale pinkish-brown to grey-brown, clearly demarcated from the pale yellow to straw-coloured sapwood which is up to 60mm wide in *A. auriculiformis*, narrower in other species. Grain usually straight, sometimes interlocked.

Microscopic characters:

Growth ring indistinct or absent, sometimes poorly defined growth zones evident. Vessels diffuse, 4-6(-9)/mm², solitary (40%) and in radial multiples of 2-3(-4), round to mostly oval, average tangential diameter (90)-1120-160(-270)µm.

h. Growth development

Most *Acacia* species grow fast. The considerable member of growth data on *A. mangium* confirms that it can achieve a mean annual diameter increment of up to 5cm and a height increment of up to 5m in the first 4 or 5 years. *A. mangium* is reported to grow 3m tall in the first year in Sabah and Sumatera, and in the Philippines it reached an average height of 8.3m and diameter of 9.4cm 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 35cm in diameter and 35m in height. In Sabah, 14-year-old *A. mangium* trees



were 30m tall and 40cm in diameter. Provenances from Papua New Guinea consistently show better growth in height and diameter, and the form is also superior.

In the first 2 years both the diameter growth and height growth of *A. mangium* trees are significantly greater at a spacing of 2m x 2m and 2.5m x 2.5m than at 3m x 3m. 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 fasciculatum* 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 ectomycorrhizal fungus *Thelephora ramaroides* has been identified in Sabah in association with *A. mangium*.

i. Ecology

The species of acacia are mainly found 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.

j. 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 56-86g of seed.

The number of seeds/kg is 40,000-80,000 for *A. aulacocarpa*, 30,000-62,000 for *A. auriculiformis*,



Fruits

Bark

15,000-40,000 for *A. catechuu*, 5,000-50,000 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*.

The germination rate is high, generally 75-80%, 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%.

A. mangium can be propagated vegetatively through single-node stem cuttings 4-5cm long and 0.5-1.5cm in diameter, leaving 0.5-1 phyllodes. The application of 500-1,000ppm indolebutyric acid (IBA) or rooting powder enables 65-75% rooting to be achieved. However, rooting is reported to be slow.

k. 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 3m x 3m canopy closure was achieved in one year).

l. 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.

m. 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.



n. 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.

o. Genetic resources

Extensive seed collections have been made by CSIRO (Australia) from *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.

p. 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.

q. Prospect

The future for the increased utilization of *A. mangium* wood for the production of particle board and medium – density fiberboard is promising, and the quality of wood chips for pulp and paper is satisfactory.

Tree



Planted stand



FAMILY **GUTTIFERAE**



Tropical trees of Indonesia

23. *Callophyllum inophyllum* L.

Callophyllum inophyllum is a member of Guttiferae family. The synonyms of this species are *Albizia moluccana* Miq. (1855) and *Albizia falcataria* (L.) Fosberg (1965) and the vernacular names of this species are; Brunei: Puah. Indonesia: jeungjing (general), sengan laut (Java). Malaysia: batai, kayu machis. Papua New Guinea; white albazia. Philippines: Moluccan sau, falcate. The local names of this species are: Indonesia: nyamplung, dingkaran. Malaysia: bintngor laut, penaga laut, penaga. Papua New Guinea: beach callophyllum. Philippines: pale maria, bitaog. Burma: ponnyet, ph'ông. Thailand: krathing, saraphee naen, naowakan. Vietnam: c[aa]y m[uf] u. Detailed descriptions of *Callophyllum inophyllum* are as follows:





Flower



Fruits

a. Origin and geographic distribution

Eastern Africa, Madagascar, island of the Indian Ocean, India, Sri Lanka, Burma, Indo-China, Thailand, Taiwan and the Ryukyu Islands, throughout Malaysia, northern Australia and the island of the Pacific Ocean.

b. Uses

The timber is obtained in many places in fairly large quantities and used for many purposes: construction, furniture and cabinetwork, cartwheel hubs, vessels, musical instrument, canoes and boats. The oil from the seeds is used for illuminations, soap making, and medicinal purposes. The latex and pounded bark are also used medicinally. The tree is planted as ornamental and shade tree, and for reforestation and afforestation. The fruit is edible.

Ecological usage

Beauty leaf makes a good specimen, street, parking lot or shade tree and is both wind and salt tolerant, making it especially useful for coastal locations. It becomes twisted and contorted when exposed to constant wind, creating an interesting specimen. Beauty Leaf is sometimes used as a tall hedge or wind break around tennis courts and similar places. It could be used more often as an urban street tree. Remember that the golfball-sized fruit is poisonous

and hard and this could be undesirable in the landscape under some circumstances. The trunk grows to about two feet in diameter.

Medical usage

Tamanu oil extracted from bintangur seeds has the effect of cicatrizing, antibacterial and anti-inflammatory. It also has analgesic effect and used for sciatica, shingles, neuritis, leprosy neuritis dan rheumatism. Recent study showed that 25-50% tamanu oil has best effect on antiinflammatory. This compound is a cancer chemopreventive agent, where 4-phenylcoumarins could inhibit the activity of virus Epstein-Barr. Among these compounds, Calocoumarin-A was the most effective on the inhibition of melanoma or skin cancer Patil et al (1993) found inophyllums, novel inhibitors on the processes of HIV-1 reverse transcriptase, from tamanu oil.

c. Descriptions

Evergreen trees, rarely shrubs, up to 40(-60)m tall, with sticky latex either clear or opaque and white, cream or yellow; bole often straight and cylindrical, but occasionally twisted, up to 100(-240)cm in diameter; buttresses usually absent, rarely small, some species with stilt or loop roots; outer bark often with characteristic diamond to boat shapes fissures becoming confluent with age, smooth, often with a yellowish or ochre tint, inner



Leaf (adaxial & abaxial side)

bar usually thick, soft, firm, fibrous and laminated, pink to red, darkening to brownish on exposure. Seedlings with crypto-cotylar germination (cotyledons remaining enclosed in stone) and short epicotyl; seedling leaves opposite, sometimes first two pairs of leaves pseudo-verticillate or lowest pairs of seedling leaves small and soon falling off.

This upright, pyramidal, densely foliated evergreen tree can reach 60 feet in height in the forest with a 30 to 40-foot spread, but is generally much smaller because it grows slowly. They are large hard woods, attaining 30m in height and 0.8m in diameter. It presents shiny and leathery leaves. The tree bark is grey or white and decorticates in large thin strips. The wood is light in weight, the heartwood pink-red, or almost brown, while the sapwood varies from species to species, often from yellow, brown (often with pink tints) to orange.

This is an asset in tropical landscapes, where many other plants grow so fast. Greenish, showy, 3/4-inch, very fragrant flowers are produced on eight-inch racemes in the summer. The round, yellow, 1.5-inch-wide fruit contains a single seed with a nutlike kernel that may be poisonous. The seven-inch-long, glossy, dark green, stiff, leathery leaves have numerous, distinct parallel veins at right angles to the midrib. The trunk has light grey, shallowly-ridged bark, and the wood is valued for

boat building and cabinet work. These species grow in a wide number of habitats, from ridges in mountain forests to coastal swamps, lowland forest and even coral cays. Species found in Papua New Guinea are often buttressed.

d. Propagation and planting

C. inophyllum can be propagated by seeds. Natural regeneration usually occurs near the mother tree. Seedlings grown in nurseries require shade.

e. Silviculture and management

The selective cutting system and removal of undesirable trees can enhance the natural regenerations of bintangor.

Trunk



FAMILY **HAMAMELIDACEAE**



Tropical trees of Indonesia

24. *Altingia excelsa* Noroña

Altingia excelsa is a member of Hamamelidaceae family and is also included in family of Verbenaceae. The synonyms of this species are *Albizia moluccana* Miq. (1855) and *Albizia falcata* (L.) Fosberg (1965). The vernacular names of this species are; Brunei: Puah. Indonesia: jeungjing (general), sengon laut (Java). Malaysia: batai, kayu machis. Papua New Guinea; white albazia. Philippines: Moluccan sau, falcate. The local name of this species is rasamala, and detailed descriptions of *Altingia excelsa* are as follows:





Leaf



Bark

a. Origin and geographic distribution

This species is distributed from the Himalayas through the moister parts of Burma towards Peninsular Malaysia (where it is extremely rare), Sumatra and West Java

b. Uses

Rasamala is regarded as the most valuable timber in West Java. Because of its ability to form very long branchless boles, it was favored for frames of bridges and columns and beams for buildings. The wood is very durable and can be used in direct contact with the ground, for example for power transmission poles, telephone line poles and railway sleepers. Furthermore, the timber is used for heavy construction, vehicle bodies, ship and boat building, heavy flooring and rafters. Pulp for the manufacture of paper can also be obtained from rasamala wood. The dried bark has been used as tinder.

Trunk



c. Descriptions

A monoecious, evergreen, large and lofty tree up to 50(-60)m tall; bole branchless for 20-35m, 80-150(-185)cm in diameter, often slightly twisted or fluted at base; bark surface almost smooth, with narrow, longitudinal fissures and finally irregularly flaky with long, thin, light grey to yellowish or brownish-grey flakes; crown irregularly globular, seedling with epigeal germination; cotyledons foliaceous, on a hairy petiole; leaves arranged spirally.

d. Propagation and planting

Originally, seedlings from natural regeneration in the forest were used (natural regeneration is usually plentiful, even in plantations). But later the seeds were sown on seed-beds. The best way to obtain viable seeds is to pick nearly ripe fruits and dry them in the sun. The weight of 1,000 seeds is about 6g. Seeds are viable for a short period and should be sown rapidly.



FAMILY **ICACINACEAE**



Tropical trees of Indonesia

25. *Gonocaryum litorale* (Blume) Sleumer

Gonocaryum litorale is a member of Icacinaceae family. The vernacular names of this species are; Indonesia: kartomadin (Aru Islands), kondo (Topadu, Sulawesi), resui (Ambai, Japen Island). The synonyms of this species are: *Gonocaryum affine* Becc., *Gonocaryum macrocarpum* (R. Scheffer) R. Scheffer ex Warb., *Gonocaryum pyriforme* Scheffer. Detailed descriptions of *Gonocaryum litorale* are as follows:





Flowers

Leaves

Fruits

a. Origin and geographic distribution

Gonocaryum comprises 9 or maybe 10 species. The distribution of *Gonocaryum litorale* is: the Lesser Sunda Islands (Timor), Sulawesi, the Moluccas, New Guinea and the Bismarck Archipelago.

b. Uses

The wood of *Gonocaryum* is used in the Philippines for furniture and cabinet work, house-hold utensils, bobbins, spindles and shuttles. It is suitable for veneer and plywood manufacturing.

c. Properties

Gonocaryum yields a medium-weight hardwood with a density of 615-820 kg/m³ at 15% moisture content. Heartwood pinkish-buff, not sharply demarcated from the sapwood. Texture fine to moderately fine.

d. Botany

Small to medium-sized trees up to 15(-20)m tall, bole straight, branchless for up to 10m, up to 30(-50)cm in diameter. Bark surface grayish. Leaves arranged spirally, simple, entire, with a yellow and characteristically wrinkled petiole, exstipulate. Seedling with hypogeal germination.

e. Ecology

G. litorale is found scattered but locally frequent in primary and secondary evergreen forest, up to 1,200m altitude (in Papua New Guinea up to 1,650 m altitude). It grows in coastal and swamp forest, generally near rivers or temporarily inundated alluvial flats, on sandy and clayey soils.

f. Propagation and planting

Gonocaryum litorale can be propagated by seed.

g. Silviculture and management

A germination rate of about 25% has been reported for fruit of *G. gracile* Miq., but germination did not start until after two years. Germination of *G. litorale* is also reported to be poor.

h. Pests and diseases

The hardwood is moderately resistant to dry-wood termites, the sapwood is susceptible to *Lyctus*.

Immature fruits



FAMILY **LAURACEAE**



Tropical trees of Indonesia

26. *Cinnamomum burmanii* (C.G. Nees) Blume

Cinnamomum burmanii is a member of Lauraceae family. The vernacular names of this species is camphorwood. The local name of this species is kayu manis. Detailed descriptions of *Cinnamomum burmanii* are as follows:



a. Origin and geographic distribution

Cinnamomum consist of about 250 species (estimates of about 150 species have also been published) found in continental Asia, Mealesia Australia, the Pacific, and a few species in Central and South America. Within Malasian area some 90 species have been recognized.

b. Uses

The timber is used for decorative work such interior finish and paneling, for furniture, cabinet making, lining chests, wardrobes, and is suitable for plywood manufactures. The heavier timber is used for medium-heavy construction under cover. The fragrant wood is suitable for making moth-proof chests. Cinnamon oils are employed in perfumes and as flavoring ingredients in foods and drinks. 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.

c. Properties

Camphorwood is a light weight to medium-weight hard wood. The heartwood varies in colour from grayish-green to pinkish, reddish or pale brown, sometimes turning to red-brown or walnut-brown on exposure. The density is 370-860 kg/m³ at 15% moisture content.

d. Descriptions

Evergreen or deciduous shrubs or small to large trees up to 50m tall; bole branchless for up to 30m,

up to 125cm 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, sub-opposite, alternate or arranged spirally, simple and entire, with glandular dots and aromatic when crushed. Seed without albumen, with a thin testa; cotyledons large, flax, convex and pressed against each other; embryo minute.

e. Wood anatomy

Macroscopic character:

Heartwood yellowish-brown to red-brown, not distinctly demarcated from the paler sapwood. Grain straight to moderately interlocked. Texture moderately and even. Plane surface greasy to the touch.

Microscopic character:

Growth rings indistinct to vague, marked by thick walled and flattened latewood fibres, occasionally also by discontinuous marginal parenchyma bands. Average of tangential diameter is 80-170µm.

Leaves





Flower

Leaves

f. Ecology

Cinnamomum grows scattered, although sometimes locally abundant, in primary lowland and hill forest or sometimes in montane forest up to 2,000m 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.

g. Growth and development

Cinnamomum trees are reported to grow rapidly. In 24-28 old trial plantation in Java, the mean annual increment was 1.2cm in diameter and 0.7-1.0m in height. *Cinnamomum camphora* grows fast under favourable condition in its natural habitat and can reach a height of 10m and a diameter of 15cm in 10 years.

h. Propagation and planting

C. burmanii can be propagated by seeds, but the species producing cinnamon are also propagated by various methods of vegetative propagation such as layering, root cuttings, cuttings from root suckers and by division of the root stock. Seeds cannot be stored, as they very rapidly lose their viability. After depulping, seed should be dried for only a short time and then sown directly afterwards under shade.

i. Silviculture and management

A mixed plantation of *Cinnamomum* and teak (*Tectona grandis* L.f.) was not satisfactory, as *Cinnamomum* did not nurse the teak trees to develop a longer clear bole. *Cinnamomum* trees resprout after fire. The cinnamon and cassia producing species are managed by coppicing.

j. 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.



Fruit

Trunk



27. *Dehaasia incrassata* (Jack) Kosterm.

Dehaasia incrassata is a member of Lauraceae family. The vernacular names of this species are; Indonesia: belumbang taloi (Lampung, Sumatra), guli kunyit (Aceh, Sumatra), medan mesang (Pelambang, Sumatra). Malaysia: medan batu, medan payang, medan tandok (Peninsular). Philippines: margapali (Filipino). The synonyms of this species are: *Dehaasia media* Blume, *Dehaasia microcarpa* Blume, *Dehaasia triandra* Merr. Detailed descriptions of *Dehaasia incrassata* are as follows:





Flower buds

Leaf

Fruits

Trunk

a. Origin and geographic distribution

Dehaasia comprises about 35 species. Distribution of this species are: Peninsular Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, the Philippines, Sulawesi, the Moluccas and New Guinea (Irian Jaya).

b. Uses

The wood of *Dehaasia* is used for light construction under cover, house posts, house piling, interior finish, paneling, furniture and cabinet work, turnery, carving, picture framing, musical instrument. Veneer and plywood of varying quality can be manufactured from the wood.

c. Properties

Dehaasia yields a medium-weight to heavy hardwood with a density of 580-900 kg/m³ at 15% moisture content. Heartwood olive-green or yellow-green. Texture fine to moderately fine and even. The wood is moderately hard to hard and fairly strong. The fruit of *D. incrassata* are reported as very poisonous and irritating to the skin. The leaves of the same species contain alkaloids.

d. Botany

Evergreen, small to medium-sized trees up to 35(-40)m tall, rarely shrubs. Bole usually fairly straight,

branchless for up to 15(-25)m, up to 70(-100)cm in diameter. Bark surface smooth to cracking, inner bark yellowish or yellowish-brown. Leaves arranged spirally, crowded of the end of twigs. Seedlings with hypogeal germination. Flowering in February-March and July-November. *Dehaasia* is closely related to *Alseodaphne* which differ only in the presence of 4 anther cells instead of 2.

e. Ecology

Timber-producing *Dehaasia* species are usually understorey trees and occur scattered in primary evergreen rain forest. They are found in lowland and hill forest, sometimes ascending into the lower montane forest up to 1,200m altitude. Habitat types include dryland forest and coastal forest.

f. Propagation

Dehaasia can be propagated by seed. Seeds have about 75% germination in 2 months up to 1.5 years.

Leaf and flowerbuds



28. *Eusideroxylon zwageri* T. & B.

Eusideroxylon zwageri is a member of Lauraceae family. The trade name of this species is ulin. The vernacular names of this species are; iron wood, bilian. Brunei: bilian, Indonesia: belian, Philippines: tambulian. Detailed descriptions of *Eusideroxylon zwageri* are as follows:





Flowers

Leaf

Fruit

Bark

a. Origin and geographic distribution

The species is a monotypic and found in eastern and southern Sumatra, Bangka, Belitung, Borneo, and Palawan.

b. Uses

Ulin is one of the heaviest and most durable timbers of Southeast Asia. It is preferably used in marine constructions such as pilings, wharfs, docks, sluices, dams, and ships.

c. Descriptions

An evergreen tree of up to 40(-50)m tall, bole straight, branchless for up to 20 m but usually less. Sometimes slightly fluted at the base, up to 150(-220)cm in diameter.

d. Growth and development

Seedlings and saplings demand some shade, but older saplings and young trees require plenty of light for vigorous growth.

e. Propagation and planting

Ulin can be propagated by seed, but nursery-raised wildlings are also often used for planting

f. Silviculture and management

In natural forest, ulin is usually cut selectively with a diameter limit of 50cm. Regeneration of logged over forest is often not sufficient.

g. Diseases and pests

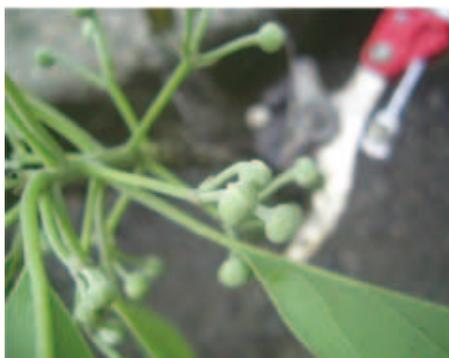
No serious diseases and pests are reported, although deer and boars may damage seedlings and saplings, and seeds are often destroyed by porcupines.



29. *Litsea elliptica* Blume

Litsea elliptica is a member of Lauraceae family. The vernacular names of this species are; Indonesia: trawas, prawas (Sundanese, Java), gogisoro (Moluccas). Malaysia: medang perawas, medang terawas, medang tandok (Peninsular). Philipines: batikuling-surutan (general), magtagbak (Palawan). Thailand: thamang (peninsular). The synonyms of this species are: *Litsea petiolata* Hook.f. (1886), *Litsea odorifera* Valetton (1909), *Litsea clarissae* (Teschner) Kostern (1968). Detailed descriptions of *Litsea elliptica* Blume are as follows:





Flower buds

a. 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. *Litsea elliptica* distribution are Peninsular Thailand, Malaysia, Singapore, Sumatra, Java, and Borneo, The Philipines, Sulawesi, The Moluccas and New Guinea; probably occasionally planted in Java.

b. Uses

The wood is used under cover, e.g., for general construction, but also for carving, sculpturing and pattern making. The aromatic leaves contain ethereal oils and are used in traditional medicine against tumours, ulcers, and stomachache, and are applied to stimulate the lacteal glands. They yield sarole used as "sarsaparilla" in the perfume and flavour-producing industry.

c. 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 the total amount of medang in trade. The minimum price for saw logs in Papua New Guinea in 1992 was US \$ 43/m³.

d. 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 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 heartwood is difficult to treat with preservatives, but the sapwood absorbs preservatives readily.

e. Descriptions

Evergreen, usually dioecious shrubs or small to medium-sized, rarely large trees up to 45m 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. Leaves alternate; subopposite or opposite, simple, entire, with glandular dots and aromatic when crushed, pinnately veined, often glaucous below; stipules absent. 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.

f. Observation

A large tree up to 45m tall, bole straight, cylindrical, up to 75cm in diameter, with the short buttresses upto 1m high, bark surface smooth, lenticellate, rarely fissured or scaly, grey-brown, inner bark pinkish, with a strongly aromatic (lemon) smell; leaves arranged spirally, blunt to acuminate, glabrous; flowers in shortly peduncled short racemes from leaf axils or on leafless twigs; fruit globose to ellipsoid. *L. elliptica* is widely distributed and occurs in primary and secondary lowland forest, usually up to 800m altitude.

g. 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. They usually constitute elements of the canopy or subcanopy layer, rarely emerging, and occur scattered but may be locally dominant.

h. Propagation

Propagation is generally by seed, but may be possible by root or branch cuttings as well. Germination is not rapid, 95% germinate in 35–115 days for *L. elliptica*. Fruits without cup germinate very poorly.

i. Silviculture and management

Natural regeneration is not favourable here. In peat-swamp forest, fast growing *Litsea* species may become dominant in logged-over forest, such as *L. cylindrical*, *L. gracilipes*, *L. nidularis* and *L. resinosa*. Most of the species coppice freely.

j. Harvesting

Nearly all the larger trees of *L. crassifolia* in kerangas and peat swamp-forest in Sarawak are hollow.

Leaf

Bark



FAMILY **LEGUMINOSAE**



Tropical trees of Indonesia

30. *Adenanthera pavonina* L.

Adenanthera pavonina is a member of Leguminosae family. The vernacular names of this species are; Coralwood (En). Indoensia: kitoke laut (Sundanese), saga telik, segawe sabrang (Javanese). Malaysia: saga tumpul (Peninsular), Philippines: malatanglin. The synonym of this species is *Adenanthera gersenii* Scheffer. Detailed descriptions of *Adenanthera pavonina* are as follows:





Leaf

Fruits

Basal trunk

a. Origin and geographic distribution

Adenanthera comprises 12 species occurring in Sri Lanka, Southern Burma (Myanmar), Indo-China, Southern China, Thailand, throughout Malesia (except for the Philippines) and Solomon Islands.

b. Uses

The wood of *Adenanthera* is used for bridge and house construction (beams, posts, joists, rafters), flooring, paving block and vehicle bodies. It may also be suitable for furniture and cabinet work, and turnery.

c. Properties

Adenanthera yield a medium-weight to heavy hardwood with a density of 595-1,100 kg/m³ at 15% moisture content. Heartwood bright yellow when fresh.

d. Descriptions

Mostly deciduous small to medium-sized trees up to 30(-40)m tall, rarely shrubs, bole straight and cylindrical to rather poorly shaped, branchless for up to 16m, up to 100(-200)cm in diameter. Leaves arranged spirally, bipinnate, without glands. Seed red, shiny. Seedlings with epigeal germination.

e. Ecology

Adenanthera species are found scattered in primary and secondary, evergreen to dry deciduous rain

forest, but also in open savanna-like vegetation, from sea-level up to 900m altitude.

f. Propagation and planting

Seeds are probably eaten and dispersed by birds. *Adenanthera* can be propagated by seed. Propagation from large cuttings is also reported to be successfully in India. Available dry seed counts per kg is 3,750 for *A. pavonina*. Seeds of *A. pavonia* become impermeable with time and after being stored for 8 months they fail to germinate. Their viability, however, is not affected as after mechanical scarification germination is 100% in 1-4 days.

g. Silviculture and management

Fairly dense planting at 2-3m x 1m is necessary to prevent trees developing poor stem forms or multiple stems. Using these spacing, canopy closure takes 2-3 years. Early thinning is important, as trees tend to die off when the stand becomes too dense.

h. Yield

Timber yield at the age of 12 years is 60-96 m³/ha.

Dried seed pods



31. *Dialium modestum* (v. Steenis) Stey.

Dialium modestum is a member of Leguminosae family. The synonym of *Dialium modestum* is *Uittenia modesta* v. Steenis. The vernacular names are; Keranji: velvet tamarind, tamarind plum (En). Indonesia: nyamut, keranji, bumbu merah (Kalimantan), kranji (Sumatra). Burma: taung-kaye. Cambodia: kralanh, kralanh lomie. Laos: kheng. Thailand: kayi-khao (peninsular), yi-thongbung (Nakhon Si Thammarat). Vietnam: xoay, x[aa]y, nh[oo]ji. Detailed descriptions of *Dialium modestum* are as follows:



a. Trade groups

KerANJI: heavy hardwood, e.g., *Dialium indicum* L., *D. platysepalum* Baker, *D. procerum* (v. Steenis) Stey.

b. Origin and geographic distribution

Dialium has a pantropical distribution and consist of about 30 species. Of these, 7 species occur within the Indo-Malesian area whereas some 20 are present in Africa and Madagascar and only 1 in Central and South America. Within Malesia the genus is confined to the western half (Peninsular Malaysia, Sumatra, Java and Borneo) and does not cross Wallace's line, an important biogeographical barrier which lies between Borneo and Sulawesi. The absence from eastern Malesia and areas further east and south implies that the Malesian species have a western origin.

c. Descriptions

Evergreen or more rarely deciduous, unarmed, small to large trees of up to 45m tall or occasionally large shrubs; bole columnar but often slightly twisted above, branchless for up to 21m, up to 120cm in diameter and usually prominently buttressed with plank-like forked buttresses; bark surface generally smooth, often rugose and occasionally flaking with small, thick scales, rarely lenticelled and hoopmarked, inner bark hard, brown, finely mottled, producing a little clear exudates soon turning red, sapwood hard, cream to yellowish-brown, ripplemarked; twigs terete, lenticellate, generally

hairy when young and glabrescent; indumentum consisting of simple, patent or adpressed hairs. Leaves alternate, either unifoliolate or simply imparipinnate; stipules small, linear-triangular, very early caduceus; leaflet alternate or sometimes opposite to subopposite, entire, subleathery, hairy above when young, indumentum beneath generally persistent. Inflorescences axillary or terminal, consisting of many-branched and many flowered panicles; bracteoles very early caduceus.

Flowers bisexual, irregular; sepals (in Asiatic species) 3 or 5; petals (in Asiatic species) 0 (5 in *D. modestum*), when present not conspicuous, clawed; disk present or absent; stamens (in Asiatic species) 2 or 6 (5 in *D. modestum*), anthers basifixed, dehiscent by longitudinal slits; ovary sessile or sometimes shortly stipitate, with (1-2) ovules, densely adpressed hairy, style solitary, excentric or central, with a punctiform stigma. Fruit an dehiscent, ellipsoid or ovoid to subglobose or slightly compressed berry-like pod, hard, brittle and glabrescent outside, sometimes glaucous, the 1-2 seeds entirely embedded in a dry mealy reddish-brown pulp. Seed usually reiform with a smooth testa, usually dark brown when dry, areoles absent, endosperm present, seedling with epigeal germination; hypocotyls elongated; cotyledons large, succulent; first two leaves opposite.



Adaxial leaf

Abaxial leaf

Bark

d. Observation

A small to medium-sized tree of up to 30m tall, bole branchless for up to 18m and up to 80cm in diameter; leaves unifoliate, leaflet 7-20cm x 3.5-7.5cm, glabrous; sepals 5, petals 5, stamens 5; fruit not brittle but with a hard pericaps, globose, 4-6cm in diameter. *D. modestum* is a fairly common species of primary, non-inundated forest up to 600m altitude. This species might well form a genus separate from *Dialium*; it should then be called *Uttienia modesta* v. Steenis.

e. Growth and development

During germination, the testa breaks at soil level, exposing the creamy white, thick cotyledons. As the seedling grows, the hypocotyls elongates and lifts the cotyledons above the soil level, leaving the testa behind on (or sometimes partly in) the soil. The clasping cotyledons then spread and do not change colour immediately but remain creamy white for some time until the first leaves start to develop. Then the cotyledons turn green and remain attached to hypocotyls until the first leaves are fully developed.

Keranji trees are moderately slow growers. A tree of *D. platysepalum* in Malaysia reached a bole diameter of 49cm after 40 years.

The fruits are dispersed by animals (e.g., monkeys) which like to eat the pulp embedding the seeds. However, the fruits are also capable of being transported by water, since they float. Transport by sea currents may lead to long-distance dispersal.

f. Ecology

Most species of keranji inhabit primary rain forest. Because of the hardness of the wood, specimens are often left by loggers on in shifting cultivation and they become relicts in secondary forest. Keranji occurs scattered, not gregarious as do many other related species, sometimes along river banks and in low-lying swampy areas and peat swamps but also on well-drained land. Keranji is generally found in the lowlands, but occasionally up to 1,150m altitude.

g. Propagation and planting

Germination of untreated seeds of *D. platysepalum* is staggered over a period of about 17 months; 75% of the seeds have germinated after 50 weeks. Mechanical scarification (cutting with secateurs on one side of the seed) is the best treatment to promote germination. About 70% of the scarified seeds germinate within a month. Treatment with concentrated sulphuric acid (H_2SO_4) is much less effective.

The seeds can be sown in beds containing a mixture of equal parts of forest topsoil and river sand. They are buried just below the soil surface and a layer of sawdust is spread on top. The beds should be shaded and watered regularly (twice a day).

There are no records of the establishment of plantations, except for *D. cochinchinense*, which is reported to be planted in villages in northern Peninsular Malaysia for its edible fruits.

h. Uses

The timber is used as keranji. Keranji is a good general-purpose timber. Because of its moderate natural durability and strength it has a limited suitability for purposes in contact with the ground such as poles and piles, fences, railway sleepers, telegraph and power transmission posts and cross-pieces, bridges, and sledges used in logging. Locally the timber is used for ship and boat building and for vehicle bodies (framework and floor boards). Keranji is chiefly used in construction, e.g., as mine timber, for joinery, beams, door and window frames, sills, posts, joists, rafters, fender supports, columns, and various parts of staircases. Keranji is also very suitable for purposes where toughness and resilience is required, such as gymnasium equipment, agricultural implements, tool handles (heavy impact), mallets, oil presses and industrial flooring. Due to the attractive

sheen which is usually dark red or brown, keranji is suitable for decorative panelling, cabinet and furniture making, toys and novelty items. Due to the hardness of the timber it is not recommended for veneer and plywood production, neither is it suitable for particle board or pulp production.

The pulpy fruits of some species are edible and are generally sold dry. The bark is rich in tannins but has been used for tanning on a very limited scale. The bark has also been used as a substitute for betel nut and medicinally against diarrhoea and herpes.

Leaf



32. *Intsia bijuga* (Colebr.) O. Kuntze

Intsia bijuga is a member of family Leguminosae. The synonyms of this species are *Intsia amboinensis* DC. *Azelia bijuga* (Colebr.) A. Gray, *Intsia retusa* (Kurz) O. Kuntze. The trade name of this species is heavy-hard wood and the vernacular names of this species are; Indonesia: merbau asam (Kalimantan), ipi (Lesser Sunda Islands). Malaysia: merbau ipil (Serawak, Sabah), kayu besi (Peninsular). Papua New Guinea: kwila, pas. Philippines: ipil, ipil laut. Cambodia: krakas prek. Thailand: lumpho-thale. Detailed descriptions of *Intsia bijuga* are as follows:





Flowers

a. Origin and geographic distribution

Intsia consists of about 8 species and are found from Tanzania and Madagascar through southern India and Burma, towards Malesia, northern Australia and Polynesia.

b. Uses

Merbau is a very good general-purpose timber. It is suitable for a wide range of purposes because of its favourable physical and mechanical properties, combined with a high natural durability and an attractive appearance. *I. bijuga* is an important source of merbau timber. Bark and leaves are used medicinally and the seeds can be eaten after careful propagation. Other uses include furniture making, paneling, stairs, handrails, musical instrument, waterwork construction such as bridges, wharves, sluices, and sheet piles.

c. Observation

A medium-sized to large tree up to 50m tall, bole branchless for up to 20m and up to 160-250cm in diameter. Leaves with 2-3 pairs of leaflets, leaflets thinly leathery with an acute to cuneate base and an acute to emarginated apex, 3.5-11cm x 1.5-8cm. Flower white or pink. *I. bijuga* is most frequently occurred in coastal forests and along tidal rivers but also found inland up to 600m altitude. The density of the wood is 630-1,040 kg/m³ at 15% moisture content.

d. Properties

Merbau is heavy and hard without characteristic figure. Heartwood light brown, orange brown, to dark red-brown.

e. Descriptions

Medium size or large, evergreen or deciduous up to 50m tall, bole sometimes of poor shape, branchless for up to 20m and with a diameter of up to 160(-250)cm. Buttresses usually present, bark 0.5-1cm thick. Leaves alternate, paripinnate with 2-4(-5) pairs of leaflets. Flower arranged spirally in simple racemes or branched terminal or lateral panicles. Fruit a stipitate pod, compressed, with several seeds. Seed large, hard, with-out an aril, dark brown at maturity.

f. Wood anatomy

Macroscopic character:

Heartwood light brown with some darker brown streaks. Grain straight. Texture moderately coarse, wood more or less lustrous. Growth rings usually distinct, because generally vessels are less numerous in the outer part of a growth ring.

Microscopic character:

Growth ring boundaries marked by marginal parenchyma bands and/or differences in vessel frequency. Average tangential diameter 185-280µm, of vessels in multiples 60-230µm. Fibres 560-790µm long. Non-septate, thick walled, with simple pits confined to the radial walls.



g. Growth and development

Experiments showed that the cotyledons contribute to seedling development up to the stage of the first pair of leaves. Initial growth of the seedling is fast, seedlings reach an average height of 40-55cm after 3 months. Hence growth will slow down, and in the period from 3-10 months after germination its average growth is only 5-6cm. Merbau seedlings need a high light intensity for optimal growth, and in the open growth is much faster than under closed canopy condition. However, experiments in Indonesia showed that growth of seedling under shelter or under shade trees was faster than in full sunlight. In Bogor, Indonesia, an 8-year-old stand of *Intsia bijuga*, had an average height of 10.7m and an average diameter of 15cm. The maximum diameter which may reached in 40 years is 43cm for *Intsia palembanica*.

h. Ecology

I. bijuga are most frequently found in coastal areas, often in a zone behind the mangrove and is, therefore, often treated as a member of the Indo-Pacific strand flora. *I. palembanica* is found inland up to 1,000m altitude. Merbau prefers a rainfall of more than 2,000mm a year and grows in primary or old secondary forests on a wide variety of soils but usually not on peat. It is sometimes found growing gregariously, and occasionally dominant.

i. Propagation and planting

Merbau seeds are protected by a hard seed-coat which is impermeable to water. Mature seeds have a moisture content of less than 10% and hence can survive for more than 3 years without any specific treatment. Germination may take up to nearly 2 years. To promote rapid and simultaneous germination, scarification followed by soaking in water is necessary. The most effective scarification technique is to use a file to scarpe off the small protrusion of the seed coat located at the opposite side of the hilum. Treatment with fungicides may protect scarified seeds from damage by fungi. Immersion in concentrated sulphuric acid for one hour is also effective in rupturing the seed coat. Seeds must be planted vertically with the hilum downward, so that the seed-coat is shed as the hypocotyl emerges from the soil. Seed may also be sown directly into the field. Seeds of *Intsia bijuga* germinate better in full sun. Seedlings can be transplanted into the field at about 3 months after sowing at a spacing of 3m x 4m or 5m x 5m. Vegetative propagation of merbau by means of 60cm long cutting was tested in the Philippines. Six weeks after planting in a sandy clay-loam medium the mortality rate was 62%.

j. Silviculture and management

Extensive stands of merbau are found in northern Papua New Guinea on sites destroyed by fire during natural droughts. After logging, dormant seeds in the soil can germinate abundantly in gaps around the stumps. Merbau is apparently a successful secondary forest tree.

k. Diseases and pests

The root of *Intsia bijuga* seedlings may be infected by nematodes. In the Philippines *Rotylenchulus* sp and *Helicotylenchus* sp. have been found in nurseries. In Kalimantan young plantation suffered from grazing by deer and mouse deer, while rats are also considered a serious pest.

l. Harvesting

Fresh logs sink in water and must be transported over land.

m. Yield

Forest inventories in Peninsular Malaysia (1970-1972 and 1981-1982) showed that there are still sufficient merbau timber in the natural forest. Annual log production figures have been more or less stable from 1981-1991. The standing stock in Peninsular Malaysia is estimated at 2.8 trees/ha (gross volume 11.7 m³/ha) over 15cm diameter and 1.9 trees/ha (gross volume 10.8 m³/ha) over 45cm diameter. The yield is still good enough to make merbau as one of the most important export timbers of Peninsular Malaysia.

n. Genetic resource

It includes species which, although not necessarily threatened with extinction now, may become so unless trade in specimens of such species is strictly regulated in order to avoid over-utilization. Stands of merbau have been exploited for many years, because it is a popular hard wood for both domestic and international market, and the *Intsia* species are considered to merit conservation.

Seeds and germinating seed



33. *Koompassia excelsa* (Becc.) Taubert

Koompassia excelsa is a species member of Leguminosae family. The vernacular names of this species are tualang. Brunei: mangaris. Indonesia: mangaris (Kalimantan), sialang (Sumatra). Malaysia: sialang (Peninsular), kayu raja (Sabah, Sarawak, Peninsular), tapang, kussi (Sarawak), mangaris (Sabah). Philippines: manggis (Sulu, Tagbanua), ginoo (Palawan). Thailand: yuan, tolæ (Yala, Pattani). The synonyms of *Koompassia excelsa* are *Koompassia parvifolia* Prain ex King. Trade groups of this species are; Tualang: medium-heavy timber, *K. excelsa* (Becc.) Taubert. Detailed descriptions of *Koompassia excelsa* are as follows:





Trunk

a. Distribution

Southern Thailand, Peninsular Malaysia, north-eastern Sumatra, Borneo and Palawan.

b. Observation

A very large tree up to 85m tall with a buttressed columnar bole up to 25m long and 100cm in diameter but sometimes reaching 290cm, bark quite smooth, hooped, shiny, publish-grey, commonly tinged delicate fluorescent green, especially upwards, crown made up of many smaller sub-crowns; leaves with 7-12(-17) leaflets of 3-4.2cm x 1-1.7cm; flowers small, sepals and petals up to 3mm long, ovary oblong, glabrous; pod 7.5-12.5cm long. *K. excelsa* is a common but usually not very abundant species which in Peninsular Malaysia is strangely absent south of the line connecting Kuala Lumpur and Kuantan. It holds the record for the tallest recorded boadleaf rain forest tree and is the sixth tallest of all trees. Solytary trees standing alone in the open are encountered comparatively often because there are difficult to cut and because local people harvest honey from the many bee nests usually present in the crown. See also the table on wood properties.

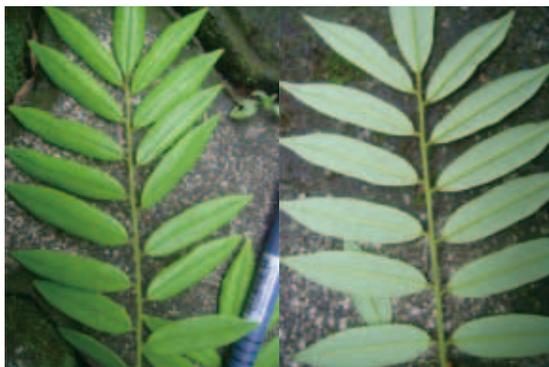
c. Growth and development

Taproot and hypocotyl emerge laterally from the fruit. The germination period for *Koompassia excelsa* is 1-3 weeks. Seedlings grow well but not as quickly as those of kempas. Trees are common on the floor of virgin forest but they may grow very slowly in the initial stage. Twenty 15-year-old trees in a 17-year-old natural regrowth had reached an average height of only 1.85m.

K. excelsa trees shed all their leaves every year and remain leafless for a few weeks. The flowers appear several months later. *K. excelsa* flowers in May and June, and fruits in August and September. *K. excelsa* has been observed to flower at irregular intervals of 5-6 years. Natural dispersal of the fruits of *K. excelsa* species is by wind; the fruit has a papery wing and the seed is flattened.

d. Ecology

Koompassia is a tree of primary tropical rain forest below 650m altitude. It is widespread and sometimes abundant, and is occasionally the dominant upper-story tree.



Adaxial leaf

Abaxial leaf

e. Propagation and planting

Freshly-collected fruits are used for propagation in Malaysia. No pretreatment is applied except for the removal of the wings. *Koopassia* seeds are not protected by a hard seed-coat. In order to ensure a high germination rate, the seed should not be stored for a long period. When stored, seeds are susceptible to fungus infection and should therefore be treated with a fungicide. Storage at low humidity is advised.

f. Silviculture and management

No specific information is available. *K. excelsa* is an acceptable species for culture.

g. Uses

The timber is used as tualang. The wood is sometimes used as firewood. The bark is used medicinally.

h. Diseases and pests

So far no serious diseases or pests have been reported.



34. *Maniltoa browneoides* Harms

Maniltoa browneoides is a member of Leguminosae family. The vernacular names of this species are; Indonesia: saputangan (general). The synonyms of this species are: *Maniltoa gemmipara* R. Scheffer ex back., *Maniltoa grandiflora* Back. and Bakh. f. non (A. Gray) R.Scheffer. Detailed descriptions of *Maniltoa browneoides* are as follows:





Flower

Leaves

Fruits

Bark

a. Origin and geographic distribution

Maniltoa comprises about 20 species. Distributions of this species are; New Guinea; occasionally planted in northern Sumatra, Java and Papua New Guinea.

b. Uses

The wood of *Maniltoa* is used for general construction, furniture, joinery, flooring, cladding, paneling, decking, lining, turnery, sliced veneer, tool handles and truck bodies. It makes good charcoal.

c. Properties

Maniltoa yields a medium-weight to heavy hardwood with a density of 740-1,120 kg/m³ at 15% moisture content. Heartwood brown or red-brown. Texture moderately fine to moderately coarse. Growth rings indistinct. The wood moderately hard to hard and fairly strong.

d. Botany

Small to large trees up to 40(-48)m tall, bole branchless for up to 19m, up to 90(-120)cm in diameter. Bark surface smooth. Flowering may start at a very young age.

e. Ecology

Maniltoa occurs in primary lowland forest up to 500(-1300)m altitude, often in swampy localities and is shade-tolerant.

f. Propagation and planting

Maniltoa may be raised from seed. *M. brownoides* has about 190 dry seeds/kg. The seeds can be sown in full sunlight as well as in shade. Seeds germinate readily with about 95%. Germination start after 10 days, and 15 days after sowing 80% of the germination seeds have appeared.

g. Silviculture and management

It seems to thrive best in a mixture of loam, peat, and sand. In lowland forest in New Guinea a density of 0.5-2.1 trees of over 35cm diameter per ha has been recorded.

Flowers

Seed pods



35. *Paraserianthes falcataria* (L.) Nielson

Paraserianthes falcataria is a species of family Leguminosae. The synonyms of this species are: *Albizia moluccana* Miq. (1855) and *Albizia falcataria* (L.) Fosberg (1965). The vernacular names of this species are; Brunei: Puah. Indonesia: jeungjing (general), sengan laut (Java). Malaysia: batai, kayu machis. Papua New Guinea; white albazia. Philippines: Moluccan sau, falcate. Detailed descriptions of *Paraserianthes falcataria* are as follows:





Flower buds



Seed pod

a. Origin and geographic distribution

Paraserinathes consist of 4 species. It is native to Sumatra, Java, Bali and Flores, the Moluccas, New Guinea, the Solomon Island, and Australia. Its origin probably is from the eastern Malesian area as the largest diversity of the species is found here.

b. Uses

The timber is used as batai (as given for the genus). The comparatively soft wood of batai is suitable for general utility purposes such as light construction, especially rafters, paneling, interior trim, furniture, and cabinet work. As the wood is not durable and susceptible to various kinds of insect and fungal attack, it should be used under cover and no contact with the ground. It is useful for light weight packing material such as packages, boxes, cigar and cigarette boxes, crates, tea chests and pallets. It is well known source for matches. In Papua New Guinea native people make various items, including shields, from this wood. *P. falcataria* is planted as an ornamental and shade tree, for reforestation and afforestation or for firewood production. The bark yields kino and has tanning properties and it is also used for packing. The leaves are used to feed chickens and goats.

c. Observation

A medium-sized to fairly large tree up to 40m tall, bole branchless for up to 20m and with diameter up to 100cm or sometimes more in diameter. Leaves up to 40cm long, with (4-)8-15 pairs of pinnae, each pinna with (8-)15-25 leaflets, leaflets oblong-falcate, (2-)3-6mm broad, flower in paniculate racemes. Pod winged along the ventral suture. *P. falcataria* has subspecies (Moluccas and New Guinea: *falcataria*, Solomon Island: *solomonensis* Nielsen, in the mountain of New Guinea: *Albizia fulva* and *Albizia eymae*. *P. falcataria* are found in primary but more often in secondary forest on river flood terraces, sometime in beach forest and regrowth from sea-level up to 2,300m altitude. The density of the wood is 300-500 kg/m³ at 12% moisture content.

d. Properties

P. falcataria is a light weight, soft to moderately soft wood. The color of the heartwood ranges from whitish to pale pinkish-brown or light yellowish-to reddish brown. The grain of the wood is straight or interlocked, texture moderately coarse but even. *P. falcataria* easy to work with machines and hand tools, but, although the wood is non-siliceous, it is reported to be abrasive to saw due to pinching

and subsequent burning of sawteeth as a result of tension stresses relieved in the wood. *P. falcataria* is not durable when used outside. Graveyard tests in Indonesia showed an average service life in contact with the ground of 0.5–2.1 years. It is often highly vulnerable to attack by termites, powder-post beetles and fungi. *P. falcataria* wood contains 49% cellulose, 27% lignin, 15.5% pentosan, 0.6% ash and 0.2% silica. The solubility is 3.4% in alcohol-benzene, 3.4% in cold water, 4.3% in hot water, and 19.6% in a 1% NaOH solution. The energy value of the wood is 19,500–20,600 kJ/kg.

e. Descriptions

Unarmed trees (or shrubs) up to 40m tall. Bole generally straight and cylindrical in dense stand, branchless for up to 20m and up to 100cm or sometime more in diameter. Bark surface white, grey, or greenish, smooth or slightly warty. Leaves alternate, bipinnate, the rachis and pinnae with extrafloral nectaries. Flower bisexual, regular, 5-merous, subtended by bract. Fruit a chartaceous, flat, straight pod, not segmented. Seed subcircular to oblong, not winged, endosperm absent, cotyledon large. Seedling with epigeal germination.

Flower buds



f. Wood anatomy

Macroscopic character:

Demarcation between sapwood and heartwood usually indistinct. Heartwood white to pale pink or light reddish-brown, with little figure or no figure at all. Grain usually interlocked, sometimes straight. The texture of the species is moderately coarse and even.

Microscopic character:

Growth ring indistinct. Average tangential diameter 160-340µm, perforations simple, fibres 1,200-1,500µm long, non-septate, thin walled.

g. Ecology

The four species of *Paraserianthes* are found in a wide variety of habitats generally ranging from sea-level to 1,600m altitude but sometimes up to 3,300m altitude. As they are pioneers, they are found in primary but more characteristically in secondary lowland rain forest, but also in light montane forest, elfin forest, and grassy plains or along roadsides near the sea. They are found on sandy and lateric soils as long as drainage is sufficient. The species are adapted to prehumid to monsoon climates (with a dry season of up to 4 months). In their natural habitat, the annual precipitation may range between 2,000-2,700mm or sometimes up to 4,000mm. The optimal temperature range is 22-29°C with a maximum of 30-34°C and minimum 20-24°C. In natural stand in Papua, *P. falcataria* is associated with species such as *Toona sureni*, *Terminalia* spp, *Agathis labillardieri*, *Pterocarpus indicus*, and *Diospyros* spp.

h. Growth and development

The growth is so fast, it is sometimes called 'miracle tree'. *P. falcataria* is even mentioned in the Guinness Book of Records as the world's fastest growing tree. On good sites, trees may attain a height of 7m in a little more than one year. Trees reach a mean height of 25.5m and a bole diameter of 17cm after 6 years, 32.5m high and 40.5cm diameter after 9 years, 38m high and 54cm diameter after 15 years. Growth of young trees in a phosphorus deficient soil is promoted by inoculation with mycorrhizal fungi (*Glomus fasciculatum* and *Gigaspora margarita*), in combination with *Rhizobium* have proved to be effective. Nitrogen-fixing nodules containing leghaemoglobin are found on roots. Tree may already flower at the age of 3 years. Two flowering periods per year have been observed in Peninsular Malaysia and Sabah. Ripe pods appear approximately 2 months after flowering.

Seeds



i. Propagation and planting

P. falcataria is strongly light-demanding and regenerates naturally only when soil is exposed to sunlight. In the forest, wildlings sprout in abundance only when the canopy is open and when the soil is cleared from undergrowth. Wilding can be successfully collected and potted for planting but they are delicate and have to be handled carefully. Seeds are difficult to collect from the ground since they are small. The weight of 1,000 seeds is 16-26g. Usually they are collected by cutting down branches bearing ripe brown pods. Germination may start after 5-10 days but sometimes it is delayed for up to 4 weeks from sowing. To hasten germination and to make it more simultaneous, seeds can be treated by soaking them in boiling water for 1-3 minutes, or by immersion in concentrated sulphuric acid for 10 minutes and subsequent washing and soaking in water for 18 hours. The germination rate can be as high as 80% to almost 100%. Seeds are usually sown by broadcasting, pressed gently into the soil, and then covered by a layer of fine sand up to 1.5cm thick. For storing, seeds are dried for 24 hours and then packed in polyethylene bags. When stored at 4-8°C, the germination rate after 18 months may still be 70-90%. Application of a surface layer of mulch is advisable and excessive shading should be avoided. The seedlings can be transplanted when they have reached a height of 20-25cm with

a woody stem and a good fibrous root system., this stage can be reached in 2-2.5 months. The seedlings are usually planted in the field with a spacing of 2m x 2m to 4m x 4m.

j. Silviculture and management

P. falcataria plantations should be kept weed-free during the first few years. The application of fertilizers may improve the yield; application of 12.5 kg/ha of the tree was found satisfactory. When the stand (for timber production) is 4-5 years old, it can be thinned to a density of 250 stems/ha. And after 10 years to 150 stems/ha. When trees are grown for timber production, artificial pruning is necessary, as they have a tendency to fork.

k. Diseases and pests

Nursery seedlings are susceptible to damping-off caused by fungi of *Rhizoctonia*, *Sclerotium*, *Fusarium*, *Pythium*, and *Phytophthora*. Sterilizing the soil before sowing and applying fungicides to soil and seed may control the seed. The disease may seriously damage plantations. Plantations can also suffer from other fungal diseases such as red root caused by *Ganoderma pseudoferrum*. Plantation in Malaysia, Indonesia, and the Philippines also include stem-borers such as the longicorn beetle *Xylocopa festiva* and the red borer *Zeuzera coffea* as pests.

l. Harvesting

Plantation are clear-cut when it has the cutting age reached. Usually harvesting is problem-free as the trees are harvested when still comparatively young and consequently have small and lightweight logs which can be yarded and loaded easily.

m. Yield

P. falcataria is a fast grower and the yield is often high. In 8-12 years rotations, mean annual increments of 50-55 m³/ha have even been reached in plantations of 9-12 years old (120 trees/ha when 9 years old and 76 trees/ha when 12 years old).

Bark



36. *Pterocarpus indicus* Willd.

Pterocarpus indicus is a member of the family Leguminaceae. The synonyms of this species are *Pterocarpus wallichii* Wight & Arn. (1834), *Pterocarpus zollingeri* Miq. (1855), and *Pterocarpus papuanus* F.v. Mueller (1886). Vernacular names of this species are; Indonesia: sonokembang, angšana. Malaysia: angšana, sena. Papua New Guinea: New Guinea rosewood. Philippines: apalit, vitali. Burma: sena, padouk, ansanah. Laos: chan dêng. Thailand: pradu, pradu-ban, sano. Vietnam: g[ɨ]a[s]n[ɨ]ng h[ɨ]w[ɨ]n[ɨ]ng. Detailed descriptions of *Pterocarpus indicus* are as follows:



a. Origin and geographic distribution

From southern Burma throughout South-East Asia towards the Santa Cruz and Pacific Islands.

b. Uses

Narra is used as a structural timber for light to heavy construction, joists, rafters, beams and interior finish. The wood is ranked among the finest for furniture, musical instrument, high-grade cabinet work, high-class interior joinery, billiard tables, carving and novelties. The bark exudes a gummy or resinous substance which is called 'kino' or 'sangre de drago' (dragon's blood). It is a powerful astringent and the boiled, shredded bark is used against diarrhoea and dysentery. It is recommended for planting in denuded areas and brush-land to stabilize the soil.

c. Observation

A medium-sized to fairly large tree of up to 40m tall. Bole often massive at age and up to 350cm in diameter, often with double leader big branches rather close to the base. The density of the wood is around 550-900 kg/m³ at 15% moisture content.

d. Properties

Narra is a medium-weight, moderately hard to hard, tough and resilient wood. The heartwood is light yellowish-brown to reddish-brown with darker irregular streaks. Modulus of elasticity is 11,100-12,300 N/mm².

e. Descriptions

A medium-sized to fairly large tree of up to 40m

tall, bole often massive at age and up to 350cm in diameter, often with double-leader big branches rather close to the base, buttresses usually present, branches drooping; leaves 12-30cm long, glabrous, generally ovate; pod shortly stipitate, almost circular.

f. Wood anatomy

Macroscopic character:

Heartwood light yellowish-brown to reddish-brown and distinctly demarcated from the straw-coloured to light grey sapwood. Texture moderately fine to moderately coarse.

Microscopic character:

Growth rings distinct, marked by concentric alignment of large pore rings. Tangential diameter is 45-375µm.

g. Ecology

Narra prefers a slightly seasonal climate but is found in both evergreen and semi-deciduous forest. Highly adaptable to other environment condition. *P. indicus* is particularly common as a canopy tree in valleys below 100m altitude.

Basal trunk





Leaf

Seeds

Basal trunk

h. Growth and development

After germination, the cotyledons are exposed above the soil on a long hypocotyl and the seed-coat is left in or on the soil. *P.indicus* is a fairly fast grower; trees are reported to reach a maximum diameter of 58cm in 40 years. The leaves fall off during the dry season. Fruit are mature 3-4 months after flowering.

i. Propagation and planting

Narra is easily propagated by seeds. The weight of 1,000 seeds is about 770g. Germination rate is improved if seeds are extracted from the indehiscent pods before sowing. Since the percentage of viable seed is often low (sometimes as low as 10-20%) and the survival ability of young seedlings is vulnerable to weed competition, vegetative propagation has become a more important technique nowadays. Stump cuttings, taken from seedlings or wildings, can be used as planting material. Narra can also be propagated successfully by tissue culture. The normal spacing for *P. indicus* is 2.5m x .5m or 3m x 3m.

j. Silviculture and management

The trees often are found scattered in dipterocarp forest where the cutting is governed by diameter limits (usually 60cm). Plantation of narra (particularly

P. dalbergioides) have a reputation to be labour-intensive, requiring much tending such as close initial spacing and regular thinning. This is because of the tendency of the trees to fork and form very short boles.

k. Diseases and pests

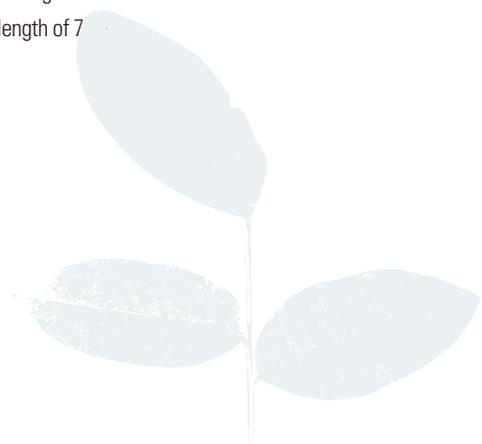
In nurseries in the Philippines, an anthracnose seedlings disease is caused by *Colletotrichum* sp. Fungi such as *Ganoderma lucidum* and *Fomes lamaensis* may cause root and stem rot.

l. Harvesting

Large narra trees are often hollow.

m. Yield

Narra trees in a 60 year old plantation in Malaysia yielded slightly more than 1m³/tree, having an average bole diameter of 49cm and branchless bole length of 7



37. *Sindora bruggemanii* de Wit

Sindora bruggemanii is a member of Leguminosae family. The vernacular names of this species are; Indonesia: tapak tapak (Kalimantan), tampora antu (Palembang, Sumatra), kayu sindoro (Batak, Sumatra). Trade groups of this species are: Sepetir: medium-heavy hardwood, e.g., *Sindora bruggemanii* de Wit, *S. coriacea* Maingay ex Prain, *S. Supa* Mer., *S. velutina* J.G. Baker, *S. wallicii* Graham ex. Bentham. Detailed descriptions of *Sindora bruggemanii* are as follows:





Leaf

Fruits

Seeds

Bark

a. Distribution

Borneo (Kalimantan) and Sumatra.

b. Observation

A medium-sized tree up to 30m tall; rarely up to 40m, with cylindrical bole; leaves with (10-)12-16 leaflets; leaflets 4-9cm x 2-3cm, leathery and glabrous; flowers with 3.5mm long puberulous calyx lobes having a narrow membranous margin and lacking spines; pod broadly elliptical, up to 15cm long, with few spines producing an aromatic resin. *S. bruggemanii* grows on non-inundated clayey or sandy-clayey soils at low altitudes, up to 100m. the density of the timber is 580-770 kg/m³ at 15% moisture content.

c. Growth and development

Sepetir tree are moderately fast to rather slow-growing. Trees of *S. coriacea* planted in Peninsular Malaysia reached an average diameter of 52cm after 40 years, but trees of *S. echinocalyx* only 33cm. The trees are deciduous and may remain leafless for several weeks. Flowers appear shortly after the new leaves. Fruits take about 2 months to reach maturity. The waxy arils of the seeds are especially attractive to rodents, which disperse the seeds.

d. Ecology

Sepetir trees occur generally scattered or sometimes gregarious (Borneo) in lowland dipterocarp forest on flat land and hillsides, up to 300m altitude, but in Peninsular Malaysia sometimes up to 800m. they generally favour well-drained soils, which are at least moderately fertile. They are, however, also found on sandstone, shales and volcanic soils (e.g., *S. irpicina*), sandy loam and clay soils (e.g., *S. beccariana*), as well as leached soils (e.g., *S. coriacea*).

e. Propagation and planting

Sepetir seeds survive for more than 3 years without any specific treatment. Germination is usually delayed. In germination test without pretreatment of the seeds, after about 3 years only 20% of the seeds of *S. echinocalyx* had germinated. When the seed-coat is mechanically scarified on one or both sides of the seed, and the seeds are soaked in water at room temperature for 24 hours, the germination rate within one month is about 70%. A good method of mechanical scarification is to scrape off the protrusion of the seed-coat located next to the hilum. Treatment with dilute sulphuric acid or hot water is much less successful. However, seeds treated with concentrated sulphuric acid for one hour may give 80% germination. For seedlings of *S. supa* a sand-humus mixture (1:1) appeared to be the most satisfactory potting

medium. Average height of seedlings after 7 months is about 20cm when potted in this mixture, and the seedlings have a high shoot to root ratio (about 3:8). A mixture of ordinary garden soil and sand (2:1) gives slightly less good results.

f. Silviculture and management

In logged-over forest the regeneration of sepetir is often abundant. Usually the number of seedlings in logged-over forest is larger than in undisturbed forest, similar to e.g., Keruing (*Dipterocarpus* spp.). From Peninsular Malaysia an average of one large tree (often 60cm in diameter) per 5 ha of undisturbed forest is reported; locally sepetir is more common, up to one large tree per 2 ha.

g. Uses

The timber is used as sepetir. Sepetir timber occurs in two forms: attractively figured, and more uniformly coloured. The first is less common but is highly appreciated for high-class cabinets and furniture, panelling and other interior finishes and fancy articles. The sometimes streaked heartwood can be successfully peeled and sliced, yielding a very handsome veneer. The more uniformly coloured and less figured material is used for light indoor constructions such as solid panel doors, windows, doors and window frames, ceilings and planking. It is a suitable timber for these purposes, because of its relatively low shrinkage, lack of degrade on drying, and small movement when dried. Other general uses of the more uniformly

coloured timber are cabinet-making and the manufacture of household utensils and plywood. Sepetir is recommended as an attractive flooring timber to withstand light or sometimes normal pedestrian traffic as in residential buildings, hotels, hospitals, offices and shops. High quality and more heavy material of certain species is sometimes used for poles, joinery, and in heavy constructions like bridges and naval constructions. Low grade material is used for packing cases and pallets.

Many species yield a wood-oil which is used for making paints, varnishes and transparent paper, for caulking boats and adulterating other oils, for illumination and sometimes as a perfume. The skin diseases and rheumatism and applied as birdlime. The oil of the seed of *S. siamensis* Teijsm. ex Miq. is sometimes used as a substitute for betel (*Areca catechu* L.), while the fruits of *S. sumatranum* are widely used in local medicine against fevers, serious bleeding in uterus and eczema on the head.

Leaf



38. *Sindora wallichii* Graham ex Bentham

Sindora wallichii is a species member of Leguminosae family. The vernacular names of this species are: Indonesia: tamparhantu, kamps hantu (Sumatra), mahasindut (Kalimantan). Malaysia: sepetir daun tebal (Peninsular). The synonym of *Sindora wallichii* is *Sindora intermedia* (J.G. Baker) Prain ex King (1897). Trade groups of this species are; Sepetir: medium-heavy hardwood, e.g., *Sindora bruggemanii* de Wit, *S. coriacea* Maingay ex Prain, *S. supa* Mer., *S. velutina* J.G. Baker, *S. wallicii* Graham ex. Bentham. Detailed descriptions of *Sindora wallichii* are as follows:



a. Distribution

Peninsular Malaysia, Singapore, Borneo and Sumatra.

b. Observation

A large tree up to 45m tall with a straight, cylindrical bole at least 65cm in diameter; leaves with 6-8 leaflets, leaflets 4-10.5cm x 2.5cm, leathery and grobous or thinly velvety pubescent beneath; flowers with up to 9.5mm long, densely pubescent calyx lobes, having long slender spines near the apex; pod ovate, broadly elliptical to circular, up to 9.5cm long, with many slender, stout spines having a swollen base. *S. wallichii* is closely related to *S. echinocalyx*. It occurs frequently in hill dipterocarp forest up to 300m altitude in Peninsular Malaysia, more scattered in primary forest below 100m altitude on sandy or clayey soils in eastern Sumatra, and is apparently rather rare in borneo. The density of the timber is 530-790 kg/m³ at 15% moisture content.

c. Growth and development

Septir tree are moderately fast to rather slow-growing. Trees of *S. coriacea* planted in Peninsular Malaysia reached an average diameter of 52cm after 40 years, but trees of *S. echinocalyx* only 33cm. The trees are deciduous and may remain leafless for several weeks. Flowers appear shortly after the new leaves. Fruits take about 2 months to reach maturity. The waxy arils of the seeds are especially attractive to rodents, which disperse the seeds.

d. Ecology

Septir trees occur generally scattered or sometimes gregarious (Borneo) in lowland dipterocarp forest on flat land and hillsides, up to 300m altitude, but in Peninsular Malaysia sometimes up to 800m. they generally favour well-drained soils, which are at least moderately fertile. They are, however, also found on sandstone, shales and volcanic soils (e.g., *S. irpicina*), sandy loam and clay soils (e.g., *S. beccariana*), as well as leached soils (e.g., *S. coriacea*).

e. Propagation and planting

Septir seeds survive for more than 3 years without any spesific treatment. Germination is usually delayed. In germination test without pretreatment of the seeds, after about 3 years only 20% of the seeds of *S. echinocalyx* had germinated. When the seed-coat is mechanically scarified on one or both sides of the seed, and the seeds are soaked in water at room temperature for 24 hours, the germination rate within one month is about 70%. A good method of mechanical scarification is to scrape off the protrusion of the seed-coat located next to the hilum. Treatment with dilute sulphuric acid or hot water is much less successful. However, seeds treated with concentrated sulphuric acid for one hour may give 80% germination.

For seedlings of *S. supa* a sand-humus mixture (1:1) appeared to be the most satisfactory potting medium. Average height of seedlings after 7 months is about 20cm when potted in this mixture, and the seedlings have a high shoot to root ratio (about 3:8). A mixture of ordinary garden soil and sand (2:1) gives slightly less good results.



Leaf

Seed pods

Seeds

Basal trunk

f. Silviculture and management

In logged-over forest the regeneration of sepetir is often abundant. Usually the number of seedlings in logged-over forest is larger than in undisturbed forest, similar to e.g., keruing (*Dipterocarpus* spp.). From Peninsular Malaysia an average of one large tree (often 60cm in diameter) per 5 ha of undisturbed forest is reported; locally sepetir is more common, up to one large tree per 2 ha.

g. Uses

The timber is used as sepetir. Sepetir timber occurs in two forms: attractively figured, and more uniformly coloured. The first is less common but is highly appreciated for high-class cabinets and furniture, panelling and other interior finishes and fancy articles. The sometimes streaked heartwood can be successfully peeled and sliced, yielding a very handsome veneer. The more uniformly coloured and less figured material is used for light indoor constructions such as solid panel doors, windows, doors and window frames, ceilings and planking. It is a suitable timber for these purposes, because of its relatively low shrinkage, lack of degrade on drying, and small movement when dried. Other general uses of the more uniformly coloured timber are cabinet-making and the manufacture of household utensils and plywood.

Sepetir is recommended as an attractive flooring timber to withstand light or sometimes normal pedestrian traffic as in residential buildings, hotels, hospitals, offices, house buildings and shops. High quality and more heavy material of certain species is sometimes used for poles, joinery, and in heavy constructions like bridges and naval constructions. Low grade material is used for packing cases and pallets.

Many species yield a wood-oil which is used for making paints, varnishes and transparent paper, for caulking boats and adulterating other oils, for illumination and sometimes as a perfume. The skin diseases and rheumatism and applied as birdlime. The oil of the seed of *S. siamensis* Teijsm. ex Miq. is sometimes used as a substitute for betel (*Areca catechu* L.), while the fruits of *S. sumatranum* are widely used in local medicine against fevers, serious bleeding in uterus and eczema on the head. The pods are used medicinally after childbirth.



FAMILY **MAGNOLIACEAE**



Tropical trees of Indonesia

39. *Magnolia montana* (Blume) Figlar

Magnolia montana belongs to the family of Magnoliaceae. The synonym of this species is *Michelia montana* Blume. The vernacular names of this species are; cempaka hutan, cempaka jahe, manglid. Detailed descriptions of *Magnolia montana* are as follows:





Leaf

a. Origin and geographic distribution

Malesia, Indonesia-Java, Kalimantan, Lesser Sunda Islands, Sumatra, Malaysia

b. Uses

Magnolia wood is used for general light construction, bridge building, flooring, door panels, vehicle bodies, packing cases and formerly also for battery separators. *Magnolia* has also been used for production of veneer and plywood, sometimes as a substitute for 'American whitewood', cement-bonded wood wool board, and as firewood.

c. Properties

Magnolia yields a lightweight to medium-weight hard wood with a density of 390-825 kg/m³ at 15% moisture content. Heartwood is white to pale brown coloured with narrow, grey brown layers of marginal parenchyma.

d. Descriptions

Evergreen or semi-deciduous, small to large trees up to 50m tall; bole straight, cylindrical, up to 200cm in diameter, without buttresses; bark surface smooth, grey to grayish-white, inner bark fibrous, yellow to brown; crown conical to cylindrical, leaves arranged spirally, simple entire. Seedling with epigeal germination; cotyledons emergent, leafy, hypocotyls elongated.

e. Ecology

Magnolia are found scattered in lowland or montane, primary rain forest, up to 2,800m altitude. The habitat is usually well-drained but occasionally waterlogged and swampy area.



f. Propagation and planting

Magnolia can be propagated by seeds. For ornamental purposes it is also propagated by various vegetative techniques. *M. montana* has $\pm 1,900$ dry fruits/kg. The seeds should be dried in the shade; they lose their viability very fast, often within 2 weeks. Seed viability can be maintained by moist storage at 5°C for about 7 months or by storage in pits at 13°C for about 4 months.

The colour of mature fruits is dark green to light brown. The fruits were harvested and put in plastic bag for 24 hours. Seed extraction was done in room temperature. Fruits will open in drier air condition. The colour of mature seeds is dark black. Seed pretreatment was done by immersion in hot water for 30 minutes, then seeds were germinated in germination media containing topsoil: sand: rice husk charcoal of 1:1:1 (v/v/v). Germination percentage could achieve 80% for new seeds in 7 days after sowing. Watering frequency was

twice, morning and afternoon. Seedlings were transplanted after 30 days after germination, or in 10–15cm height into transplanting medium containing topsoil: sand: rice husk charcoal of 1:1:1 (v/v/v). Survival rate after replanting could reach to 70%. Seedlings were maintained by regular watering (twice a day), fertilizer application (twice a month) with the concentration of 1 gram/seedling. Pest and diseases control was done by applying Curacox or Decis with concentration of 1ml/ 10L water for 10 seedling-beds of 1m x 5 m. Shading was not needed.

g. Silviculture and management

Magnolia can be propagated by seeds. *M. montana* requires moist, deep and fertile soils and is moderate light demander. Although planted *M. montana* grows very fast, the stem is crooked. A rotation of 50 years is recommended to produce sawn timber.

Seeds



Bark



FAMILY **MELIACEAE**



Tropical trees of Indonesia

40. *Aglaia elliptica* Blume

Aglaia elliptica is a member of Meliaceae family. The vernacular names of this species are; Indonesia: bajing talang (Sumatra), langsung-langsar (Kalimantan), pisek (Sulawesi). Malaysia: peler tupai (Peninsular), segera, bunyau (Iban, Serawak), Philippines: malatumbaga (general), mata-mata (Bikol), malasaging (Filipino). The synonyms of this species are; *Aglaia oxypetala* Valetton (1901), *Aglaia harmsiana* Perk (1903), *Aglaia havilandii* Ridley (1930), *Aglaia longipetiolata* Elmer (1937). Detailed descriptions of *Aglaia elliptica* are as follows:





Flower buds

a. Origin and geographic distribution

Aglaia currently consists of 105 species. Distribution of this species are: Southern Burma (Myanmar), peninsular Thailand, Peninsular Malaysia, Sumatra, Java, Bali, Flores, Borneo, Sulawesi, and the Philippines.

b. Uses

The wood is used 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.

c. Descriptions

A small to medium-sized, sometimes fairly large tree up to 20(-40)m tall, bole branchless for up to 15m, up to 60cm in diameter, with steep buttresses up to 1.5m high. Bark surface dark reddish-brown or greenish-brown, inner bark magenta. *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 2,000m altitude. The density of the wood is 755-860 kg/m³ at 15% moisture content.

d. Wood anatomy

Macroscopic characters:

Heartwood usually dark brown or reddish-brown with purple tinge. Texture moderately fine to moderately coarse.

Microscopic characters:

Growth rings absent. Average of tangential diameter is 115-155µm.

e. Ecology

Aglaia usually occurs scattered and is locally common but never dominant. It is found in both primary and secondary forest, general in evergreen rain forest or sometimes in monsoon or deciduous forest. 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 1,500m altitude, but occasionally individual species ascend as high as 2,500(-3,800)m. The preferred soils are usually sandy to loamy or clayey, but many species also occur on limestone or on granitic soils.



Leaf (adaxial and abaxial side)

f. Propagation

The seeds does not need any pretreatment before being sown in full light and is sown as soon as possible after harvesting. Germination is semi-hypogeal.

g. Silviculture and management

The trees of *Aglaia* 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.

h. Diseases and pests

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



Fruits

Bark



41. *Khaya anthoteca*

Khaya anthoteca belongs to the family of Meliaceae. The vernacular names of this species are; Uganda mahogany, white mahogany (En). Acajou blanc (Fr). Detailed descriptions of *Khaya anthoteca* are as follows:





Leaf (adaxial and abaxial side)

a. Origin and geographic distribution

Khaya comprises 6 species, 4 in tropical Africa and 2 in Madagascar and the Comores. Several species have been introduced widely in other part of both the wet and dry tropics for their timber. *K. ivorensis* is planted in trials in Peninsular Malaysia, whereas another 3 species have been planted in many trials in Indonesia.

b. Uses

The wood of African sources of Khaya is used for furniture and cabinet work, high quality decorative interior finishing, high quality staircases, paneling, flooring, boat planking and cabins, banisters, handrails, carving, turnery and occasionally for construction, canoe building and boat decking. The wood is highly valued for the production of decorative veneer and plywood, which is also its main application in South-East Asia.

K. ivorensis and *K. senegalensis* have been used for enrichment planting (especially the former) and afforestation and the latter has also been planted in parks and along roads, e.g., in Jakarta and Singapore. *K. anthotheca* has been used in a taungya. The wood produces quality charcoal. Seeds of *K. senegalensis* and *K. grandifoliola* oil are used in West Africa for cooking. The bark is used medicinally against fever.

c. Botany

Deciduous, monoecious, small to large or very large trees up to 50(-60)m tall; bole straight and cylindrical to slightly sinuous, branchless for up to 25(-30)m up to 150(-400)cm in diameter, larger trees with prominent buttresses up to 7m high; bark surface smooth but becoming scaly, the circular scales leaving shallow pits, grey and brown mottled. Leaves arranged spirally, in tufts at the end of twigs, paripinnate, estipulate; leaflets entire. Flowers in an axillary large, much-branched, 4-5-merous; calyx lobes almost to the base; petals free. Male flower with urceolate to cup-shaped staminal tube, bearing 8-10 anthers; disk cushion-shaped. Female flowers with a superior, 4-5-locular ovary with 12-16(-18) ovules in each cell, style-head discoid; disk indistinct. Fruit an erect, globose, woody capsule; columella sharply ridged. Seeds 8-18 per cell, in single rows, flattened and narrowly winged all around. Seedling with epigeal germination; cotyledons not emergent; hypocotyl slightly developed or absent; first 2 leaves opposite, simple, subsequent ones arranged spirally and trifoliate or imparipinnate, later paripinnate

Height in 4 years (*K. ivorensis*), but in enrichment planting trials and in taungya systems annual height increment in the first 2 years was only 0.3-0.5m (*K. anthotheca*, *K. ivorensis*). Extensive trials with *K.*



anthotheca, *K. grandifoliola* and *K. senegalensis* in Indonesia showed a mean annual increment of 0.8-2.4cm in diameter and 0.5-1.5m in height. In 26-year-old plantations of *K. ivorensis* in peninsular Malaysia a mean annual increment of 1.7-1.9cm in diameter and 1 m in height was achieved. In Nigeria growth of *K. grandifoliola* seedlings were promoted by inoculation with endogen spores and they developed vesicular-arbuscular mycorrhizas. *K. anthotheca* and *K. grandifoliola* and *K. senegalensis* are much smaller. *K. ivorensis* develops according to Rauh's architectural tree model, characterized by a monopodial trunk which grows rhythmically and so develops tiers of branches. In *K. ivorensis* the monoaxial state may persist to a height of 10m. In West Africa *K. anthotheca* flowers from January to February and again from September to October. Fruits develop in 2-3 months. Seeds are probably dispersed by wind.

d. Ecology

K. senegalensis is a species of seasonal climates where it is found in a wide range of habitats, from closed deciduous forest to savanna, up to 1,500 m altitude, with an annual rainfall 650-1,300mm and dry season of 4-7 months. *K. anthotheca* and *K. ivorensis* are found in wet ever-green to semi – deciduous or deciduous forest. *K. anthotheca* is generally found scattered or rarely in small

groups, often in the vicinity of water, in areas with an annual rainfall of 1,200-1,800mm and a dry season of 2-4 months, up to 500m altitude. Annual rainfall in areas where *K. ivorensis* occurs is 1,600-2,500mm, and the dry season lasts 2-3 months. *K. grandifoliola* is found in dry evergreen forest, gallery forest and savanna woodlands at up to 1,300m altitude in areas with an annual rainfall of 1,200-1,800mm and a dry season of 3-5 months.

Basal trunk





Seeds

Trunk

e. Silviculture and management

Khaya can be propagated by seeds and by cuttings; tissue culture on an experimental scale is successful. In Indonesia direct sowing of *K. anthotheca* in the field failed. Seed counts range from 3,200-8,600 per kg, but counts from specimen in the Bogor Botanical Gardens average 2,700-3,450 seeds/kg. Seed viability drops sharply after only two weeks, but the germination rate of seed of *K. senegalensis* stored at 5°C-15°C in airtight receptacles for 2 years was still 30%. Pretreatment before sowing is not necessary and the germination rate of fresh seed is high, being 75-90% in 10-30 days. Young seedlings require light shading. Seedlings are left to grow fairly tall, 0.6-1.8m, and stay for up to three years in the nursery before they are made into stumps or striplings. The latter perform better under south-east Asian conditions. Vegetative propagation of *K. anthotheca* by means of cuttings applying 50mg of Rootone F/cutting

showed a rooting of about 75%. Generally, Khaya is planted under light shade, but full overhead light is required for good growth. *K. anthotheca* requires fertile deep soils and plenty of water; *K. senegalensis* is very resistant to flooding and can be considered for planting on swampy soils. The stem form of *K. ivorensis* is variable and strong lateral competition is needed to obtain straight and upright trunks. When natural regeneration has become established under the canopy the old trees are harvested with various cutting and regeneration system.

f. Genetic resource and breeding

Provenances of Khaya species, but mainly of *K. anthotheca* and *K. ivorensis*, are kept in various tropical countries. In Sabah selection of *K. ivorensis* is focusing on resistance to hybsipyla and involves 9 provenances and 21 progenies.



42. *Maesopsis eminii* Engler

Maesopsis eminii is a species member of Meliaceae family. The synonyms of this species are *Albizia moluccana* Miq. (1855) and *Albizia falcata* (L.) Fosberg (1965) and the vernacular names of this species are: Brunei: Puah. Indonesia: jeungjing (general), sengan laut (Java). Malaysia: batai, kayu machis. Papua New Guinea; white albazia. Philippines: Moluccan sau, falcate. The local name of this species is kayu afrika and detailed descriptions of *Maesopsis eminii* are as follows:





Pinnatisect leaf

Single leaflet

Fruits

Bark

a. Origin and geographic distribution

M. eminii are found naturally between 6°S and 8°N in tropical Africa along the Gulf of Guinea from Liberia to Angola and through Zaire, southern Sudan and Uganda to Kenya and Tanzania.

b. Uses

In Africa *M. eminii* is commonly retained in home gardens for shade, fuel and timber, while the leaves are used as fodder. In Africa and India it is often planted as a shade tree in coffee, tea and cardamom plantations, in Zaire also to shade cocoa trees. Because of its fast growth, it is widely planted for fuel wood, although its light wood is not an ideal fuel. It is good general purpose timber for indoor construction, for joinery, boxes, furniture and millwork, core stock for plywood and particle board.

c. Descriptions

Unarmed, evergreen to deciduous tree, 15-25(-45)m tall with an open, spreading crown. Bole exceptionally straight, cylindrical, up to 15m tall and 50(-180)cm in diameter; buttresses small or absent; bark pale grey to grey brown or almost white, smooth or with deep, vertical, often twisted furrows; slash red outside, yellow near the wood. Branchlets with patent short hairs.

d. Propagation and planting

M. eminii is mostly propagated by seed obtained from fresh ripe fruit, after the pericarp has been mechanically removed and the seed has been dried for several days. To improve germination, seed may be soaked in water for 1-2 days. Fresh seed has yielded over 90% germination, but viability decreases rapidly after 3 months. Potted striplings and stumps have given good results.

e. Silviculture and management

Thinning is required after the 5th year to allow a proper crown/stem ratio to develop. Established plantations may be coppiced. *M. eminii* is self pruning. *M. eminii* competes well with weeds but cannot suppress *Imperata grass*.



43. *Melia azedarach* L.

Melia azedarach belongs to the family of Meliaceae. The synonyms of this species are *Melia sempervirens* (L.) Sw. (1788), *Melia dubia* Cavanilles (1789), *Melia composite* Wild. (1799) and the vernacular names of this species are; Chinaberry, Persian lilac, pride of India (En). Indonesia: gringging, mindi (Java), marambung (Sumatra). Malaysia: mindi kecil. Philippines: paraiso, balagango (Tagalong). Singapore: mindi kechil. Thailand: lian, lian-baiyai. Detailed descriptions of *Melia azedarache* are as follows:





Flowers and leaves



Single leaflet



Fruits



Bark

a. Origin and geographic distribution

M. azedarach is a widely distributed tree, probably of South Asian origin, widely distributed in tropical, subtropical, and warm temperate regions. It is found wild in the Himalayan foothills of India and Pakistan at altitudes of 700-1,000m, widely scattered in China, through Malesia to the Solomon Islands and northern and eastern Australia. It is naturalized in a wide belt in the cooler parts of eastern and southern Africa, in the Americas from Argentina to the southern United States and Hawaii, and throughout the Middle East and the Mediterranean as far north as Croatia and southern France. The most frost-tolerant cultivars can be planted outdoors in sheltered areas in the British Isles.

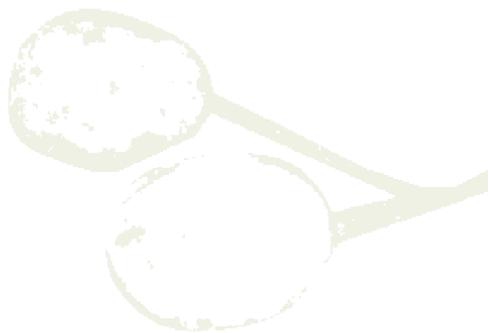
b. Uses

In South-East Asia, *M. azedarach* is primarily used for fuelwood (e.g., in the Philippines) and is also planted as a shade tree in coffee and abaca (*Musa textilis*) plantation and as an avenue tree. It is a well-known ornamental grown for its scented flowers and shade. In South Asia, *M. azedarach* is better known for its medicinal uses. Various plant

parts have anthelmintic, anti malarial, cathartic, emetic medicinal properties, and are also used to treat skin diseases. The fruits are also highly valued for their medicinal properties in Malaysia and imported from China. However, some toxic components occur in the seed oil, the oral intake of which may cause severe reactions and even death. *M. azedarach* wood is also used to manufacture agricultural implements, carts, tool handles, and furniture because of its termite resistance.

c. Properties

M. azedarach contains numerous compounds with anti-feedent and growth-disrupting properties in insects. The fruit of *M. azedarach* are highly toxic to warm-blooded animals; the consumption of 6-8 fruits can cause nausea, spasms, and death in children. The proximate oral lethal dose for pigs of purified ethanolic extract of fruits was found to be 6.4mg/kg live weight. The bark exudes a water-soluble gum. The wood of *M. azedarach* resembles mahogany. It makes good construction timber, durable even in exposed locations and not affected by termites. Its density is 510-660 kg/m³, its energy value is 24,000-25,000 kJ/kg.



d. Descriptions

Deciduous tree up to 45m tall, bole fluted below when old, up to 60(-120)cm in diameter. Bark grey-brown, smooth, lenticellate, becoming lightly fissured or scaly with age; inner bark yellowish; sapwood whitish, heartwood rusty brown. Crown widely spreading, with sparsely branched limbs. Leaves bipinnate, petiole 8-30cm long. Flower purplish, fragrant, bisexual or male. Fruit a drupe, ellipsoid-globose. Seed oblongoid, 3.5mm x 1.6mm, smooth, brown.

e. Growth development

Under optimal condition, *M. azedarach* grows fast. In Uganda it has grown about 1.7m in height annually for several years after planting. It is generally deciduous, but some forms in the humid tropics are evergreen. It flowers from March to May in the northern hemisphere, though some forms flower throughout the summer and even throughout the year. Fruit drop is limited and ripe fruits cling to the branches for several months even when leaves have fallen. The tree re-sprouts after cutting and re-grows after pollarding, making it suitable for pole production.

f. Ecology

The natural habitat of *M. azedarach* is seasonal forest, including bamboo thickets, Tamarindus woodland and *Eucalypt* savanna. Its natural habitat from the Himalayan foothills of Baluchistan (Pakistan) and Kashmir (India) to the lowland of Papua New Guinea indicates that it is highly adaptable and tolerates a wide range of conditions. The mean maximum temperature of the hottest month may reach 39°C, the mean minimum temperature of the coldest month - 5°C, although many forms tolerate a narrower range only. It is generally found from 0-1,200m altitude, in Himalayas up to 1,800-2,200m altitude. Annual rainfall in its natural habitat ranges from 600-2,000mm. In Africa it is planted as a drought-tolerant shade tree and ornamental. Although optimal growth is obtained on well-drained, deep, sandy loams, *M. azedarach* tolerates shallow soils, saline, and strongly alkaline soil, but not very acid soils. It is found on poor, marginal, sloping, and stony land, even in crevices in sheer rock.



Seedling

g. Propagation and planting

Although successful vegetative propagation through stem cuttings, root suckers, and air layering has been reported, propagation is usually by seed. Drupes need to be macerated until the seed can be gently eased out. Seeds are soaked in water for 1-2 days, depulped, and dried in the shade. They can be stored in a cool and well-ventilated place, in cloth or gunny bags. Plastic and other airtight containers should not be used for seed storage. Seed should be planted within two weeks after harvesting, as viability drops rapidly thereafter. Sowing is mostly done in a nursery at 15cm x 2.5cm in a sunny place, keeping the seed lightly covered with soil or mulch. Seedlings may be thinned to 15cm x 15cm when 2 months old, and transplanted when 7-10cm tall.

h. Silviculture and management

A few weedings are required during the first 2 years after planting. When grown for timber, stems are pruned to a height of about 6m to obtain a branch-free bole. In Paraguay, *M. azedarach* grown in small woodlots for timber, is often interplanted with a variety of food crops. It is planted at a spacing of 4m x 3m, thinned after 3 years to 400 trees/ha and after 6 years to 200 trees/ha.

i. Diseases and pests

Although some bacterial and fungal diseases have been observed on leaves, twigs, and fruit, no serious damage has been reported. Generally *M. azedarach* is also little affected by pests.

j. Harvesting

Pollarding of *M. azedarach* for fuel wood and poles is usually done on 5-10 years old trees.



44. *Melia excelsa*

Melia excelsa is included in family of Meliaceae. The synonyms of this species are *Azadirachta excelsa* (1961), *Azadirachta integrifolia*, and the vernacular names of this species are; Thailand: sadao-tiam, Peninsular Malaysia: sentang, Sabah: ranggau or limpaga. Philippines: maranggo or bird's eye kalanthus. Detailed descriptions of *Melia excelsa* are as follows:





Leaf

Fruits

a. Origin and geographic distribution

It has been confirmed that *M. excelsa* is indigenous to Borneo, and it is thought that it may be indigenous to the neighboring Philippines islands of Palawan and Luzon. *M. excelsa* is also found in southern Thailand and Peninsular Malaysia.

b. Uses

Its young leaves and flowers are edible and its seeds and leaves are used to extract azadirachtin (approximately 3.3-3.5mg/gram for seeds), which is used as an insecticide. A new limonoid from its seed kernels, marranging, has been isolated and found to be two or three times more active than azadirachtin. Leaf extracts of *M. excelsa* also have greater efficacy than those of neem. Its bark can be boiled and consumed as a medicine to cure dysentery and diarrhea. Its wood is valued for construction, furniture-making, and carving. Various part of *M. excelsa* have different uses as follows:

- **Wood:** for general construction, ceiling, window, door, furniture, and carving.
- **Seeds:** for neem oil extraction
- **Leaves:** can be used also as an insecticide
- **Flower:** used as medicine for stomach diseases

c. Descriptions

It may attain height of 45m and a breast height diameter (DBH) of about 200cm, there is a specimen of this size on Scotland Road in Pinang, Malaysia. Stands in Semengoh near Kuching in Sarawak are about 40-45m tall with long, straight, clear boles up to 25-30m and dbh about 60-80cm.

d. Growth and development

Because *M. excelsa* is a new plantation species, there are no records on the growth and yield of this species as a plantation product. Raksakeo (1986) reported that 10 years-old *M. excelsa*, bordering a rubber plantation in Trang, planted on clay soil with fertilizer application produced long, straight, clear boles with girths of 110cm and heights of 20m. Average growth rate of *M. excelsa* is about 10cm growth and 2m height per year.

e. Ecology

M. excelsa is a lesser known species that thrives in moist tropical rain forests where precipitation is usually above 1,600 mm/annum. It may also do well in tropical dry condition found in the lowlands; however it has been found at 250m altitude. Usually a strong light demander, dominates other moist evergreen forest species. *M. excelsa* grows best in the lowland where the topography is level



Bark

or flat. Annual rainfall should be 1,600mm or more. At the original sites in Borneo, rainfall is usually above 2,000 mm/annum. However, the species has also been successfully introduced to areas of tropical countries where rainfall is about 1,500 mm/annum. The species does well in Borneo, Peninsular Malaysia, and southern Thailand where average temperature is 22-25°C. The species cannot tolerate frost.

f. Propagation and planting

Fruit and seeds of *M. excelsa* mature at different times throughout its range. Seed mature in May – June in the upper part of southern Thailand, and in June-July in the lower part. In Serawak seeds mature and are ready for collection in August-September. Seeds should be collected from as many mother trees as possible to ensure a broad genetic base in future plantation. Seed collection can be done from the forest floor after fruits are fully mature and fall from the trees.

Experience in southern Thailand indicated that fresh fruits falling from the trees germinated well above 85%, which was regarded as acceptable. However, old fruits falling on the ground germinated very poorly, and sometimes not at all. Therefore, fruit of *M. excelsa* should be collected

while they are still greenish-yellow or yellowish-green directly from the trees to ensure high germination. After collection, fruit should be put into well-ventilated containers such as weaving basket or gunny sacks to prevent fermentation, and transported back to the nursery as soon as possible. Upon arrival, fruit should be soaked in water for depulping. Dried seeds will contain about 500 seeds/kg. Seeds should be sown immediately after drying because viability drops very quickly after 1-2 weeks. *M. excelsa* can be propagated sexually from seeds or asexually by vegetative propagation. It usually germinates within 6-10 days by epigeal germination. *M. excelsa* seedlings grow very fast in the early stages, and are usually ready for outplanting in about 3 months. Because seedlings grow very fast, 5 x 8cm polybags are usually used. The recommended potting medium is a mixture of coconut husk and topsoil in a 3:1 ratio which is about enough for three months or until seedling are ready for outplanting. If coconut husk is not available, a mixture of top soil and compost, or topsoil and rice husk, at a 3:1 ratio is also recommended. However, in these cases, a fertilizer application of NPK (15:15:15) every fortnight is suggested.

g. Silviculture and management

To successfully establish industrial plantations, planting sites need intensive preparation. All shrub, bushes, undesired species, and noxious weeds should be cut, dried, and burnt to get rid of debris, which is a habitat for pests and insects. After burning, plowing is necessary in a crosscut pattern, followed by harrowing. To get rid of *Imperata* grasses, the land should be thoroughly plowed twice in crosscut and then harrowed to remove the rhizomes. This should be followed by spraying with a systematic translocated herbicide, such as Glyphosate 48% (commercial name: Round-up) at 2-4 L/ha. Staking of the planting site is recommended to ensure uniform spacing. In southern Thailand, spacing of 3m x 3m or 4m x 4m is used for *M. excelsa*. However, as the species is a strong light demander, the wider spacing of 4m x 4m is preferable. Narrow spacing is not recommended as investment cost will increase and early thinning will be necessary. Thin trees are of no commercial value as they are too small due to competition. Planting holes can be dug directly and compost or barnyard manure or fertilizer added. If planting has to be done on slope, it is advisable to treat the land with soil conservation measures, such as contour planting, terracing, or alley hedge rows, to counter erosion. Planting should be done at the onset of the rainy season. Planting site

preparation should be completed at least a month before the rain start. Planting hole should be 30 x 30 x 30cm. A half kilogram of compost or barnyard manure mixed with topsoil should be added to each hole before planting.

h. Diseases and pests

At the nursery stage, seedlings may be damaged by common pests and, if water is excessive, by dumping-off. It is important to always use well drained potting media. The insect *Hypomeces squamosus* often damaged seedlings of *M. excelsa* by defoliation, however it is not usually a serious problem.

Seedling in natural stand



45. *Swietenia candolei* Pittier

Swietenia candolei is a member of Meliaceae family. The vernacular names of this species are; small or narrow-leaved mahogany, West Indian mahagoby, Spanish or Cuban mahagoby (En). Detailed descriptions of *Swietenia candolei* are as follows:





Leaf

a. Origin and geographic distribution

Native to the West Indian Islands but now very rare due to over exploitation. Planted throughout the tropics in reforestation projects and plantations, for instance in Java and the Philippines and occasionally in gardens in Peninsular Malaysia. Naturally distributed in the Caribbean region (S. Florida, Bahamas, Antilles, Haiti and Jamaica). The species is extensively planted mainly in southern Asia (India, Sri Lanka, Bangladesh) and in the Pacific (Malaysia, Philippines, Indonesia and Fiji).

b. Uses

The timber is regarded as the best quality mahogany. Mahogany has potential use for large scale timber production plantations, especially in dry areas, due to the excellent timber quality. The wood density is 560–850 kg/m³ at 15% moisture content. It is also used in agroforestry, for soil improvement and as an ornamental.

c. Production and international trade

Mahogany is one of the most important tropical timbers on the world market. Most mahogany traded is from natural stands, although small quantities are available from planted trees. Main exporting countries are Brazil, Bolivia and Peru. The

most important importers are the United States (buying mainly from Brazil) and Great Britain (in 1989: 85,000m³ of sawn timber).

d. Properties

Mahogany is a medium – weight timber which is rather soft. The heartwood is reddish or pinkish, the colour darkening with age to a deep red or brown, sapwood usually yellowish and up to 40mm wide. The density is 500-800 kg/m³ at 15% moisture content.

e. Descriptions

Small to large, monoecious but often functionally dioecious trees up to 40 (-60)m tall with a straight cylindrical bole branchless for up to 18 (-25)m, up to 150 (-200)cm in diameter and with broad buttresses. The genus *Swietenia* consists of three species, i.e. *S. macrophylla*, *S. mahagoni* and *S. humilis*, but poorly defined biologically, because of hybridise freely. The most important ecological characteristic that distinguishes *S. mahagoni* and *S. macrophylla* is the ability to grow under dry conditions. It occurs naturally in climates with annual rainfall of only 580–800mm.



f. Wood anatomy

Macroscopic characters:

Heartwood reddish, pinkish, salmon-coloured or yellowish when fresh, darkening to deep red or brown with age, distinct from the yellowish or whitish sapwood.

g. Observation

A small to medium-sized tree up to 30m tall, bole often short and much-branched, buttresses short and blunt; leaves with 2-4 pairs of leaflets of 5-6cm x 2.5-3.3cm, on young trees sometimes larger; inflorescence 8-15cm long; flower with glabrous sepals and petals; capsule 6-10cm long; seed 2-6cm long. Plantation-grown wood is usually somewhat less dense than that from trees of the forest and weighs 560-740 kg/m³ at 15% moisture content.

h. Ecology

Under natural conditions mahogany thrives in both deciduous and evergreen rain forest and occurs scattered or in small groups, but more than 4-8 trees/ha are rarely encountered. The optimum annual rainfall is 1,400-3,500mm with a dry period of 0-4 months. Mahogany grows from sea-level to 1,500m altitude, in areas with a mean annual temperature of 20-28°C, the range of the coldest

and warmest month being 11-22°C and 22-30°C, respectively.

i. Propagation and planting

Ripe fruits must be collected to achieve a good germination rate. These open after 2 days of storage and the seeds are very viable. The germination rate of fresh seeds is 60-90%. They can be stored up to 2 months, or longer (up to one year) if kept cool (2-5°C) in sealed containers at about 45% relative humidity. The weight of 1,000 seeds of *S. macrophylla* is 400-500g. Seeds are sown in the nursery in drills of 2-4cm deep or they are pushed into flat beds, leaving part of the wing exposed. Generative propagation is mainly practiced for mahagoni, due to ability to produce large amount of seeds in a season.

Seed

Bark



j. Silviculture and management

Although natural regeneration in *S. macrophylla* stands may be plentiful, it is usual to plant seedlings raised in nurseries. One year-old mahogany seedlings attain optimal height and diameter growth when fertilized with 3.6g N², 2.4g P₂O₅ and 3.6g K₂O. Phosphorus appears to be the most limiting element for mahogany seedling growth. Monoculture plantations of mahogany are susceptible to pests, and for that reason mixed plantations with other fast-growing species are often preferred. *Leucaena leucocephala* (Lamk) de wit and *Paraserianthes falcataria* (L) Nielsen are used as shade trees in young mahogany plantations. Thinning usually starts 6 years after planting, and progressively reduces the number of trees to 220-400 trees/ha in plantations of 20 years old, and to 120-150 trees /ha in 35-years old plantations. In industrial plantation, *S. mahagoni* is generally planted in initial spacing of 3 x 1m. In Perhutani land, the tree in some cases is planted in the edge of compartments. The semi-fast growing tree is thinned in 10 or more years, and may be final harvested at 15–20 years old.



k. Diseases and pests

In the Philippines stem rot of mahogany trees is caused by *Botryodiplodia theobromae*; it also infests the seeds. In South-East Asia the most destructive pest is the mahogany shoot-borer moth *Hypsipyla robusta* Moore. The attack is commonly noticed on saplings and pole-size trees when terminal shoots show symptoms of dieback, finally resulting in alformed trees.

l. Harvesting

Mahogany plantations are clear-cut when the rotation age has been reached (40-60) years and subsequently replanted with nursery-raised seedlings. Mahogany logs float in water and can be transported by river. The sapwood is susceptible to staining; an anti-sap stain dip should be used during drying.

m. Yield

In rotations of 50-60 years, average annual volume increments of 15-20 m³/ha can be achieved for plantations of *S. macrophylla*; on poor sites 7-11 m³/ha. *S. mahagoni* grows slower, but the quality of the timber is slightly better.

46. *Swietenia macrophylla*

Swietenia macrophylla belongs to the family of Meliaceae. The trade group of this species is mahogany: mediun-weight, hard wood, *Swietenia macrophylla* King and *S. mahagoni* (L) Jacq. The vernacular names of this species are: mahogany: baywood (En). Acajou (Fr). Indonesia: mahoni (general). Thailand: mahonikkani-baiyai, mahokkani-bailek (Bangkok) Vietnam: gi[as] ng [uwj]a. Detailed descriptions of *Swietenia macrophylla* are as follows:





Trunk

a. Origin and geographic distribution

Swietenia consists of 3 species and is distributed in tropical America between 20 N and 18 S. The area of distribution extends from central Mexico through Central America and the West Indies, including southern Florida, toward Bolivia, Peru and Brazil. At present, mahogany is widely cultivated throughout the tropics including Malaysia, Indonesia and the Philippines.

b. Uses

The timber is used as mahogany; the wood is generally less dense and of slightly lower quality than of narrow-leaved mahogany.

c. Production and international trade

Mahogany is one of the most important tropical timbers on the world market. Most mahogany traded is from natural stands, although small quantities are available from planted trees. Main exporting countries are Brazil, Bolivia and Peru. The most important importers are the United States (buying mainly from Brazil) and Great Britain (in 1989: 85,000m³ of sawn timber).

d. Properties

Mahogany is a medium – weight timber which is rather soft. The heartwood is reddish or pinkish, the colour darkening with age to a deep red or brown, sapwood usually yellowish and up to 40mm wide. The density is 500-800 kg/m³ at 15% moisture content.

e. Descriptions

Small to large, monoecious but often functionally dioecious trees up to 40(-60)m tall with a straight cylindrical bole branchless for up to 18(-25)m, up to 150(-200)cm in diameter and with broad buttresses.

f. Wood anatomy

Macroscopic characters:

Heartwood reddish, pinkish, salmon-coloured or yellowish when fresh, darkening to deep red or brown with age, distinct from the yellowish or whitish sapwood.

g. Growth development

Healthy seeds start germinating about 15 days after sowing. Young trees have straight and slender stems, and branches are formatted 2-3m above

the ground with a position oblique to the main stem. Initial growth is fast, depending on site conditions. Under optimal conditions, seedlings of *S. macrophylla* may reach 3m in one year and 6m in two years. In Indonesia the average height of 10 year-old trees in plantations is 10m (average diameter 35cm).

h. Ecology

Under natural conditions mahogany thrives in both deciduous and evergreen rain forest and found scattered or in small groups, but more than 4-8 trees/ha are rarely encountered. The optimum annual rainfall is 1,400-2,500mm with a dry period of 0-4 months. Mahogany grows from sea-level to 1,500m altitude, in areas with a mean annual temperature of 20-28°C, the range of the coldest and warmest month being 11-22°C and 22-30°C, respectively.

i. Propagation and planting

Ripe fruits must be collected to achieve a good germination rate. These open after 2 days of storage and the seeds are very viable. The germination rate of fresh seeds is 60-90%. They can be stored up to 2 months, or longer (up to one year) if kept cool (2-5°C) in sealed containers at about 45% relative humidity. The weight of 1,000 seeds of *S. macrophylla* is 400-500g. Seeds are sown in the nursery in drills of 2-4cm deep or they are pushed into flat beds, leaving part of the wing exposed.

j. Silviculture and management

Although natural regeneration in *S. macrophylla* stands may be plentiful, it is usual to plant seedlings raised in nurseries. One year-old mahogany seedlings attain optimal height and diameter growth when fertilized with 3.6g N², 2.4g P₂O₅ and 3.6g K₂O. Phosphorus appears to be the most limiting element for mahogany seedling growth. Monoculture plantations of mahogany are susceptible to pests, and for that reason mixed plantations with other fast-growing species are often preferred. *Leucaena leucocephala* (Lamk) de wit and *Paraserianthes falcataria* (L) Nielsen are used as shade trees in young mahogany plantations. Thinning usually starts 6 years after planting, and progressively reduces the number of trees to 220-400 trees/ha in plantations of 20 years old, and to 120-150 trees/ha in 35 years old plantations. A light-demanding species such as mahogany will grow most rapidly on open sites.

Adaxial leaf



Abaxial leaf





Seeds

Bark

k. Soil type

Soil condition under natural mahogany stands may not necessarily reflect the most suitable soil conditions for plantation-grown mahogany, since evidence indicates that natural distribution is partly dependent on disturbance rather than soil type alone.

l. Diseases and pests

In the Philippines stem rot of mahogany trees is caused by *Botryodiplodia theobromae*; it also infests the seeds. In South-East Asia the most destructive pest is the mahogany shoot-borer moth *Hypsipyla robudta* Moore. The attack is commonly noticed on saplings and pole-size trees when terminal shoots show symptoms of dieback, finally resulting in malformed trees.

m. Harvesting

When mahogany plantations have reached the rotation age, then clear clearing are conducted and subsequently replanted with nursery-raised seedlings. Mahogany logs float in water and can be transported by river. The sapwood is susceptible to staining; an anti-sap stain dip should be used during drying.

n. Yield

In rotations of 50-60 years, average annual volume increments of 15-20 m³/ha can be achieved for plantations of *S. macrophylla*; on poor sites 7-11 m³/ha. *S. mahagoni* grows slower, but the quality of the timber is slightly better.



47. *Swietenia mahagoni* (L.) Jacq.

Swietenia mahagoni belongs to the family of Meliaceae. The vernacular names of this species are; small or narrow-leaved mahogany, West Indian mahagoby, Spanish or Cuban mahagoby (En). Detailed descriptions of *Swietenia mahagoni* are as follows:





Leaf

Seeds

a. Origin and geographic distribution

Native to the West Indian Islands but now very rare due to over exploitation. Planted throughout the tropics in reforestation projects and plantations, for instance in Java and the Philippines and occasionally in gardens in Peninsular Malaysia. Naturally distributed in the Caribbean region (S. Florida, Bahamas, Antilles, Haiti and Jamaica). The species is extensively planted mainly in southern Asia (India, Sri Lanka, Bangladesh) and in the Pacific (Malaysia, Philippines, Indonesia and Fiji).

b. Uses

The timber is regarded as the best quality mahogany. Mahagoni has potential use for large scale timber production plantations, especially in dry areas, due to the excellent timber quality. The wood density is 560–850 kg/m³ at 15% moisture content. It is also used in agroforestry, for soil improvement and as an ornamental.

c. Production and international trade

Mahogany is one of the most important tropical timbers on the world market. Most mahogany traded is from natural stands, although small quantities are available from planted trees. Main

exporting countries are Brazil, Bolivia and Peru. The most important importers are the United States (buying mainly from Brazil) and Great Britain (in 1989: 85,000m³ of sawn timber).

d. Properties

Mahogany is a medium – weight timber which is rather soft. The heartwood is reddish or pinkish, the colour darkening with age to a deep red or brown, sapwood usually yellowish and up to 40mm wide. The density is 500-800 kg/m³ at 15% moisture content.

e. Descriptions

Small to large, monoecious but often functionally deciduous trees up to 40(-60)m tall with a straight cylindrical bole branchless for up to 18(-25)m, up to 150(-200)cm in diameter and with broad buttresses. The genus *Swietenia* consists of three species, i.e. *S. macrophylla*, *S. mahagoni* and *S. humilis*, but poorly defined biologically, because it hybridised freely. The most important ecological characteristic that distinguishes *S. mahagoni* and *S. macrophylla* is the ability to grow under dry conditions. It is found naturally in climates with annual rainfall of only 580–800mm.



f. Wood anatomy

Macroscopic characters:

Heartwood reddish, pinkish, salmon-coloured or yellowish when fresh, darkening to deep red or brown with age, distinct from the yellowish or whitish sapwood.

g. Observation

A small to medium-sized tree up to 30m tall, bole often short and much-branched, buttresses short and blunt; leaves with 2-4 pairs of leaflets of 5-6cm x 2.5-3.3cm, on young trees sometimes larger; inflorescence 8-15cm long; flower with glabrous sepals and petals; capsule 6-10cm long; seed 2-6cm long. Plantation-grown wood is usually somewhat less dense than that from trees of the forest and weighs 560-740 kg/m³ at 15% moisture content.

Basal trunk



h. Ecology

Under natural conditions mahogany thrives in both deciduous and evergreen rain forest and distributed scattered or in small groups, but more than 4-8 trees/ha are rarely encountered. The optimum annual rainfall is 1,400-2,500mm with a dry period of 0-4 months. Mahogany grows from sea-level to 1,500m altitude, in areas with a mean annual temperature of 20-28°C, the range of the coldest and warmest month being 11-22°C and 22-30°C, respectively.

i. Propagation and planting

Ripe fruits must be collected to achieve a good germination rate. These ripe fruits open after 2 days of storage and the seeds are very viable. The germination rate of fresh seeds is 60-90%. They can be stored up to 2 months, or longer (up to one year) if kept cool (2-5°C) in sealed containers at about 45% relative humidity. The weight of 1,000 seeds of *S. macrophylla* is 400-500g. Seeds are sown in the nursery in drills of 2-4cm deep or they are pushed into flat beds, leaving part of the wing exposed. Generative propagation is mainly practiced for mahagoni, due to ability to produce large amount of seeds in a season.



Bark

j. Silviculture and management

Although natural regeneration in *S. mahagoni* stands may be plentiful, it is usual to plant seedlings raised in nurseries. One year-old mahogany seedlings attain optimal height and diameter growth when fertilized with 3.6g N², 2.4g P₂O₅ and 3.6g K₂O. Phosphorus appears to be the most limiting element for mahogany seedling growth. Monoculture plantations of mahogany are susceptible to pests, and for that reason mixed plantations with other fast-growing species are often preferred. *Leucaena leucocephala* (Lamk) de Wit and *Paraserianthes falcataria* (L) Nielsen are used as shade trees in young mahogany plantations. Thinning usually starts 6 years after planting, and progressively reduces the number of trees to 220-400 trees/ha in plantations of 20 years old, and to 120-150 trees/ha in 35-years old plantations. In industrial plantation, *S. mahagoni* is generally planted in initial spacing of 3m x 1m. In Perhutani land, the tree in some cases is planted in the edge of compartments. The semi-fast growing tree is thinned in 10 or more years, and may be final harvested at 15–20 years old.

k. Diseases and pests

In the Philippines, stem rot of mahogany trees is caused by *Botryodiplodia theobromae*; it also infests the seeds. In South-East Asia the most destructive pest is the mahogany shoot-borer moth *Hypsipyla robusta* Moore. The attack is commonly noticed on saplings and pole-size trees when terminal shoots show symptoms of dieback, finally resulting in malformed trees.

l. Harvesting

When mahogany plantations have reached the rotation age (40-60 years) then clear cutting are conducted and subsequently replanted with nursery-raised seedlings. Mahogany logs float in water and can be transported by river. The sapwood is susceptible to staining; an anti-sap stain dip should be used during drying.

m. Yield

In rotations of 50-60 years, average annual volume increments of 15-20 m³/ha can be achieved for plantations of *S. macrophylla*; on poor sites 7-11 m³/ha. *S. mahagoni* grows slower, but the quality of the timber is slightly better.

FAMILY **MIMOSOIDEAE**



Tropical trees of Indonesia

48. *Samanea saman* (Jacq.) Merrill

Samanea saman is a member of Mimosoideae family. The local names of this species are; Indonesia: trembesi, kayudan, ki hujan. Malaysia: hujan-hujan, pukul lima. Philippines: acacia. Cambodia: âmpül barang. Laos: (do:k) sa:m sa:. Thailand: kampu, chamchuri, chamcha. Vietnam: me t[aa]y. Detailed descriptions of *Samanea saman* are as follows:





Leaf

Seedling

Seed pods

Basal trunk

a. Origin and geographic distribution

S. saman is a native of northern tropical South America.

b. Uses

It has been planted as a shade tree in cocoa, coffee, vanilla, and in young nutmeg and teak plantation. It can be used as a hedge tree, if lopped heavily. Mature trees are highly valued as a host for the laccifer insect (*Laccifer lacca*). Green leaves of *S. saman* are a high quality feed for sheep, goats and cattle and are used as a supplement during the dry season. Because of its prolific flowering, *S. saman* is also profitable for honey production. The wood, which is not durable, produces a high quality timber for carving, furniture and paneling. It provides a good quality firewood and charcoal, although it produces much smoke, even when very dry.

c. Descriptions

A large, evergreen, unarmed tree, up to 25(-40) m tall at maturity with a trunk diameter at breast height up to 2m, with wide spreading crown up to 25-30m in diameter. Bark finely fissured, light grey to greysih brown. Branchlets puberulous to tomentose. Leaves bipinnate, not sensitive to the touch, stipules lanceolate, small, not spinescent, caducous. Seed with epigeal germination.

d. Propagation and planting

S. saman is commonly propagated by seed, but can also be propagated through stem and root cuttings. Germination of untreated seed increases in the course of the first year of storage. Seed sown in containers placed in full light generally have a germination rate of over 90%.

e. Silviculture and management

Folding of the leaves and dropping branches allow rainfall to reach the grass directly during the night and on cloudy days. On sunny days, the unfolded leaves provide shade and help to conserve moisture. When planted in hedges tree should be maintained by heavy lopping. Pollarding is also used for firewood production.

Seedling



FAMILY **MORACEAE**



Tropical trees of Indonesia

49. *Ficus callosa* Willd.

Ficus callosa is a member of Moraceae family. The synonyms of this species are; *Ficus longespathulata* Sata, *Ficus malunuensis* Warb., and *Ficus portiana* Regel. The local name of this species is fikus and kalukoi. Detailed descriptions of *Ficus callosa* are as follows:





Adaxial leaf

Abaxial leaf

Fruits

Bark

a. Origin and geographic distribution

From Sri Lanka and India to Burma (Myanmar), Indo-China, Peninsular Malaysia, The Andaman Islands, Thailand, Indoensia (Sumatera, Java, Sulawesi, and lesser Sunda Islands), Borneo (Sabah), the Philippines.

b. Uses

Ficus is a good material for furniture plywood, boat making and veneer. White to creamy with a distinct wood grain, kalukoi wood is used for light construction (sash door, panel cores, pulp and paper making, wall board, pencil slat and matchstick).

c. Properties

Ficus yield a light weight to medium-weight hard wood with a density of 190-740 kg/m³ at 15% moisture content.

d. Descriptions

Ficus is a large tree with a diameter at breast height (DBH) reaching a maximum of 55cm, and with merchantable height (MH) and total height of 17m and 29m, respectively. The crown is conical to spreading, especially in the open. Leaves are simple, forming a whorl with a cordate (heart-shaped) base and the margins almost touching each other. The bark is khaki in color, 1cm thick, with prominent leaf/branch abscission layers. The inner bark is whitish and, unlike most other species of the Moraceae family, produces a colorless sap that causes skin irritation and burning.

e. Wood anatomy

Macroscopic character:

Heartwood pale yellow-brown or various shades from yellow to pink-gray. Texture moderately coarse to coarse.



Microscopic character:

Growth ring indistinct, when present marked by marginal parenchyma, vessel medium-sized to very large.

f. Ecology

The species are common and form an important element of lowland rainforest, both as canopy and understory trees. Most species prefer perhumid forest, but several are found in areas with a monsoon climate and in teak forest, also in location where the soils dries out. *Ficus* does not grow in mangrove vegetation but is often present in brackish swamps behind the mangrove. *Ficus* species are generally found below 1,500m altitude, some between 1,500 and 2,750m or rarely up to 3,200m.

g. Propagation and planting

The seeds turn brown when mature. Propagation is aided by giant bats, which eat the ripe fruit and drop it minced with the seeds. The tiny seeds of kalukoi germinate within 10 days but tend to go through a grass stage, taking two months to develop bigger leaves.

h. Silviculture and management

The species is susceptible to damping off (fungal infestation due to overcrowding, limited sunlight and over watering). To prevent this, use a seed box filled with fine sand. Using the broadcast method, sow the seeds at appropriate distances to avoid overcrowding. For higher germination and more robust seedlings, allow more sunlight by using semi-transparent plastic shade. Seedlings are ideally potted at 2cm height.

Leaves



50. *Parartocarpus venenosus* (Zoll. & Moritzi) Becc.

Parartocarpus venenosus is a species member of Moraceae family. The vernacular names of this species are; Indonesia: bulu onoko (Javanese), pejatai (West Kalimantan), purut (Sundanese) Malaysia: ara berteh paya (Peninsular), Philippines: malanangka (Filipino), buratu (Ibanag), pangi (Iloko). Thailand: le khaem, phaya raklueang (peninsular). The synonyms of this species are: *Gymnartocarpus venenosus* (Zoll. & Moritzi) Boerl., *Parartocarpus triandra* (J.J. Smith) J.J. Smith, *Parartocarpus woodii* (Merr.) Merr. Detailed descriptions of *Parartocarpus venenosus* are as follows:



a. Origin and geographic distribution

Parartocarpus comprises 3-5 species. The distribution of this species are: Peninsular Thailand, throughout the Malesian region (except for the Lesser Sunda Islands), and the Solomon Islands.

b. Uses

The wood of *Parartocarpus* is used for light construction, light flooring, furniture, door and window frames, and also for blockboard, particle board and plywood. Furthermore, it is suitable for shuttering, crates and pallets, paneling, boat building, vehicle bodies, non-striking tool handles, sporting goods, musical instruments, turnery and toys. The fruits are edible but the seed are reputedly poisonous.

c. Properties

Parartocarpus yields a lightweight to medium-weight hardwood with a density of 310-670 kg/m³ at 15% moisture content. Heartwood yellowish-white or grey white, not clearly differentiated from the white sapwood. The wood is rather soft,

fairly easy to saw and peel but should be treated immediately upon felling and after sawing to prevent blue stain.

d. Descriptions

Evergreen, medium-sized to large trees up to 45m tall. Bole usually straight, cylindrical or fluted, branchless for up to 16m, up to 90cm in diameter. Bark surface smooth or dippled to slightly scaly. Leaves arranged spirally, simple, entire. Seedlings with epigeal germination. *Parartocarpus* maybe easily confused with *Artocarpus* because of the similarity of the syncarps. *Parartocarpus* differs in having a usually well-developed involucre below the inflorescence and no perianth.

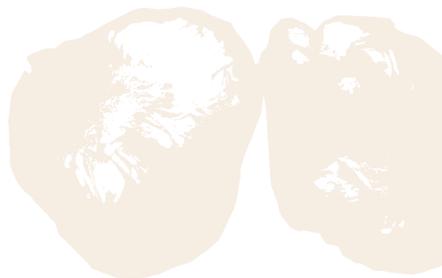
e. Ecology

Parartocarpus occur scattered in lowland to submontane or rarely montane, primary, evergreen rain forest, up to 1,800m altitude. *P. venenosus* is a characteristic element of peatswamp, freshwater and tidal forest but like *P. bracteatus*, also occurs on heavy clay or even sandy soil in well-drained locations.

Leaf



Fruit





Seeds

Basal trunk

f. Propagation and planting

Parartocarpus can be propagated by fruitlets. Fruitlets picked off the tree have a germination rate of about 75% in 27-120 days, but when collected from the ground it is only about 15% in 33-136 days.

g. Silviculture and management

In peat-swamp forest in Singapore and Johore (Peninsular Malaysia) the density of large *P. venenosus* trees is 2-4/ha.

h. Diseases and pests

The wood is not resistant to termite and marine borers. The sapwood is susceptible to pinhole borers and *Lyctus*.



FAMILY **MYRISTICACEAE**



Tropical trees of Indonesia

51. *Endocomia macrocoma* (Miq.) W.J. de Wilde

Endocomia macrocoma is a member of Myristicaceae family. The vernacular names of this species are; Indonesia: kamorree (Biak, Japen Island), kelapa tiyung (West Javas), mandarahan payo (Simeulue Island). Malaysia: kumpang lumau (Iban, Borneo). The synonyms of this species are: *Horsfieldia macrocoma* (Miq.) Warb., *Horsfieldia merrillii* Warb., *Horsfieldia prainii* (King) Warb. Detailed descriptions of *Endocomia macrocoma* are as follows:





Flower

Leaf

Fruits

Bark

a. Origin and geographic distribution

Endocomia comprises 4 species and grows from the Andaman Islands, Burma (Myanmar), Indo-China, southern China, Thailand, Sumatera, West Java, Borneo, the Philippines, the Moluccas and New Guinea, possibly also in Sulawesi.

b. Uses

The use of *Endocomia* wood is probably similar to that of other Myristicaceae genera which are used for partitioning, flooring, light temporary construction, concrete shuttering, cladding, match boxes and match splints, pattern making, packing cases and crates. In Papua New Guinea *Endocomia* is reported to be used for house building. The wood is suitable for the production of plywood.

c. Properties

Endocomia yields a lightweight hardwood with a density of 245-425 kg/m³ at 15% moisture content. Heartwood sometimes not well developed but large trees often with dark central core. Texture rather fine to moderately coarse and even. The wood is soft to moderately hard and weak.

d. Botany

Monoecious, small to medium-sized or sometimes large trees up to 50m tall. Bark surface smooth or shallowly fissured. Flowers small. Seedling with hypogeal germination. Flowering and fruiting is almost throughout the year.

e. Ecology

Endocomia is mainly encountered as a scattered, middle-storey tree of lowland and lower montane, primary or occasionally secondary, evergreen to semi-deciduous forest, up to 1,000m altitude. It grows on a wide range of soils, on dry land as well as in periodically inundated locations.

f. Propagation

Endocomia can be propagated by seed.

Fruits



52. *Horsfieldia spicata* (Roxb.) J. Sinclair

Horsfieldia spicata is a member of Myristicaceae family. The vernacular names of this species are; penarahan (trade name). Horsfieldia (En). Brunei: kumpang. Indonesia: darah-darah, pendarah. Malaysia: dara kerbau (Peninsular), darah-darah (Sabah), kumpang (Serawak). Philippines: duguan (Filipino). Detailed descriptions of *Horsfieldia spicata* are as follows:





Flower buds

Leaves

Fruit

Bark

a. Origin and geographic distribution

Horsfieldia comprises about 100 species distributed from Sri Lanka and north-eastern India to Indo-China, southern China, Thailand, throughout the Malesian region (except for the Lesser Sunda Islands), the Caroline Islands, the Solomon Islands and northern Australia. Most of the species grow within Malesia and many, often endemic ones, are present in Borneo (40) and New Guinea (30).

b. Uses

The wood of *Horsfieldia* is used for light or temporary construction, flooring, boatbuilding, interior trim, joinery, sporting goods, packing cases, crates, matchboxes and match splints, and for the production of particle board and plywood.

c. Properties

Horsfieldia yields a lightweight to medium-weight hardwood with a density of 295-650 kg/m³ at 15% moisture content. Heartwood pink-brwn, grey brown, or red-brown. The wood is soft to moderately hard and weak. It can be easily sawn.

d. Botany

Evergreen, small to medium-sized or rarely large trees up to 30(-60)m tall, bole generally straight, cylindrical, up to 60(-90)cm in diameter. Bark

surface smooth or rough with superficial cracks and fissures. Seedling with hypogeal germination.

e. Ecology

Horsfieldia is found scattered in lowland or lower montane or rarely montane rain forest. This species grows up to 1,200 (-2,000)m altitude, on dry land as well as in swamp forest. They grow as canopy or subcanopy trees in primary forest but may persist in secondary growth. Most species are restricted to a certain soil type.

f. Propagation

Horsfieldia can be propagated by seed. Seeds of *H. brachiata* germinate about 30% in 10-22 weeks, seeds of *H. fulva*, with aril, have about 85% germination in 7-12 weeks and those of *H. tomentosa* about 75% in 7-13 weeks.



53. *Myristica fragrans* Houtt

Myristica fragrans is a member of Myristicaceae family. The vernacular names of this species are; Indonesia: mendarahan (general), pala. Detailed descriptions of *Myristica fragrans* are as follows:





Leaf

Young fruit

a. 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 of the genus.

b. 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. *Myristica 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 fruit of *Myristica fragrans* is edible.

c. Properties

Myristica wood is lightweight to medium-weight. The heartwood is pale brown or brown to orange-brown. The density of the wood is 400-790 kg/m³ at 15% moisture content.

d. Descriptions

Small to large evergreen trees up to 35(-45)m tall, bole cylindrical, up to 70(-100)cm in diameter.

e. Ecology

Most species are found scattered in lowland tropical evergreen rain forest up to 800m altitude. They are nearly always elements of the second storey, although some may occasionally reach the canopy top. Generally they do not tolerate waterlogging or excessive drying out of the soil. Quite number of species are found in freshwater swamp or peat-swamp forest, but others prefer well-drained fertile places such as hillsides and ridges.





Ripen fruit

Bark

f. Propagation and planting

Myristica is usually propagated from seed collected from under the tree. The seeds dries out easily and cannot be stored, and loses its viability in about one month.

g. Silviculture and management

When one-year old seedlings of *M. andamanica* were planted at an average height of 30cm the survival was 90%; partial overhead shade proved essential.

h. Diseases and pests

The foliage of *M. malaccensis* is invariably galled; the galls develop with in two weeks after leaf renewal. Living trees are rarely, if ever, attacked by borer.



Fruit



FAMILY **MYRTACEAE**



Tropical trees of Indonesia

54. *Eucalyptus deglupta* Blume

Eucalyptus deglupta is a member of Myrtaceae family. The local name of this species is leda, and detailed descriptions of *Eucalyptus deglupta* are as follows:



a. Origin and geographic distribution

E. deglupta are found between tropical latitudes 9°N and 11°S in a markedly discontinuous distribution through Mindanao (Philippines), Sulawesi, Ceram and Irian Jaya (Indonesia), and Papua New Guinea including New Britain. Some literature reported on natural habitat of this species in New Ireland (Papua New Guinea), e.g., in Streets (1962), is erroneous; the mistake has been traced to a mis-labelled herbarium specimen. The best developed stands are found on riverine sites less than 150m above sea level on the north coast of East New Britain, Papua New Guinea and near sea level in the Bislig Bay area of Mindanao, Philippines. The range of altitude is from sea level into 2,500m.

b. Uses

Wood:

The wood is used for furniture (including veneer and plywood), joinery, mouldings, flooring, wood based panels, both heavy and light construction and boat building. Most plantation-grown wood is destined for short-fibre pulp production. *E. deglupta* is also used for firewood (21,107 kJ/kg) and charcoal.

Descriptors: fuelwood; round wood; transmission poles; posts; stakes; building poles; roundwood structures; sawn or hewn building timbers; for heavy construction; beams; for light construction; carpentry/joinery; flooring; wall panelling; containers; boxes; furniture; veneers; boats; wood based materials; plywood; particleboard; fibreboard; hardboard; pulp; short fibre pulp; charcoal.

Non-wood:

This eucalyptus yields a good quality honey. Leaf oils are present, but not in sufficient quantities to be of commercial interest.

c. Descriptions

E. deglupta is a large tree, commonly 35-60m high, 0.5-2.0m diameter, occasionally reaching 80m height and 3m diameter. The bole is typically straight, cylindrical and self-pruning, often clear of branches for more than 75% of the total height. Buttressing to 3-4m high is common on individuals growing on unstable soils.

Bark:

A gum, smooth, 3-8 mm thick, exfoliating in strips of varying shape and size, leaving a smooth, white to pale green surface which ages through light green, green, grey, pink, red and orange to a deep purple, all colours mentioned being visible on different parts of the trunk simultaneously.

Basal trunk





Leaf

Seeds

d. Propagation and planting

Seed production is often profuse. Nine to ten years old trees in Malaysia produced an average of 87g of seed per tree in a single harvest. Capsules may be picked when they are greenish brown and will open to release the seed after 2-3 days of drying in the sun. After drying, seeds may be stored for at least two years in airtight containers in a refrigerator.

For natural regeneration, water is the most important vehicle for dispersal, continually leading to new riverine stands on fresh alluvial deposits. In addition, the seeds have a small wing which

combined with their small size and light weight enables them to drift into nearby bare areas. Seeds have been reported to travel horizontally a distance equivalent to a little more than the height of the tree in a 10 km/h wind.

Germination is epigeal and takes place in 4-20 days. The optimum temperature for germination ranges from 32-35°C which is high for a eucalyptus but fits with the natural situation of a dark coloured, sandy seedbed in full tropical sunlight. No pre-treatment of seeds is required.





e. Silviculture and management

Successful site preparation procedures include removal of slash, control of weeds and soil cultivation. In the past burning of slash has been practiced prior to planting but this practice is not encouraged now because of the adverse effects of burning on the soil. When initially controlled, most woody vegetation is usually quickly overtopped by the tree seedlings. Grass is a severe weed problem for this species and other eucalyptus, and it must be controlled by herbicides or other means. As seedlings of this eucalyptus are prone to wilting in dry weather, planting has to be done during rainy periods and seasonal conditions are important in

timing planting. After a month in the field, seedlings will usually be able to withstand short periods of moisture stress. Fertilizer is often applied at the time of planting to boost early growth. Early growth on good sites is very rapid, from 4.5-6.0m height in the first year is normal in New Britain. Refilling of vacancies caused by mortality must be done before the end of the first growing season otherwise the new seedlings will not catch up.

In trials, 2 x 2m spacing resulted in the trees becoming stagnated within only two years. so wider spacings of 4 x 4m have been adopted without thinning for pulpwood production.

Seeds



Bark



55. *Eucalyptus pellita* F. Muell

Eucalyptus pellita is included in the family of Myrtaceae. The trade group of *Eucalyptus* is light weight to medium-weight or heavy hard wood, e.g., *Eucalyptus alba* Reinw. Ex Blume, *E. deglupta* Blume, *E. urophylla* S.T. Blake, and the vernacular names of this species are: Indonesia: ampupu, leda. Papua New Guinea: Kamerere. Philippines: bagras. Thailand: yukhalip (General). Detailed descriptions of *Eucalyptus pellita* are as follows:



a. Origin and geographic distribution

Eucalyptus is a genus of over 500 species, most of them endemic to Australia. Only 2 species are confined to the Malesian area (New Guinea, the Moluccas, Sulawesi, the Lesser Sunda Islands and the Philippines). Several species extend from northern Australia towards eastern Malesia. At present over 10 species are known from the southern region of New Guinea. As botanical exploration of the savanna and monsoon forests of this region continues, the number of species encountered here is expected to increase. The largest diversity is in the coastal regions of New South Wales and in south-western Australia. At present, many species are being cultivated outside their natural distribution area, for example in the Malesian area but also in continental Asia, tropical and subtropical Africa, southern Europe and South and Central America.

b. Uses

The wood of *Eucalyptus* is used as a general-purpose timber. It is suitable for light or heavy construction. In house building its applications are for doors, window frames, interior finishing and both light and heavy duty flooring. Because of its moderate durability and moderate resistance to insect attacks the timber is also applied in contact with the ground, in railway sleepers, poles and posts. Other applications are in ship and boat building, vehicle bodies, joinery, boxes and crates vats, carving, turnery, handles, sporting goods and agricultural implements. The timber is suitable for the production of veneer and plywood particle board, hardboard and wood-wool boards ones of

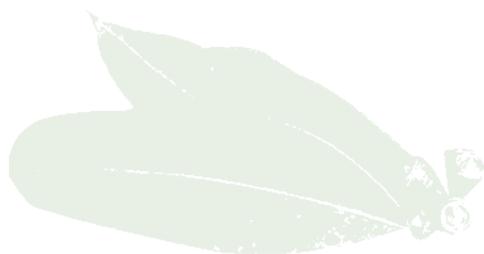
the major uses of eucalyptus the production of pulp for paper manufacture. *Eucalyptus* is also a very important supplier of firewood, which generally burns very quickly because of the high oil content, while many produce a good-quality charcoal. Several species are being used in reforestation projects.

c. Properties

Eucalyptus wood is light, medium-weight or heavy. The heartwood is light brown to reddish-brown, sometimes dark reddish-brown on exposure, the sapwood is white, cream or light pinkish, 20-60mm thick and more or less distinctly demarcated from the heartwood.

d. Descriptions

Small to very large trees of up to 60(-87)m tall; bole generally well-shaped, up to more than 200cm in diameter; bark surface smooth, fibrous, stringy or tessellated. Plant heterophyllous, i.e. with juvenile and adult phases occurring in most species; adult leaves generally alternate but sometimes opposite, simple, pendulous, rarely erect. lanceolate, often falcate, with a distinct midrib, pinnately veined or with parallel veins, aromatic when crushed, glabrous.



e. Wood anatomy

Macroscopic characters:

Heartwood varying from light to dark reddish-brown except in *E. citriodora* where it is light brown to grey-brown and sometimes waxy to the touch; sapwood whitish, pinkish or cream, usually 25-60mm wide but width varying with growth rate. Grain in straight to interlocked, forming a ribbon stripe when quarter-sawn, fiddle back figure sometimes evident in *E. citriodora* with very conspicuous vessel lines. Kino veins (gumveins) are a prominent feature of the genus.

Microscopic characters:

Growth rings generally indistinct, sometimes evident in *E. camaldulensis*, having some thick walled latewood cells.

f. Growth development

Seeds of *E. pellita* have a germination rate of 50-60% and one gram of dry seeds produces 1,000-2,000 seedlings. Shoot growth of young trees appears to be continuous, provided soil moisture is adequate. Young trees have a conical crown with a definite leader and almost horizontal branches. As the tree ages, branches curve up at the ends and the leader becomes less dominant.

g. Ecology

Almost all species of *Eucalyptus* are adapted to a monsoon climate. Many species can even survive a severe dry season, e.g., the cultivated species

of *E. alba*, *E. camaldulensis*, and *E. citriodora*. *E. deglupta* is the only species of *Eucalyptus* which is adapted to lowland and lower montane rain forest habitats. It does not grow naturally in areas with a pronounced dry season, but it occurs in areas where the annual rainfall usually exceeds 150mm.

h. Propagation and planting

Eucalyptus can be propagated easily from seed and sometimes from cuttings. Seeds germinate in 4-20 days. Seedlings are best raised in trays filled with sterile, fine, loamy sand. The trays should be kept in the shade for the first few days after sowing but light can be gradually increased to 50% full sunlight. Seedlings can be transferred to planting tubes when they have 2-3 leaf pairs. Further growth requires full sunlight. The seedlings are ready for planting in the field when they are 25-30cm in height, usually after 3-4 months.

Seedling





Leaf

Branch

Seed pods

Bark

i. Silviculture and management

Good weed control (usually a 1m strip along each planting line) is essential and 4-5 weedings each year for 2 years may be necessary before site occupancy is achieved. Growth is usually rapid and subsequent management depends on the purpose for which the trees are being grown. If grown for pulpwood, trees can be harvested after 6-10 years. Plantations grown for saw logs will require thinning.

j. Diseases and pests

Heart rot is sometimes found in older trees of *E. pellita* but is unsuch asly to be a problem in trees grown on a short (e.g., 10 years) rotation. Field observations suggest that heart rot is more common in trees growing on less well-drained sites. *Eucalyptus* seedlings are susceptible to damping – off in the nursery.

k. Harvesting

When eucalyptus plantations have reached the rotation age then clear cutting are conducted, and subsequently replanted with nursery-raised seedlings. Buttresses, often 3-4m height, are frequent on specimens of eucalyptus growing on river alluviums and non-stable soils in the natural area of distribution of the species; to harvest the logs, scaffolding has to be built so the stem can be sawn through above the buttresses.

l. Yield

Mature eucalyptus trees may yield much timber. Occasionally the logs of *Eucalyptus* trees in New Britain are branchless for 45m and have a diameter of 2.3m, yielding 175m³ of timber per tree.



56. *Eucalyptus urophylla* ST Blake

Eucalyptus urophylla is a member of Myrtaceae family. The local name of this species is ampupu. Detailed descriptions of *Eucalyptus urophylla* are as follows:





Leaf (adaxial and abaxial)

Branch

Bark

a. Origin and geographic distribution

E. urophylla is found between tropical latitudes 9°N and 11°S in a markedly discontinuous distribution through Mindanao (Philippines), Sulawesi, Ceram and Irian Jaya (Indonesia), and Papua New Guinea including New Britain. Some literature reported in natural habitat of this species on New Ireland (Papua New Guinea), e.g., in Streets, is erroneous; the mistake has been traced to a mis-labelled herbarium specimen. The best developed stands are found on riverine sites less than 150m above sea level on the north coast of East New Britain, Papua New Guinea and near sea level in the Bislig Bay area of Mindanao, Philippines. The range of altitude is from sea level to 2,500m.

b. Uses

Wood

E. urophylla has wood properties which are very suitable for a wide range of purposes. Young trees provide satisfactory firewood and charcoal. The wood of *E. urophylla* is less dense than most eucalypts. The basic density is in the range 540-570 kg/m³. The heartwood is pinkish-brown to red brown and contains little gum. Fibres are relatively short, about 1.0mm in length. The wood is very suitable for producing bleached chemical pulp and has good pulp yield (49.5%). The timber of older trees can be sawn and used for general construction purposes.

In general, the wood is suitable for building poles and fence posts. The average annual volume increment is 20-30 m³/ha. The wood density was examined in a trial of 11 provenances planted in 1982 in Malawi. The range in density was 564-453 kg/m³ and there was a trend to lower density with higher altitude seed source. Descriptors: fuelwood; round wood; building poles; sawn or hewn building timbers; for light construction; flooring; wall panelling; exterior fittings; fences; furniture; wood based materials; fibreboard; medium density fibreboard; pulp; charcoal.

Non-wood

The range of oil yields (w/w% dry leaves) in the seedling leaves was 1.1% for *E. urophylla*, 0.5% for *E. wetarensis* and 0.3% for *E. orophila*. The bark has a 10% tannin content.

c. Descriptions

E. urophylla is similar to other eucalyptus which are vigorous, light demanding species and growth is curtailed with increasing weed competition. Under favourable conditions the species is capable of annual growth rates in excess of 30 m³/ha MAI after provenance selection. The species has some level of drought and frost tolerance but is generally grown where neither of these factors are limiting.



Trunk

d. Propagation and planting

The species is usually propagated by seeds and established using containerized stock. Flowering usually starts within two years and seeds are produced abundantly within 4 years growth. Summer flowering in the natural habitat and insect pollination results in mature seeds six months later. *E. urophylla* has an average of 450,000 viable seeds/kg. Seed is orthodox and can be stored for extended periods at low humidity and temperature. Techniques for the collection, processing, testing and storage of *E. urophylla* seed are given in. It requires no germination pre-treatment.

Nursery establishment is generally by sowing untreated seeds in germination beds. The resulting seedlings are transplanted into containers when they have two pairs of leaves. The potting medium is usually a free-draining loam-sand mix. Seedlings usually reach planting-out size (25cm) in 10-12 weeks. The species coppices readily and is easily propagated by rooted cuttings or in tissue culture. In Brazil, *E. urophylla* or hybrids of *E. urophylla* and *E. grandis* are routinely raised using rooted cuttings derived from stump sprouts.

e. Silviculture and management

Intensive site preparation by ploughing is beneficial, and on compacted sites deep ripping may also be used. Fertilizer (N,P,K) is applied in each planting hole. Boron deficiency has been identified as one of the more important causes of poor stem form and malformed leaves in *E. urophylla* plantings in Guangdong Province, China, and require an addition of boron to the soil. Spacing between planting spots varies, and is commonly 3 × 2m in pulpwood and charcoal plantations but may be closer in fuelwood or pole plantations. The tree is highly sensitive to competition in the early stages, and the plantations must be kept weed-free for 6-12 months after planting. After that time, the dense crown inhibits competing weeds. Mechanical cultivation is advisable to remove umperata grass or other dominant vegetation prior to planting. A provenance trial site in Malawi was cleared, stumped, then slash burnt and the ground pitted 30cm × 30cm × 30cm.

Seeds



57. *Syzygium syzygioides* (Miq.) Amshoff

Syzygium is a member of Myrtaceae family. The vernacular names of this species are: Kelat: Indonesia: ki tembaga, jambu laut. Malaysia: jambu (Peninsular), obar (sabah), obah (Sarawak). Papua New Guinea: water gum. Philipines: makaasim. Burma (Myanmar): thabye-gui. Thailand: wa, daeng. The trade groups of this species are: Kleat: medium-weight to heavy hardwood, e.g., *Syzygium buettnerianum* (K. Schumann) Niedenzu, *S. claviflorum* (Roxb.) A.M. Cowan & J.M. Cowan, *S. fastigatum* (Blume) Merr & Perry, *S. grande* (Wight) Walp., *S. longiflorum* K. Presl, *S. nervosum* DC., *S. polyanthum* (Wight) Walp., *S. syzygioides* (Miq.) Merr. & Perry. Detailed descriptions of *Syzygium syzygioides* are as follows:





Leaves

a. Origin and geographic distribution

Syzygium is a very large genus with about 1,000 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.

b. 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, implement, fibreboard, and veneer and plywood. It is also used for charcoal and as fuelwood.

c. Production and international trade

Peninsular Malaysia exports small amounts of Kelat timber. In 1983 the exports of sawlogs was 4,600m³ (51% to Singapore and 49% to Hongkong)

with a value of US \$ 180,000. Kelat is occasionally exported from Peninsular Malaysia as "mixed medium hardwood".

d. Properties

Kelat is a medium-weight to heavy hardwood. The colour of the heartwood varies between species from grayish-brown, golden brown or pinkish-brown to red-brown or purple-brown. In general, kelat can be converted without difficulty and machines well both green and air-dry. 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.

e. Descriptions

Small to medium-sized, sometimes large tree up to 45(-50)m tall, or rarely shrubs, with bole up to 150(-200)cm in diameter. Leaves opposite and simple, glabrous, secondary veins close-set to widely spaced, with a distinct intramarginal vein, dotted with minute oil glands, petiole but sometimes subsessile, lacking stipules. Inflorescence axillary, terminal, on leafless branches. Flowers bisexual and regular; calyx with short to long tube; stamens usually numerous; ovary inferior. 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 germination; cotyledons usually equal and peltate, petiole or not; stem 4-angular near top; leaves decussate; tip of seedling often red.

f. 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 surface. Growth rings absent or inconspicuous, but occasionally concentric, 3-5mm 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 alens; rays invisible or barely visible to the naked eye.

Microscopic characters:

Vessels diffuse, 5-20(-38)/mm², solitary and in radial multiples of 2-3(-8), less frequently in clusters, round to oval; perforations simple; intervessel pits alternate; tyloses sparse to abundant, thinwalled. Parenchyma sparse to very abundant, entirely or predominantly paratracheal, aliform, sometimes limited to the abaxial sides of the vessels.

g. 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 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.

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.

Flowers





Leaf



Basal trunk

h. Ecology

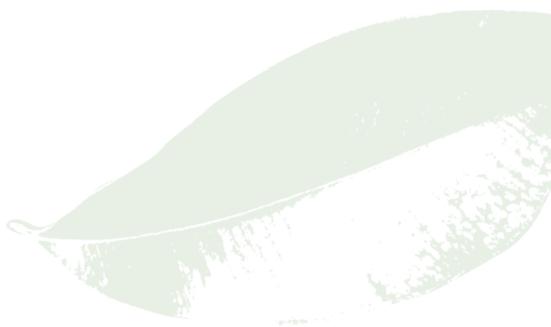
Syzygium can be found from sea-level to high in the mountains and is common over large areas, especially as understory tree, in primary as well as secondary forest. Some species may dominate the vegetation, e.g., *S. grande* and *S. syzygoides* in forest bordering the rocky and sandy bays in Peninsular Malaysia. Very few species are trees of the second and third storey of the forest. In montane heath forest *Syzygium* species are common understory trees.

i. 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 3,000–8,500. Seeds lose their 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. 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. 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.





j. 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.

k. 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. The following noxious insect species have been observed on *Syzygium* in Indonesia; *Argyroplocemormpa* (a tip-boring caterpillar on *S. polyanthum*), *Coccus viridus* (feeding on the sap), *Acarina* (mites) and *Alcides patruiles* (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*.

l. Yield

In pure plantations of *S. polyanthum* on fertile soil in Java the mean annual increment at 7 years was 21.5 m³ of wood per ha, at 8 years in another plantation (spacing 2m x 3m) 9.1m³ of timber (clear bole wood volume) per ha, and at 17.5 years (spacing 1m x 2.5m) 7.4 m³ of timber per ha. In natural forest in Riau, the same species showed a mean annual increment of 10.5m³ of wood per ha.

FAMILY **PAPILONACEAE**



Tropical trees of Indonesia

58. *Dalbergia latifolia* Roxb.

Dalbergia latifolia is a member of Leguminosae. The vernacular names of this species are; Indonesia: sonokeling, sonobrits, sonosungu. Vietnam: tr[aws]c. Detailed descriptions of *Dalbergia latifolia* are as follows:





Leaf (adaxial and abaxial)

Basal trunk

a. Origin and geographic distribution

Nepal, western and north-eastern India and Java; planted in mainland South-East Asia, Java and Africa.

b. Uses

The timber is used as sonokeling. The species is planted as shade tree. Sonokeling is well known for its applications in high-class furniture, cabinets and as a decorative timber used, for example, in passenger ships and for instrument cases. Sonokeling is one of the most popular woods for carving and engraving. It is also used for making musical instruments and sports equipment.

c. Observation

A medium-sized to large tree of up to 43m tall, bole straight or slightly twisted and usually branchless for 3-12m with diameter of up to 180cm.

d. Properties

Sonokeling is a medium-weight to heavy hard wood. The heartwood is dark purplish-brown with very dark brown to black streaks and is clearly demarcated from the 3-5cm thick whitish to yellowish sapwood. The density of sonokeling wood is 770-860 kg/m³ at 15% moisture content.

e. Descriptions

A medium-sized to large tree of up to 43m tall, bole straight or slightly twisted and usually branchless for 3-12m with a diameter of up to 180cm, buttresses prominent, leaflet obtus to emarginated with or without a small cusp. Seedling with epigeal or hypogeal germination; the cotyledons equal, being massive food-storing organs.

f. Wood anatomy

Macroscopic character:

Heartwood deep red-brown, often with purplish streaks. Texture moderately fine. Growth rings usually distinct.

Microscopic character:

Growth rings boundaries marked by marginal parenchyma bands.

g. Ecology

Sonokeling are found in Java in deciduous forest in periodically very dry localities. Older trees are very drought-resistant. Sonokeling thrives well in areas with up to 6 dry months with mean monthly rainfall of less than 40mm. It tolerate maximum temperatures of 35-48°C and minimum temperatures of 0-6°C. In java sonokeling grows naturally up to 600m altitude, but it is successfully cultivated as high as 1,000m altitude.



h. Growth and development

Seedling of sonokeling have a strong taproot and are practically devoid of any secondary roots when young. In Java an annual volume increment of 15 m³/ha have been recorded for young plantation on favourable sites.

i. Propagation and planting

Usually sonokeling is propagated from root suckers of 1-2.5cm diameter. Root and stem cuttings can also be used. Seeds have no dormancy, and the germination rate is often low (30-40%). The weight of 1,000 seeds of sonokeling is approximately 50g. Application of growth regulators (auxins) enhances rooting and callus formation. In Nepal and India successful methods of tissue culture have been developed for both sonokeling and sonosisso.

j. Silviculture and management

In Java sonokeling is only planted on sites which are not sufficiently productive for teak (*Tectona grandis* L.f.). It is generally grown in pure stands, but sometimes mixed with mahogany (*Swietenia* sp.). Pruning and thinning are recommended 5-10 years after planting.

k. Diseases and pests

In East Java *Fusarium solani* caused widespread damage to sonokeling plantations over 15 years old. The symptoms are inward rolling of young leaves, dieback, and discoloration of other leaves, and red streaks formed on outer layer of the sapwood. Plant pre-inoculated with *Glomus fasciculatum* showed better growth and were less susceptible to wilt disease.

Seedlings



FAMILY **PINACEAE**



Tropical trees of Indonesia

59. *Pinus caribaea* Morelet

Pinus caribaea is a member of family Pinaceae. The vernacular names of this species are; Caribbean pine, pitch pine, Nicaragua pine (En). Detailed descriptions of *Pinus caribaea* are as follows:





Tree

Bark

a. Distribution

Central America, Cuba and the Bahama Islands; planted throughout the tropics, e.g., in Malaysia, Indonesia and the Philippines.

b. Observation

A large tree up to 45m tall, but in plantations usually much smaller, with a straight and cylindrical bole, deeply fissured bark, and orange-brown twigs later turning grey-brown; needles in bundles of (2-)3(-5), 15-25cm long, in whorls at the end of the shoots and soon shed, most of them in

the second year; cones solitary, ovoid, 4-14cm long, readily shed from the branches. Caribbean pine is often divided into 3 varieties: *var. hondurensis* Barret & Golfari (Honduras pine) is most commonly planted in South-East Asia, *var. caribea* and *var. bahamensis* Barret & Golfari much less so. The later variety is reported to have some tolerance to shoot moth attack. *P. caribaea* has often been mistake for *P. elliottii* in the past. In Malesia it often does not produce seeds.

Needles



60. *Pinus merkusii* Junghuhn & deVriese

Pinus merkusii is a member of family Pinaceae. The synonyms of this species are: *Pinus sumatrana* Junghuhn, *Pinus merkuisiana* Cooling & Gaussen. The vernacular names are: Merkus pine, Mindoro pine, Sumatran pine (en). Indonesia: dammar batu, dammar bunga, uyan (Aceh, Sumatra), Philippines: Tapulau (Sambali, Tagalog), Thailand: son-song-bai. Detailed descriptions of *Pinus merkusii* are as follows:





Needles

Cones

Bark

a. Origin and geographic distribution

Eastern Burma, Indo-China, southern China, northern Thailand, the Philippines, Sumatra, commonly planted in South-East Asia.

b. Uses

Merkus pine is a general-purpose timber; it can also be used for construction work, flooring and boat building as it is fairly durable and heavy. Good quality oleoresin is collected from this species, often on plantation scale. The tree is used to shade out alang-alang grass with fairly good results.

c. Properties

Pinus is a medium-weight, moderately hard wood. The colour of the heartwood is yellowish-brown to red brown, depending on the resin content (more resin yields darker wood). The sapwood is yellowish-white to light reddish-yellow, and sharply defined from the heartwood.

d. Descriptions

A large tree up to 50(-70)m tall with straight and cylindrical bole free of branches for 15-25m and an average diameter of 55cm, but occasionally up to 140cm, thick bark which forms plates and is grey brown underneath, but scaly and more reddish tinged upwards, and heavy horizontal or ascending branches; needles in pairs, slender but rigid.

e. Wood anatomy

Macroscopic character:

Sapwood merging into heartwood except in old trees. Sapwood whitish or creamy white, heartwood yellow or yellowish-red to orange-brown. Texture coarse. Growth rings distinct but irregular in width.

Microscopic character:

Growth rings distinct with prominent latewood bands. Cell wall thickness 3-5µm. Transition from earlywood to latewood fairly abrupt.

f. Growth and development

Young trees of mainland provenances of *P. merkusii* pass from 3-5 years through a so-called "grass stage" characterized by densely cluster needles and short shoots and minimal height growth.

Tree



g. Propagation and planting

Successful natural regeneration is only possible where a relatively large amount of sunlight reaches the ground. In Sumatra ripe seeds are produced most abundantly between July and November, but viable seeds are produced throughout the year. The weight of 1,000 seeds of Sumatran *P. merkusii* is about 17g, and of continental provenance of *P. merkusii* 25-33g. Seeds of *P. merkusii* are reported to have a rather short viability; seeds from Sumatra can be stored dry for only 1-2 years, and those from continental Asia during even shorter periods.

h. Silviculture and management

In plantations of *P. merkusii* the first thinning is usually carried out in the 9th or 10th year, and about every 5 years thereafter. Rotation cycles of 30 years are needed for optimal timber production and have been stipulated by the Indonesian forestry administration. For the production of pulp wood, a cutting cycle of 15 years is usually practiced. Weeding operations depend on the species, site and priority.

i. Diseases and pests

Damping-off is the most common nursery. Regular spraying with fungicides, careful monitoring of the moisture level in the nursery beds and potting media, and sterilization of the nursery medium may reduce damping off substantially.

j. Harvesting

Several methods of harvesting the resin are practiced. The resin is found in the intercellular canals in the wood (especially sapwood) and products are often termed. Turpentine and wood resin can be obtained as by-products from the kraft pulping of pines. Turpentine is removed from the chip digester during the initial steaming and condensed from the relief gases.

k. Yield

On suitable site pines can achieve a mean annual increment of up to 28(-40) m³/ha up to the 13th year could be achieved. For an average site quality the mean annual increment of *Pinus merkusii* is 22.4 m³/ha in a 25-year rotation.

Seeds



FAMILY **PODOCARPACEAE**



Tropical trees of Indonesia

61. *Dacrydium elatum* (Roxb.) Wallich ex Hook.

Dacrydium elatum is a member of Podocarpaceae family. The synonyms of *Dacrydium elatum* are: *Dacrydium junghuhnii* Miq. *Dacrydium pierrii* Hickel, *Dacrydium beccarii* Parl. var. *subelatum* Corner. The vernacular names of this species are: 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, and the trade groups of this species are: Sempilor: lightweight to medium-weight softwood, e.g., *Dacrydium beccarii* Parl., *D. elatum* (Roxb.) Wallich ex Hook., *D. nidulum* de Laubenf. Detailed descriptions of *Dacrydium elatum* are as follows:





Tree

a. Origin and geographic distribution

Dacrydium consist of about 25 species and is distributed from mainland South-East Asia through Malesia (but not on Java and the Lesser Pulau Island except for Sumba), toward New Caledonia, Fiji, Tasmania, New Zealand and southern Chile. *Dacrydium* has a long fossil record dating back to 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 moist primitive species are distributed.

b. Use

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. *D. elatum* is probably the main source of sempilor timber in South-East Asia. A volatile oil can be distilled from the wood.

c. Descriptions

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, freshly 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.

d. Observation

A medium-sized to fairly large tree up to 40m tall, bole up to 100cm diameter, crown a large billowy dome with tufts of more or less erect branchlets; adult leaves imbricate, triangular and scale-like, sharply keeled outside, 1-1.5mm x 0.4-0.6mm; apex of microsporophyll triangular; mature seed completely exposed above the short cone bract, 4-4.5mm long. *D. elatum* generally occurs scattered in moist rain forest at 300-1,700m altitude. It is often associated with *Podocarpus* spp. and *Agathis* spp. the density of the wood is 425-720 kg/m³ at 15% moisture content.

e. Growth and development

Root nodules have been observed in *Dacaryum*, but it is unknown whether these fix nitrogen.

f. 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 600-2,500m altitude.

g. Propagation and planting

Dacrydium can be propagated by seed, wildings or cuttings. Fruits are macerated carefully to remove the fleshy receptacles. Seed should be graded by flotation, discarding empty one, and sown in nursery beds immediately after collection. The nursery beds must be shaded, as seedlings do not thrive in full light.

h. Silviculture and management

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.

i. Diseases and pests

The mistletoe *Korthalsella dacrydii* (Ridley) Dans. Has been observed on *Dacrydium*, but is probably insignificant.



Leaves



Branch



Basal trunk



62. *Nageia wallichiana* (Presl) O. Kuntze.

Nageia wallichiana is a member of Podocarpaceae family. The vernacular names of this species are: Brown podocarp (En). Indonesia: bali (Kalimantan), kayu cina (Sumatra, Sulawesi), ki bima (Java). Malaysia: podo kebal musang gunung (Peninsular), mengilan (Sabah), manggilan (Dusun, Serawak). Philippines: malaalmaciga (Tagalog), almaciga nga lalaki (Sibuyan), makapola (Negros). Burma (Myanmar): thitmin. Thailand: phayamai (south-eastern), khunmai (peninsular). The synonym name of this species are: *Podocarpus wallichianus* Presl, *Podocarpus blumei* Endl., *Decussocarpus wallichianus* (Presl) de Laubenf. Detailed descriptions of *Nageia wallichiana* are as follows:





Leaves

Flower buds

Fruits

Bark

a. Origin and geographic distribution

Distribution of *N. wallichiana* are: 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.

b. Uses

N. wallichiana is an important source of podocarp timber; the wood is used house construction, mouldings, interior finish, furniture, veneer, and sometimes for making canoes.

c. Descriptions

A large tree up to 54m tall, bole branchless for up to 30m, up to 100cm in diameter; leaves elliptical to ovate. *N. wallichiana* occur scattered and is often common in primary lowland and montane rain forest.

d. Ecology

Found in small group of 3-5 trees intercalated in closed evergreen forest or at open degraded forests from 500 to 700m altitude.

Tree



63. *Podocarpus neriifolius* D. Don

Podocarpus neriifolius is a member of Podocarpaceae family. The vernacular names of this species are: 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). The synonyms of this species are: *Podocarpus discolor* Blume, *Podocarpus leptostachya* Blume, *Podocarpus neglecta* Blume, *Podocarpus decipiens* N.E. Gray, *Podocarpus polyantha* (Wasscher) Gaussen and the trade groups of this species are: Podocarp: lightweight to medium-weight softwood, e.g., *Podocarpus bracteatus* Blume, *P. neriifolius* D. Don, *P. rumphii* Blume. Detailed descriptions of *Podocarpus neriifolius* are as follows:



a. Origin and geographic distribution

Podocarpus consist of about 95 species which are distributed throughout the tropics (often in the highlands) and in temperate forest 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. *P. neriifolius* is the most widespread species of the genus, occurring from Nepal, India, Indo-China and Thailand, throughout Malesia, toward the Solomon Islands and Fiji; also planted in gardens.

b. Descriptions

Pollen cones axillary or occasionally terminal, solitary or grouped, sessile or on a short naked peduncle, cylindrical, up to 4mm 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 leathery structure exposed above the receptacle. Seed usually more or less green when mature, rarely becoming fleshy or reddish. Seedling with epigeal germination.

c. Observations

A medium-sized to fairly large tree up to 35(-45) m tall, bole columnar, branchless for up to 22m, up to 100cm in diameter, rarely spurred or even buttressed, bark surface grayish-brown; foliage

buds ovate, acute or blunt, often with spreading scale; juvenile leaves acuminate, adult leaves (7-)8-18cm x (1.0-)1.1-1.8cm, midrib above abruptly raised, (0.4-)0.6-0.8mm wide; pollen cones solitary or in two 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 2,100m 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/m³ at 15% moisture content. See also the table on wood properties.

d. Growth and development

Growth of *P. neriifolius* is slow; the mean annual diameter increment in India is reported to be only 3mm. A 35 years old tree of *P. teysmannii* Miq. (a usually small tree from Peninsular Malaysia and

Tree





Leaves

Fruits

Bark

Sumatra) at the arboretum of the Forest Research Institute Malaysia was 17m tall and 25cm 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 ascales surrounding the newly growing shoots.

Nodules are regularly present on the roots but their function is unclear. They contain endotrophic 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.

e. 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 the genus occurring on coastal sands. Some other species also occur down to sea-level, but most are distributed between 750 and 2,500m altitude and may constitute sharakteristic elements

of the vegetation. Several species are found in alpine shrub vegetation up to 3,750m.

f. Propagation and planting

Podocarpus can be propagated by seed. There are about 4,500 dry seeds of *P. polystachyus* in 1kg. *P. neriifolius* seed germinates for 90% in 20-67 days. Seed may not be viable after more than 3 months of storage.

Thee seedlings are transplanted into the field when 30-40cm tall. Usually, planting holes spaced 4m x 5m are prepared one week earlier.

g. Silviculture and management

Natural regeneration of *P. neriifolius* is sparse in heath forestm although it regularly produces seeds.

h. Uses

P. neriifolius is one 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.

i. Diseases and pests

Glomerella blight or brown lesion disease in *P. neriifolius* is caused by *Glomerella cingulata*.

FAMILY **RUBIACEAE**



Tropical trees of Indonesia

64. *Anthocephalus cadamba* (Roxb.) Miq.

Anthocephalus cadamba is a member of Rubiaceae family. The synonyms of this species are *Albizia moluccana* Miq. (1855) and *Albizia falcataria* (L.) Fosberg (1965). The vernacular names of this species are: Brunei: Puah. Indonesia: jeungjing (general), sengan laut (Java). Malaysia: batai, kayu machis. Papua New Guinea; white albazia. Philippines: Moluccan sau, falcate. The local names of this species are: Indonesia: jabon, laran, emajang. Malaysia: kelempayan, laran, selimpoh. Papua New Guinea: labula. Philippines: katoan bangkal. Burma: mau-lettan-she, maukadon, yemau. Cambodia: thkow. Laos: koo-somz, sako. Thailand: krathum bok, takoo. Vietnam: c[aa]y g[as]o, c[af] tom, g[as]o tr[aws]ng. Detailed descriptions of *Anthocephalus cadamba* are as follows:





Seeds

Seedlings

a. Origin and geographic distribution

Nepal, Bangladesh, India, Sri Lanka, Buma, Indo-China, southern China, Thailand, eastward through Malaysia to New Guinea.

b. Uses

The timber is used as kadam. *A. cadamba* is planted as an ornamental and shade tree or for reforestation and afforestation and agro-forestry. Leaves and bark are used in traditional medicine. Inflorescences and fruits are said to be edible.

c. Descriptions

Medium-sized to large deciduous trees up to 45m tall; bole straight and cylindrical, often branchless for more than 25m, up to 100-(160)cm in diameter but generally less sometimes with small buttresses up to 2m high and extending up to 60cm from the trunk; outer bark very light and smooth when young, grey to grey-brown with shallow fissures when old, sometimes with small ridges, often cracked and rather coarsely flaky; Seedling with epigeal germination; cotyledons sessile, herbaceous, acute, green; leaves opposite.

d. Propagation and planting

Propagation is possible by natural regeneration from seed, by nursery-grown seedlings, stumps and stem cuttings. The weight of a million air-dry seed is about 38-56g. The germination of fresh seeds is variable, but generally low (about 25%). When stored cool in airtight boxes for 2.5 months, a much higher germination rate can be obtained (up to 95%). Properly stored seeds can remain viable for about 2 years.

e. Silviculture and management

If enough seed-producing trees are available, clearing the soil at the time of seed ripening can effect natural regeneration from seed. Plantations established from nursery seedlings seldom show the same favorable growth rate as natural regeneration, for reasons still unknown but probably related to local site conditions. The trees provide only light shades. After planting, the soil around the young trees needs to be kept free from competing vegetation, especially from climbers and plants causing shade. Thinning is very easy owing to the beautifully straight stems without defects and the very regular small crowns.



FAMILY **RUTACEAE**



Tropical trees of Indonesia

65. *Zanthoxylum rhetsa* (Roxb.) DC.

Zanthoxylum rhetsa is a member of Rutaceae family. The vernacular names of this species are: Indonesia: kayu lemah (Javanese), kayu tana (Madurese), ki tanah (Sundanese). Malaysia: hantu duri. Philippines: kayutana. Burma: kathit-pyu. Thailand: kamehat ton. The synonyms of this species are: *Fagara rhetsa* Roxb., *Zanthoxylum budrunga* (Roxb.) DC., *Zanthoxylum limonella* (Dennst.) Alston. Detailed descriptions of *Zanthoxylum rhetsa* are as follows:





Leaf (adaxial and abaxial)

Fruits

Bark

a. Origin and geographic distribution

From India and Sri Lanka to Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Java, the Philippines, Sulawesi, the Lesser Sunda Islands and southern Papua New Guinea.

b. Uses

The wood of *Zanthoxylum* is used for house building (planking, rafters, scantlings), furniture and various small articles like jewelry boxes, kris handles and sheaths, axe handles, gun stocks. The fruits of *Z. rhetsa* are used as a spice and yield an essential oil that shows anthelmintic activity.

c. Properties

Zanthoxylum yields a lightweight to medium-weight hardwood with a density of 335-790 kg/m³ at 15% moisture content. Heartwood bright yellow to pale brown sapwood. Texture fine to moderately fine and even. The bark of several species contains alkaloids. The fruit of *Z. rhetsa* yields a volatile oil, about 50% which consists of sabinene.

Tree



d. Botany

Evergreen or deciduous, scandent or erect shrubs or small to medium-sized trees up to 35m tall; bole up to 60cm in diameter. Twigs armed. Leaves alternate, paripinnate or imparipinnate. Leaflets 1-15, opposite to alternate. Seedling with epigeal germination. In Java ripe fruits of *Z. rhetsa* are available in February and March. *Zanthoxylum* belongs to the subfamily *Rutioideae* and includes the genus *Fagara*. It is often misspelled as *Xanthoxylum*.

e. Ecology

The timber-yielding *Zanthoxylum* species are found in primary and secondary forest and thickets. This species grows up to 2,100m altitude. *Z. rhetsa* is generally found in rather dry, often monsoonal forest and thickets, up to 500m altitude.

f. Propagation and planting

The trees can be propagated by the seeds.

g. Silviculture and management

Z. rhetsa can be planted in the open provided it is above 400m altitude. At lower altitudes it will benefit from some shade. It is not resistant to fire.

h. Pests and diseases

The heartwood of *Z. rhetsa* is resistant to dry-wood termites and moderately resistant to fungi. The sapwood is usually non-susceptible to *Lyctus*.

FAMILY **SANTALACEAE**



Tropical trees of Indonesia

66. *Santalum album* Linn.

Santalum album is a small tropical tree of the Santalaceae family, commonly known as the source of sandalwood. This species has been utilised, cultivated and traded for many years, some cultures placing great significance on its fragrant and medicinal qualities. It still commands high prices as essential oil, but has lost the once extensive use as a timber for fine woodworking. For these reasons it has been extensively exploited, the population in the wild is vulnerable to extinction. The plant is widely cultivated and long lived, although harvest is viable after 40 years. Detailed descriptions of *Santalum album* are as follows:





Flower buds

Leaf

Fruits

Bark

The nomenclature for other ‘sandalwoods’ and the taxonomy of the genus are derived from this species historical and widespread use. Many languages contain a word that describes this specific plant. *S. album* is included in the family *Santalaceae*, which is placed in the order *Santalales*, and is commonly known as White or East Indian Sandalwood. It is the type species of the genus *Santalum*, nominated by Linnaeus in the first botanical Descriptions; this was published in *Species Plantarum* in 1753 with the note “Habitat in India”. The species name, *Santalum ovatum*, used by Robert Brown in *Prodromus Florae Novae Hollandiae* was described as a synonym of this species by Alex George in 1984. The epithet *album* refers to the ‘white’ of the heartwood.

The species was the first to be known as Sandalwood, although it is often appended with a descriptions of a region. Other species in its genus bear this common name. Cogenors of *S. album* include *Santalum spicatum*, the Australian Sandalwood, and many of these ‘sandalwoods’ are distinguished by a regional name. The taxonomy of *Santalum album* are as follows:

There are two main species used to produce Sandalwood products, such as soap, incense, medicines, fragrant sticks and oils. These are *Santalum album* and *Santalum spicatum*. Both of

these species have a poor form, growing 3–12m in height and 0.1–0.3m in diameter. Bark, flowers, fruit and pollination of the plants (particularly *S. album*) are all described in details in the literature. The wood is a pale yellow colour and *S. album* often has alternating light and dark concentric zones. The heartwood is characteristically aromatic, persistent and tastes peculiar due to the extractives produced when sapwood is converted to heartwood. Sandalwood has been used by humans (particularly in India) as an oil, scented burning sticks and aromatic carving wood for centuries. Due to the slow growing nature of the sandalwood tree and the high demand for its heartwood properties it is the second most expensive legal wood. This equates to \$2,000/m³. Plantations of sandalwood should, therefore, be a profitable investment if managed properly.

a. Origin and geographic distribution

The species of *Santalum* are found in Indonesia is *Santalum album* (Sandalwood). This economic-important species is certainly native to parts of Indonesia and possibly India. In Indonesia, it is endemic to East Nusa Tenggara, formerly distributed on Timor, Sumba, western of Flores, Alor and Roti Islands. However, only on Timor is there still a significant population of this species.

b. Uses

The fragranced wood are widely used all over the world for the fancy wood. The oil extracted from the lower parts of stem are used for many purpose such as perfume and medicines.

S. album has been the primary source of sandalwood and the derived oil. These often hold an important place within the societies of its naturalised distribution range. The high value of the plant has led to attempts at cultivation, this has increased the distribution range of the plant. The long maturation period and difficulty in cultivation have been restrictive to extensive planting within the range. Harvest of the tree involves several curing and processing stages, also adding to the commercial value.

c. Descriptions

A tree to 15-18m in height, typically with a straight stem and a high bushy crown when grown in dense shade. It is evergreen, with slender drooping branchlets. Bark reddish-brown to dark brown, smooth in young trees, rough and fissured in older trees.

Sandalwood has the bowl-like type of flowers, with four outer petals and four inner petals that arranged alternately. Flowers are hermaphrodite with a papillate stigma and four anthers bearing

less-sticky pollen. There were 107 days needed to complete the flowering phase to fruit maturation and seed set. Floral buds occurred in the late of rainy season on January-February, while the mature fruit bearing single seed were set in the beginning of dry season on April-May. Flowers were visited by insect representing 3 orders (Diptera, Hymenoptera, and Lepidoptera); mostly conducted the diurnal foraging activity. Bees, flies and diurnal butterflies were the most common floral visitors.

d. Ecology

S. album are found in arid coastal deciduous forests at sea level and dunes or cliff tops up to 700m. Sandy or stony red soils are usual, but a wide range of soil types are inhabited. This habitat has a temperature range above freezing to 38°C, annual rainfall between 500 and 3,000mm are also typical.

Basal trunk





Seedling

e. Propagation and planting

Seed propagated is usually raised in large containers. Although it can grow photo-autotrophically for several months, vigour and growth decline without attachment to a host. Two to three months following *S. album* germination, cuttings of a herbaceous pot host are planted into each *S. album* seedling container.

S. album can be propagated by dibbing seeds, transplanting nursery raised seedlings and vegetative propagation by cuttings.

Many of the 29 genera in the Santalaceae family, including both *S. album* and *S. spicatum*, are partially or completely parasitic. This means, that for a plant to grow, it must have another plant to feed off to gain its food energy. The host plant may be from a wide range of species that can tolerate similar environmental conditions to *Santalum*. An extensive list of host species and related biomass growth, sandal height and number of root connections between plants (haustorial connections) has been compiled by Ananthapadmanabha et al.

Past negative ideologies have led to avoidance of the use of parasitic plants in a forest production system. These include the idea that there is a negative growth effect of parasites, due to competition on the host species. This may be true for some genera but there has recently been studies on the effect of *Santalum* species on hosts plants which showed there was an increase in host growth. Part of this has been attributed to high gibberelic acid concentrations in the sandalwood leaves which are a good nutrient source when broken down in soils.



FAMILY **SAPINDACEAE**



Tropical trees of Indonesia

67. *Nephelium juglandifolium* Blume

Nephelium juglandifolium is a member of Sapindaceae family. The vernacular names of this species are: rambutan (En, trade name). Brunei: buah hitam, buah sati inchi. Malaysia: meritam (sabah), sibu (Serawak). Thailand: ngoh. Indonesia: lungsir, lengsar (java), sorogol (Sundanese). The synonym names of this species are: *Nephelium altissimum* Teijsm. & Binnend. and *Nephelium tuberculatum* Radlk. Detailed descriptions of *Nephelium juglandifolium* are as follows:





Leaf (adaxial and abaxial)

a. Origin and geographic distribution

Nephelium comprises 22 species which occur from India (Assam), peninsular Burma (Myanmar), Indo-China, southern China, Hainan and Thailand to Peninsular Malaysia (10 species), Sumatra (8 species), western java (3 species), Borneo (8 species), Sulawesi (1 species), and the Philippines (4 species). The distribution of *Nephelium juglandifolium* are: Peninsular Malaysia, Sumatra and West Java.

b. Uses

The wood of *Nephelium* is used for general construction (e.g., planking, beams) and furniture. It has also been applied for tool handles because of its toughness and as firewood. The sarcotesta of the fruits of many species-including the well known, cultivated rambutan (*Nephelium lappaceum*) is edible, but the sarcotesta of some species is too small or too acid to be edible.

c. Properties

Nephelium yields a medium-weight to heavy hardwood with a density of 615-1,110 kg/m³ at 15% moisture content. Heartwood brown or pale purple-red or pale grayish-brown. The wood is easy to work and can be finished well. It is durable under cover and generally resistant to insect attacks, but susceptible to fungal attack.

d. Descriptions

Evergreen, small to fairly large trees up to 35(-44)m tall, up to 90(-140)cm in diameter, bark surface smooth to slightly flaking or sometimes dippled. Seedlings with hypogeal germination. Ectomycorrhizae have been observed in *Nephelium*. Growth is in distinct flushes. Tree architecture is according to Scaronne's model. Identification without fruits is almost impossible.





Branch

Bark

e. Ecology

Timber-yielding species of *Nephelium* are generally found as middle storey trees in evergreen, lowland or sometimes montane, primary or sometimes secondary rain forest on hill and ridges, up to 600(-1,950)m altitude. The habitat varies between species, but most are found in well-drained locations on sandy to loamy or clayey river banks and in swamps.

f. Propagation and planting

Nephelium is usually propagated by seed, but in commercial fruit production of *N. lappaceum* vegetative propagation (budding) is used. The seed of *Nephelium* should be sown immediately after collection. When stored, the seed should be kept in polyethylene bags at 20°C in sawdust moistened with juice from the fruit, as the juice inhibits germination. In this way seed can be stored up to 4 weeks. In general germination was good and rapid, being 85-100% in (7-)13-52(-58) days after sowing, and no important differences were found between seed sown with or without adhering pulp.

g. Silviculture and management

It may be necessary to inoculate the planting stock with ectomycorrhizae before planting out. In a 50ha plot in natural forest at Pasoh (Peninsular Malaysia), a total of 280 *Nephelium* trees with a diameter over 10cm were present.

Tree



FAMILY **SAPOTACEAE**



Tropical trees of Indonesia

68. *Madhuca macrophylla* (Hassk.) H.J.Lam

Madhuca macrophylla is a member of Sapotaceae family. The vernacular names of this species are: Indonesia: pasra, karet munding (Sundanese, Java). The synonym of *Madhuca macrophylla* is *Payena macrophylla* (Hassk.) Burck. Detailed descriptions of *Madhuca macrophylla* are as follows:





Leaf (adaxial and abaxial)

Bark

a. Distribution

Western Java.

b. Observation

A medium-sized tree up to 25(-35)m tall; leaves clustered at tips of twigs, broadly spatulate to spatulate or obovate, 15-55cm x 6-22cm, secondary veins diminishing until inconspicuous near margin, glabrous or sparsely hairy beneath, stipules up to 3.5mm long, caducous; flowers with sepals pubescent outside and along margins and at tip inside, 8-13 lobed corolla woolly on both side, 22-28 stamens and hairy ovary; fruits often two together, pendulous, ellipsoid, 2.5-4cm x 1.5-3cm, 1-2 seeded; seed with thin, shining brown testa, albumen absent and cotyledons thick. *Madhuca macrophylla* grows in mixed forest below 600m; it is an uncommon species. The timber is reported to be fairly durable.

c. Growth and development

Large seedlings and samplings may have leaves that are larger, narrower, and more pointed than those of mature trees.

d. Ecology

Madhuca is found in primary forest. Several species occur in permanent or seasonal freshwater forest or peat-swamp forest (e.g., *M. motleyana*). Usually *Madhuca* species are restricted to lowland rain forest and occur up to 1,000m altitude.

e. Propagation

Seeds of *M. utilis* take 3-16 weeks to germinate.

f. Silviculture and management

Very little or no special attention is given to this species in silvicultural practises. Regeneration in logged-over forest is usually plentiful, similar to that in other Sapotaceae genera. In the forest the trees are managed and harvested in the same way as meranti, as they often grow together with Shorea trees and the timber is similar. Planting is not practised.

g. Uses

The timber may be used in house building.

69. *Manilkara kauki* (L.) Dubard

Manilkara kauki is a member of Sapotaceae family. The vernacular names of this species are: Indonesia: sawo kecil (Java, Bali), kayu sawo (Java), sabo (Bali). Malaysia: sawah, sawai, sawau (Peninsular). Papua New Guinea: sner. Thailand: lamut-thai, lamut-sida (central). Vietnam: vi[ees]t. The synonym name of *Manilkara kauki* is *Mimusops kauki* L. Detailed descriptions of *Manilkara kauki* are as follows:





Tree

a. Trade groups

Manilkara: heavy hardwood, e.g., *Manilkara fasciculata* (Warb.) H.J.Lam & Maas Geest., *M. kanosiensis* H.H.J. Lam & B.J.D. Meeuse, *M. kauki* (L.) Dubard.

b. Distribution

Burma, Indo-China, Thailand, Peninsular, Malaysia, throughout Indonesia (except Kalimantan), Papua New Guinea and northern-eastern Australia.

c. Observations

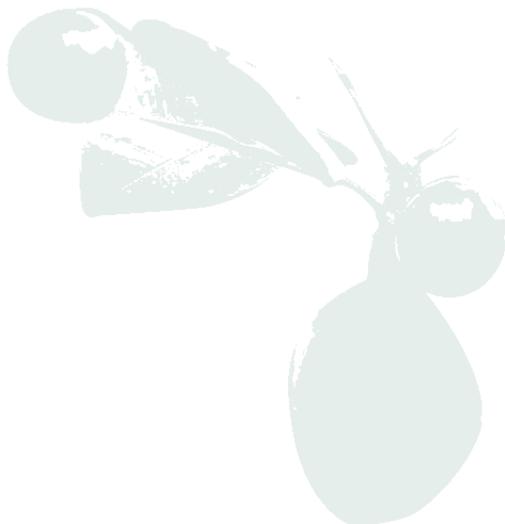
A medium-sized tree, up to 25m tall, often with gnarled and low-branched bole, sometimes columnar, up to 100cm in diameter; leaves clustered at apex of twigs, silky white velvety beneath; flower bud ovoid, pedicle not incrassate, curved and long, calyx up to 7mm long, ovary with distinct globose disk; fruit ovoid or obovoid, up to 3.7cm long. *Manilkara kauki* usually grows in coastal regions with a comparatively dry climate, generally below 500m altitude.

d. Growth and development

Flowering and fruiting of *Manilkara kauki* is reported to occur throughout the year in Indonesia, differing per region. In Bali, ripe fruits are found from April to July. The trees are considered slow growers. Trees of *Manilkara kauki* reach a trunk diameter of 2-6cm after 8 years. The architecture of the tree is according to Aubreville's model.

e. Ecology

Manilkara trees occur in lowland, sometimes in hills up to 500m altitude. They are often or more confined to coastal areas, and are particularly found in the drier regions South-East Asia. *Manilkara kauki* grows especially on regosols; it prefers sandy loam soils, often at banks of small seasonal streams and on coral beaches, and is commonly associated with *Drypetes* spp., *Eugenia* spp., *Schoutenia ovata* Korth., *Pterospermum diversifolium* Blume, *Pongamia pinnata* (L.) Pierre and *Diospyros maritima* Blume.



f. Propagation and planting

Seed should be sown in the shade. Germination starts 2.5-5 weeks after sowing. Experiment with *Manilkara kauki* showed that the position of the seed in the soil is important for successful germination. Germination occurs most rapidly when the longitudinal axis of the seed is in a horizontal position. A germination percentage of 80% may be reached, although germination of *M. hexandra* seeds in nurseries in India is reported to be much lower. When seeds are soaked in a ethepon or chlormequant chloride solution for 24 hours, 55-66% of the seeds germinate. Seedling of *Manilkara kauki* are transplanted into the field when they are about 45cm tall. Experiments with seedlings showed that growth is promoted by applying 50 mg per kg potting medium of N.P.K. fertilizer.

g. Silviculture and management

Seedlings of *Manilkara kauki* are planted into the field at spacing of 2m x 1m. plantations tend to become very dense after about 8 years, and thinning is then necessary.

h. Uses

The timber is used for construction and particularly for furniture and carving; it is also used for turnery and mills. The fruits are edible. This species is used as rootstock for sapodilla (*Manilkara zapota*). Flowers and seeds are used medicinally. The trees are planted as fruit trees and ornamentals, often near palaces and temples.

Leaf



Leaves



Fruits



Trunk



70. *Mimusops elengi* L.

Mimusops elengi is a member of Sapotaceae family. The vernacular names of this species are: Asian bulletwood (En), Bukal, tanjung (En, Fr.). Indonesia: tanjung (general, trade name), karikis (North Sulawesi), tanjung laut (Moluccas). Malaysia: bitis (general, trade name), mengkula (Peninsular). Philippines: betis (general, trade name). Thailand: kun (Peninsular). Burma (Myanmar): kaya. The synonym of *Mimusops elengi* is *Mimusops parvifolia* R.Br. Detailed descriptions of *Mimusops elengi* are as follows:



a. Origin and geographic distribution

Mimusops comprises about 40 species, 20 of which occur in Africa, some 15 in Madagascar, 5 in the Mascarenes and Seychelles, and 1 (*M. elengi*) in Asia and the Pacific. *Mimusops elengi* is probably native India, Sri Lanka, Burma, Indo-China, Thailand, and the Andaman Islands, but is commonly planted through-out Malesia towards the Solomon Islands, New Caledonia, Vanuatu and northern Australia, and many other tropical countries.

b. Uses

The heavy, strong, and durable wood of *M. elengi* is suitable for heavy general construction, bridge building, boat and ship building, marine construction, flooring, bearings, doors, and framing. It has also been used for poles and piles, foundation sills, railways sleepers, paving blocks, mine timber, tool handles, wheelwrighting, walking sticks, waving shuttles, bobbins, toys, sporting goods, musical instruments. A good quality veneer and plywood can be manufactured from the wood. The leaves are used medicinally for headache and sore eyes, and are smoked to cure infections of the nose and mouth.

c. Properties

M. elengi yields a heavy hardwood with density of 780-1,120 kg/m³ at 15% moisture content. Heartwood deep red or dark red-brown, often with darker streaks, distinct, but not sharply demarcated from the paler 5-7cm wide sapwood. Texture very fine to fine and even.

d. Descriptions

Evergreen, monoecious, small to medium-sized tree up to 30(-40)m tall, bole often short and divided into several large main branches but sometimes brunchless for up to 15(-20)m, up to 100cm in diameter. Leaves alternate or distantly spiral. Flowers bisexual or functionally male or functionally female. Seedlings and trees are considered to grow slowly.

Tree





Leaves

e. Ecology

M. elengi is fairly common near the sea, but may also be found in rocky locations and inland forest, up to 600m altitude. It thrives in areas with perhumid or slightly seasonal rainfall types, is usually found in seasonally dry habitats but can stand waterlogging for up to 2 months. It requires a fertile soil.

f. Propagation and planting

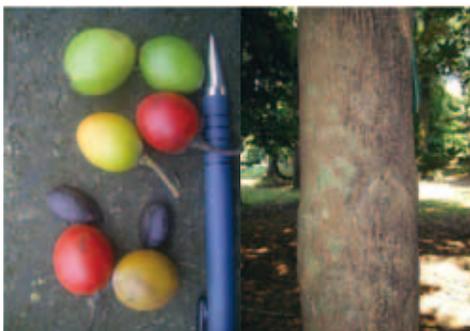
M. elengi can be propagated by seed or cuttings. Seed can be stored for about 9 months and needs 'after-ripening' during the first month of storage. There are about 2,000 dry seeds/kg. Seeds have 70-90% germination in 17-82 days. It is best sown directly in containers. The seeds is known dispersed by bats, but monkeys, squirrels and wild pig probably also eat the fruits.

g. Silviculture and management

The seedlings can be planted out when 20-30cm tall. The rooting success of cuttings 10-15cm long and with a diameter of 0.5-1cm is 70-90%. It is a shade-tolerant species which retains a full crown and reproduces satisfactorily under fairly dense shade.

Fruits

Trunk



71. *Palaquium amboinense* Burck

Palaquium amboinense is a member of Sapotaceae family. The vernacular names of this species are: Indonesia: kawang (Java), siki ayer, siki batu (Ambon). The synonyms of *Palaquium amboinense* are *Palaquium javanense* Burck, *Isonandra amboinensis* (Burck) Baehni. Detailed descriptions of *Palaquium amboinense* are as follows:





Basal trunk

a. Trade groups

Nyato: lightweight to medium-heavy hardwood, e.g., *Palaquium amboinense* Burck, *P. burckii* H.J. Lam, *P. hexandrum* (Griffith) Baillon, *P. luzoniense* (Fernandez-Villar) S. Vidal, *P. maingayi* (C.B. Clarke) King & Gamble, *P. microphyllum* King & Gamble, *P. obovatum* (Griffith) Engl., *P. obtusifolium* Burck, *P. xanthochymum* (de Vriese) Pierre ex Burck. Bitis: heavy hardwood, e.g., *P. ridleyi* King & Gamble, *P. stellatum* King & Gamble.

b. Distributions

Java, the Lesser Sunda Islands, Sulawesi, the Moluccas and New Guinea (including New Britain and Bougainville).

c. Observation

A medium-sized to large tree, sometimes up to 50m tall, with straight bole up to 120cm in diameter; leaves more or less clustered at tips of twigs, elliptical or narrowly obovate to obovate; with tertiary veins transverse to almost parallel to secondary veins, glabrous on both sides; flowers in 1-6 flowered clusters, borne on 4-15(-20)mm long pedicels, yellowish-white; fruit narrowly ovoid to ovoid, 2.5-5cm long, glabrous. *Palaquium amboinense* occurs in lowland forest, in East Java up to 750m altitude, in Timor up to 900m. The timber is fairly light with a density of 450-510 kg/m³ at 15% moisture content, is not durable and splits; it is difficult to saw.

d. Growth and development

The few data available show a slow rate of growth. In Peninsular Malaysia the mean annual girth increment for *P. maingayi* and *P. rostratum* is only 1.5cm and 1.8cm, respectively; these trees take 100 and 70 years respectively, to attain a diameter of 55cm. However, a *P. rostratum* tree in arboretum attained a diameter of 57cm in 40 years. *P. gutta* has a mean annual girth increment of 3.8cm and attains about 8m height in 7 years, 17m in 23 years and a diameter of about 50cm in 50 years.

There is usually good natural regeneration, but seedlings are often choked out or retarded in growth by other trees and brush. Fruit is borne abundantly some years, but little of it survives. In many cases flowers do not reach maturity because of attack by insects or because of unfavourable weather conditions. Flowers may remain closed for a long time (up to 18 months), probably waiting for favourable weather conditions for opening. There seems to be no definite and regular periodicity of flowering and fruiting seasons. There are however, certain years, when there is a rather general and heavy seed crop. The ripe fruit is greedily eaten by fruit bats; but not the seeds. There are often large numbers of ripe seeds on the ground underneath bat roosts. Fallen fruits are quickly consumed by squirrels, birds, insects and other animals. Only a small proportion of the seeds have a chance to germinate.

e. Ecology

Most *Palaquium* species grow in lowland forest. Only occasionally are species found at higher elevations, e.g., *P. regina-montium* in Peninsular Malaysia and *P. rionse* in Borneo. Usually, the trees occur scattered in the forest; rarely *Palaquium* species form almost pure stands, e.g., *P. xanthochymum* locally in Peninsular Malaysia. Many species are common in freshwater swamp forest, some grow commonly in peat swamps, e.g., *P. ridleyi* and *P. maingayi*.

f. Propagation and planting

Carefully selected seeds will show a germination rate of 75-85% or more. *Palaquium* can also be grown from cuttings and marcots, but the percentage of success is not high. It is also possible to propagate the tree by layering and by cleavage, but these methods are less successful than the planting of seedlings. Nursery seedlings can be planted in the fields when about 20cm tall. In argoforestry systems, spacing may be 3m x 2m.

g. Silviculture and management

Natural regeneration of *Palaquium* trees is often plentiful in secondary or logged-over forests. The enrichment planting system ensures sufficient regeneration in natural forest, but the samplings are often poorly competitive. *Palaquium* trees need a considerable amount of light for optimal development. Trees freed by cutting away the overshadowing vegetation show much increased vigour. Forest with a fair amount of natural regeneration of *Palaquium* can be gradually changed over to an almost pure forest by gradually removing other species.

h. Uses

The timber is used as nyatoh for house construction, boards and simple furniture, but in Central Java also for gamelan musical instruments and fine furniture. A fat can be obtained from the seeds, which is used for cooking or as illuminant.

i. Diseases and pests

Palaquium trees are susceptible to the fungus jamur upas (*Corticium salmonicolor*).

Leaves



Flower buds



Seeds



Trunk



72. *Palaquium sumatranum* Burck

Palaquium sumatranum is a member of Sapotaceae family. The vernacular names of this species are: Indonesia: balam sudu-sudu, balam pipit (Sumatra), nyato gunung (Kalimantan). Thailand: phikun pa (Trang). Trade groups of this species are: Nyatoh: lightweight to medium-heavy hardwood, e.g., *Palaquium amboinense* Burck, *P. burckii* H.J. Lam, *P. hexandrum* (Griffith) Baillon, *P. luzoniense* (Fernandez-Villar) S. Vidal, *P. maingayi* (C.B. Clarke) King & Gamble, *P. microphyllum* King & Gamble, *P. obovatum* (Griffith) Engl., *P. obtusifolium* Burck, *P. xanthochymum* (de Vriese) Pierre ex Burck. Bitis: heavy hardwood, e.g., *P. ridleyi* King & Gamble, *P. stellatum* King & Gamble. Detailed descriptions of *Palaquium sumatranum* are as follows:



a. Distributions

Southern Thailand, Sumatra, the Riau Archipelago, Belitung, and Borneo (Kalimantan, Sabah).

b. Observation

A large tree up to 45m tall, with columnar bole up to 80cm in diameter, leaves evenly distributed, narrowly elliptical or elliptical to obovate, with distinct, reticulate tertiary veins often parallel to secondary veins, glabrous on both sides; flowers in 2-5 flowered clusters, borne on 5-10mm long pedicels (up to 22mm in fruit), greenish or brownish-white; fruit ovoid, obovoid or ellipsoid, 2-5cm long, glabrous. *P. sumatranum* grows in primary forest in the lowland, sometimes up to 1,200m altitude.

Tree



c. Growth and development

The few data available show a slow rate of growth. In Peninsular Malaysia the mean annual girth increment for *P. maingayi* and *P. rostratum* is only 1.5cm and 1.8cm, respectively; these trees take 100 and 70 years respectively, to attain a diameter of 55cm. However, a *P. rostratum* tree in arboretum attained a diameter of 57cm in 40 years. *P. gutta* has a mean annual girth increment of 3.8cm and attains about 8m height in 7 years, 17m in 23 years and a diameter of about 50cm in 50 years.

There is usually good natural regeneration, but seedlings are often choked out or retarded in growth by other trees and brush. Fruit is borne abundantly some years, but little of it survives. In many cases flowers do not reach maturity because of attack by insects or because of unfavourable weather conditions. Flowers may remain closed for a long time (up to 18 months), probably waiting for favourable weather conditions for opening. There seems to be no definite and regular periodicity of flowering and fruiting seasons. There are however, certain years, when there is a rather general and heavy seed crop. The ripe fruit is greedily eaten by fruit bats; but not the seeds. There are often large numbers of ripe seeds on the ground underneath bat roosts. Fallen fruits are quickly consumed by squirrels, birds, insects and other animals. Only a small proportion of the seeds have a chance to germinate.



Leaves

d. Ecology

Most *Palaquium* species grow in lowland forest. Only occasionally are species found at higher elevations, e.g., *P. regina-montium* in Peninsular Malaysia and *P. rionse* in Borneo. Usually, the trees occur scattered in the forest; rarely *Palaquium* species form almost pure stands, e.g., *P. xanthochymum* locally in Peninsular Malaysia. Many species are common in freshwater swamp forest, some grow commonly in peat swamps, e.g., *P. ridleyi* and *P. maingayi*.

e. Propagation and planting

Carefully selected seeds will show a germination rate of 75-85% or more. *Palaquium* can also be grown from cuttings and marcots, but the percentage of success is not high. It is also possible to propagate the tree by layering and by cleavage, but these methods are less successful than the planting of seedlings. Nursery seedlings can be planted in the fields when about 20cm tall. In argoforestry systems, spacing may be 3m x 2m.

f. Silviculture and management

Natural regeneration of *Palaquium* trees is often plentiful in secondary or logged-over forests. The enrichment planting system ensures sufficient regeneration in natural forest, but the samplings are often poorly competitive. *Palaquium* trees need a considerable amount of light for optimal development. Trees freed by cutting away the overshadowing vegetation show much increased vigour. Forest with a fair amount of natural regeneration of *Palaquium* can be gradually changed over to an almost pure forest by gradually removing other species.

Trunk



g. Uses

The timber is used as nyatoh. Nyatoh wood is in general suitable for house construction, but not when in contact with the ground. Some *Palaquium* species may even be used for columns, beams and rafters. Sometimes the trees are used for making canoes. The most important uses of nyatoh are for the manufacture of fine furniture, decorative doors and veneers, and panelling. The wood is also suitable for flooring boards, partitions, household appliances and sometimes for musical instruments, whereas the buttress wood is commonly used for making oars, cartwheels, and handles of hoes and axes.

Bitis, being generally more heavy and more durable than nyatoh, is generally used for heavy construction, heavy-duty flooring, posts, door and window frames, and paving blocks.

Gutta-percha, i.e. latex from *Palaquium* trees, especially *P. gutta*, has been praised for its insulating property and imperviousness to water.

As such, it has been in demand for the insulation of subterranean and submarine electrical cables. It has also been used in the manufacture of golf balls, certain types of surgical appliances, transmission bells, and acid-resistant receptacles. Other uses have included splints for fractures, supports, pipes, speaking tubes, in telephone receivers, as adhesives and an ingredient of chewing gum. At present its main application is for protecting wounds and in dental clinics, where it is proving to be useful for people allergic to synthetic fillers.

The fruits of several species (e.g., *P. burckii*, *P. ericaly* H.J. Lam, *P. hexandrum*, *P. lanceolatum*, *P. macrocarpum*, *P. philippenes*, *P. rostratum*, *P. stellatum* and *P. walsurifolium*) are edible. The seeds often contain a fat which is used for cooking or as an illuminant, and is sometimes used for the manufacture of soap and vegetable butter.

h. Diseases and pests

Palaquium trees are susceptible to the fungus jamur upas (*Corticium salmonicolor*).



73. *Payena leerii* (Teijsm. & Binnend.) Kurz

Payena leerii is a member of Sapotaceae family. The vernacular names of this species are: Indonesia: balam beringin, balam suntei (Sumatra), kolan (Kalimantan). Malaysia: getah sundek, balam sundek (Peninsular). Philippines: edkoyan (Tagbanua). The synonyms of *Payena leerii* are *Payena croixiana* Pierre, *Madhuca leerii* (Teijsm. & Binnend.) Merr. Trade groups of this species are: Nyatoh: lightweight to medium-heavy hardwood, e.g., *Payena acuminata* (Blume) Pierre, *P. lanceolata* Ridley, *P. lucida* (WALLICH EX g. Don) A.DC., *P. maingayi* C.B. Clarke, *P. obscura* Burck (partly). Bitis: heavy hardwood, e.g., *P. leerii* (Teijsm. & Binnend.) Kurz, *P. obscura* Burck (partly). Detailed descriptions of *Payena leerii* are as follows:



a. Distributions

Peninsular Malaysia, Sumatra, the Riau Archipelago, Bangka, Borneo and the southern Philippines (Palawan, Mindanao, Sulu Archipelago); cultivated in Java and South America.

b. Observation

A medium-sized to fairly large tree up to 40m tall, with columnar bole up to 80cm in diameter, buttressed; leaves broadly ovate to oblong-lanceolate, glabrous on both side; flowers very small, up to 0.5cm long, white or yellowish-white; fruit cone-shaped or narrowly so, with a flat broad base, 2.5-5cm long, glabrous or subglabrous. *Payena leerii* is closely related to *P. obscura* and is most commonly found in primary forest, up to 1,000m altitude. The timber is usually heavy with a density of 760-1,060 kg/m³ at 15% moisture content. The gutta-percha is of good quality, but the yield is generally low.

Leaves



c. Growth and development

Water shoots often have unusually large leaves. There seems to be no definite time for flowering and fruiting trees can be found throughout the year, and sometimes a single tree bears flowers and fruits at the same time. In plantation of *P. leerii* on Java, with initial planting distances of 2m x 2m, the canopy closed after 10-12 years. The trees then reached 6-13m in height.

d. Ecology

Payena trees are commonly found in primary mixed dipterocarp forest, but occasionally also in secondary forest at forest edge, e.g., along rivers. They occur from the lowland up to 1,500-(2,000)m altitude, on a variety of soils, from peat swamps to podzols, and from clayey to sandy soils, rarely on limestone. *Payena* trees generally belong to the middle or uppermost storey of the forest, but are not emergents. Locally, *Payena* species are not uncommon, although they usually occur scattered, e.g., *P. acuminata* in Java and Borneo, *P. lucida* in many areas, and *P. obscura* in Peninsular Malaysia. For plantations of *P. leerii*, high-rainfall areas at medium altitudes and loamy soils are preferable.



Flowers

Leaf

Fruits

Bark

e. Propagation and planting

P. leerii is usually propagated by seed in nursery. Fresh seed should be used, as viability declines rapidly. Seeds of *P. lucida* are 2-3cm long and germinate in 2-5 weeks. When sown within a week of harvesting, up to 80% of the seed may germinate. Saplings are planted at a spacing 2m x 2m in the fields. Mature trees usually provide fruits abundantly. Some species (*P. acuminata*, *P. maingayi*) occasionally produce fruits with more than one seed, but these seeds are reported to be less viable.

f. Silviculture and management

In young plantations of *P. leerii* for gutta-percha production, *Paraserianthes falcataria* (L.) Nielsen is often used to provide shade. In the first 7-8 years after planting, weeding is necessary about 4 times per year, later only once a year. When the canopy has closed 10-12 years after planting, weeds are shaded out completely, and the ground is covered with fallen leaves. For timber production, pure stands of *Payena* are probably not a good management target. It is better to plant dipterocarp species with more valuable timber. Natural regeneration is usually plentiful in logged-over forest.





g. Uses

The timber is used as bitis, sometimes as nyatoh. Nyatoh is a general-purpose timber with properties similar to those of mixed consignments of red meranti. It is much used for the manufacture of fine furniture, decorative doors and panelling. The wood is suitable for moulding, skirting, cabinet making, joinery, interior finishing and flooring. It makes good-quality veneer which is used in the production of plywood. The nyatoh-producing species with lighter wood which usually belong to *Palaquium* and *Madhuca* are preferred, as they are less difficult to work. The timber is generally reported as moderately durable; it is perishable when exposed to the weather or in contact with the ground and is not very well suited for outdoor purposes.

Bitis is much more durable and is used for heavy constructional work, paving blocks, agricultural implements and turnery and also for heavy-duty flooring, posts, and door and window frames. Although *Madhuca utilis* (Ridley) H.J. Lam ex K. Heyne, *Palaquium stellatum* King & Gamble are the main bitis-producing species, *Payena leerii* may also supply this type of timber.

The latex of several *Payena* species (especially *P. leerii*, *P. obscura*), called gutta-percha, has been used to insulate submarine cables, in dentistry, in orthopaedics for fracture splints, for the manufacture of surgical instruments and for covering golf balls, and also to haft knives and to make blowpipe mouthpieces, and as a substitute for chewing gum. At the present, its main application is in dental clinics where it is used as filler for people who are allergic to synthetic fillers. However, the most important gutta-percha producing species is *Palaquium gutta* (Hook. f) Baillon. The fruits of *Payena leerii* are edible.

h. Diseases and pests

Nyatoh trees are reported susceptible to the fungus *Corticium salmonicolor*. In Peninsular Malaysia, a large species of longhorn beetle has been reported to attack living nyatoh trees. The larvae bore long tunnels, especially at the base of the trunk, and may severely damage the timber.

74. *Pouteria campechiana*

Pouteria campechiana is a member of Sapotaceae family. Detailed descriptions of *Pouteria campechiana* are as follows:





Flower buds

Leaves

Fruit

Trunk

a. Properties and descriptions

Shrubs to large tree, with latex, up to 50m tall. Inflorescence small, axillary or sometimes on a short leafless shoot, 1-many-flowers. Flowers usually bisexual, sometimes unisexual. Fruit a berry with persistent sepals and style and fleshy pericarp, 1-6 seeded. Seed with a thin to rather thick glossy testa and narrow to broad, linear to broadly oblong hilum; endosperm absent to abundant, cotyledons thick and thin. Seedling with epigeal germination, with strongly developed toproot; first pair of leaves opposite or subopposite; subsequent leaves spiral and soon similar to leaves of adult trees.

b. Growth and development

The trees flowers fairly frequently in comparison with dipterocarpaceae, and there is tendency for many individuals in certain area to flowers simultaneously. Fruit may ripen in about 7 months after flowering. They are eaten by such as monkeys, squirrels and bats, which scatter the seeds. Probably some birds eat the fruits as well.

c. Propagation and planting

The seeds are fairly large to large (about 1-4cm long) and may germinate rapidly (4-6 weeks after shedding).

d. Silviculture and management

Natural regeneration is often scarce in logged-over forest and trees are very slow to colonize secondary forest.

e. Diseases and pests

Living nyatoh trees are reportedly attacked by longhorn beetles in Peninsular Malaysia, the larvae damaging the timber at the base of the trunk by boring long tunnels, and by fungi in Indonesia.

Fruit and seeds



75. *Pouteria duclitan* (Blanco) Baehni

Pouteria duclitan is a member of Sapotaceae family. The vernacular names of this species are: Indonesia: karet anjing (Sundanese, Java), nyato (Javanese, Java), sambiring (Sulawesi), Philippines: duklitan, malayhot (Tagalog), bungalong (Iloko). Detailed descriptions of *Pouteria duclitan* are as follows:





Basal trunk

a. Origin and geographic distribution

Sumatera, Borneo, the Philippines, Java, The Lesser Sunda Islands, Sulawesi, the Moluccas and Irian Jaya.

b. Uses

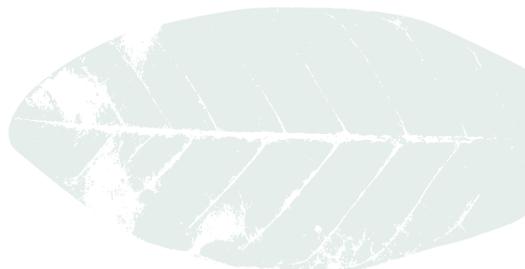
The timber is used as nyatoh for carving, inlaying, musical instrument, cabinet work, pictures frame, matches and fan ribs. The wood is not durable and rarely used in house-building.

c. Observation

A medium-sized to large tree up to 50m tall, with a straight bole up to 150cm in diameter. *P. duclitan* is locally fairly common at low and medium altitudes, at Java up to 1,200m. In Java it is found in periodically inundated localities and on limestone in teak forest, mixed and secondary forest. The wood is moderately heavy and hard.

d. Properties and descriptions

Shrubs to large tree, with latex, up to 50m tall. Inflorescence small, axillary or sometimes on a short leafless shoot, 1-many-flowers. Flowers usually bisexual, sometimes unisexual. Fruit a berry with persistent sepals and style and fleshy pericarp, 1-6 seeded. Seed with a thin to rather thick glossy testa and narrow to broad, linear to broadly oblong hilum; endosperm absent to abundant, cotyledons thick and thin. Seedling with epigeal germination, with strongly developed taproot; first pair of leaves opposite or subopposite; subsequent leaves spiral and soon similar to leaves of adult trees.





Leaf

Branch

Fruits

Trunk

e. Growth and development

The trees flowers fairly frequently in comparison with dipterocarpaceae, and there is tendency for many individuals in certain area to flowers simultaneously. Fruit may ripen in about 7 months after flowering. They are eaten by such as monkeys, squirrels and bats, which scatter the seeds. Probably some birds eat the fruits as well.

f. Propagation and planting

The seeds are fairly large to large (about 1-4cm long) and may germinate rapidly (4-6 weeks after shedding).

g. Silviculture and management

Natural regeneration is often scarce in logged-over forest and trees are very slow to colonize secondary forest.

h. Diseases and pests

Living nyatoh trees are reportedly attacked by longhorn beetles in Peninsular Malaysia, the larvae damaging the timber at the base of the trunk by boring long tunnels, and by fungi in Indonesia.



FAMILY **SONNERATIACEAE**



Tropical trees of Indonesia

76. *Duabanga moluccana* Blume

Duabanga moluccana is a member of the Sonneratiaceae family. The local names of this species are: Indonesia: benuang laki, gayawas hutan, kalanggo. Malaysia: magas, tagahas. Papua New Guinea: duabanga. Philippines: loktob, arek, bukag. Detailed descriptions of *Duabanga moluccana* are as follows:



a. Origin and geographic distribution

Borneo, the Philippines, eastern Java, the Lesser Sunda Islands, Sulawesi, the Moluccas and New Guinea.

b. Uses

The timber is used especially for temporary construction, furniture, boats and veneer. The decoction of the bark has been used in Indonesia for dyeing matting black.

c. Properties

Duabanga is a light weight and comparatively soft wood. The heartwood is white or pale yellow to reddish brown or grayish-brown. The density of this wood is 270-560 kg/m³ at 15% moisture content.

d. Descriptions

A medium-sized to fairly large tree up to 35m tall, but sometimes reaching 45m, with columnar bole up to 100cm in diameter, not buttressed but slightly fluted at base, young parts brownish hairy; leaves ovate, oblong or sometimes lanceolate.

Leaves



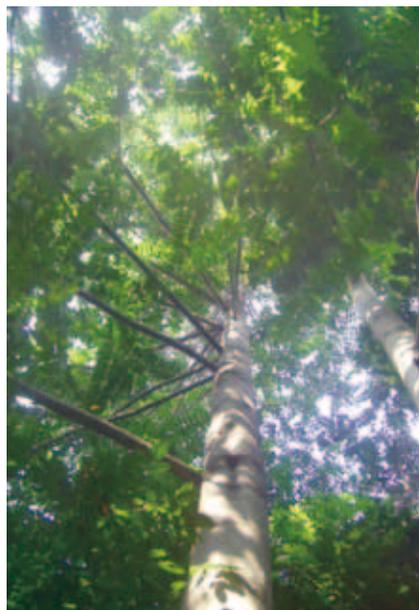
e. Ecology

Duabanga is characterized as a pioneer or early successional species. It is found up to 1,200m 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. In Papua New Guinea, *D. moluccana* usually grow on the edges of freshwater swamp and floodplains.

f. Growth and development

Duabanga is one of the fast growing trees species. The average annual increment in height and in diameter is reported as 67cm and 2.5cm, respectively, in Indonesia. It grows to 60-70cm in diameter in 25 years. The trees are evergreen or leafless for short period in dry season.

Tree





Flowers



Leaf



Fruits



Trunk

g. Propagation and planting

The winged seed of *Duabanga* is very small and a single fruit contains 7,000-8,000 seeds. The weight of 10,000 seeds is about 1g. 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 seeds for propagation. It is recommended to select superior mother trees to obtain good quality seed.

h. Silviculture and management

Selective logging does create open areas where the light demanding *Duabanga* seedlings can be established, but in areas with a long logging intensity other species, which are more adapted to shade, will predominate. A rotation of 50-70 years is recommended.

i. Diseases and pests

Insect, deer, and cattle feed on seedlings and young plants. In South Kalimantan, 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 30cm long and 1.5cm in diameter.

j. Yield

D. moluccana has a mean annual increment of 4 m³/ha. In a 50-year-old plantation with about 40 trees/ha, the logs had a diameter of 70-100cm, with a timber volume of 5-10 m³/tree, the total standing stock was 200-250 m³/ha.

Seeds



FAMILY **STERCULIACEAE**

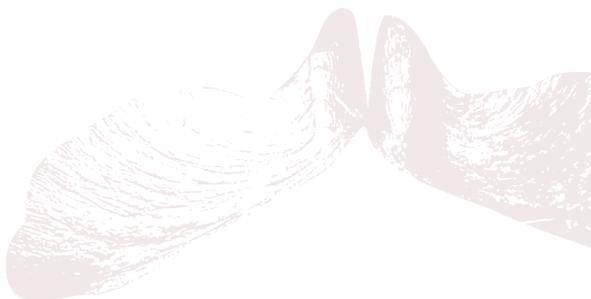


Tropical trees of Indonesia

77. *Heritiera javanica* (Blume) Kosterm.

Heritiera javanica is a member of Sterculiaceae family. The vernacular names of this species are Mengkulang: teralin (Fr). Brunei: kembang. Indonesia: palapi, teraling. Malaysia: kembang (Peninsular, Sabah). Philippines: lumbayau. Burma: kanazo. Laos: hao. Thailand: chumpreak (Trat). mengkulang jari. Laos: hao. Thailand: chum-phraek (trat), thong sok (Trang). The synonym of *Heritiera javanica* is *Tarrietia javanica* Blume (1825). Detailed descriptions of *Heritiera javanica* are as follows:





a. Trade groups

Mengkulang: medium-heavy hardwood, e.g., *Heritiera javanica* (Blume) Kosterm., *H. simplicifolia* (Masters) Kosterm.

b. Origin and geographic distribution

Heritiera consist of about 35 species and is distributed over a large area comprising tropical Africa (2 species), southern Asia from India to New Guinea (the majority of the species), Micronesia (1 species), and tropical Australia (3 species). About 20 species occur in Malesia.

c. Descriptions

Medium-sized to large monoecious trees, up to 50m tall, with usually tall and straight bole (but often stunted and low-branched in *H. littoralis*), branchless up to 20m, and up to 100(-135)cm in diameter; trunk with well developed, but usually thin, buttresses; bark greyish to reddish-brown outside; shallowly fissured and scaly or spotted, inner bark generally pink to red, laminated; twigs usually slender and terete, usually with prominently raised leaf scars, often with clustered or stellate hairs, and scaly. Leaves alternate, principally compound with palmately aranged leaflets, but also unifoliolate, and then seemingly simple; petiole swollen at both ends; leaflets entire, usually finely scaly beneath. Inflorescence axillary, paniculate,

pubescent at the base, scaly or stellate-hairy toward tip. Flowers unisexual, very small, with 4-5(-6) lobed calyx and lacking corolla; male flowers much more numerous than female ones, having an androgynophore bearing 8-10 sessile anthers and with or without minute sterile ovaries; female flowers slightly larger than male ones, having 4-5(-6) sessile small ovaries with short styles, alternating with small groups of sterile anthers. Fruit an ellipsoid to globose (often oblique) nut with woody wall, provided with a ridge often apically enlarging into a wing (i.e. a samara). Seed with a fairly thin testa, lacking albumen. Seedling (of *H. littoralis*) with hypogeal germination; first 2 leaves opposite or subopposite, often scale-shaped, subsequent leaves arranged spirally.

d. Observations

A large tree, up to 45m tall with columnar bole 20-25m long and up to 100(-130)cm in diameter, buttresses thin; leaves palmately compound with characteristic tufts of hairs in the axils secondary veins, petioles 5-10cm long; panicles much-branched, up to 13cm long; fruit with large wing, glabrous. *H. javanica* is one of the major species for mengkulang but less important than *H. simplicifolia*. It is widely distributed in lowland forest, mainly on ridges up to 600m, and is locally common, e.g., in the Philippines (Mindanao, Basilan), where the species is co-dominant with dipterocarp species.



Seed

The wood is slightly less heavy, less hard and less strong than that of *H. simplicifolia*. The density of the wood is 635-850 kg/m³ at 15% moisture content.

e. Growth and development

The fruits are either dispersed by water (mangrove species) or wind (inland forest species). The fruit of *H. littoralis* floats in water with the ridge upwards, and is impermeable to water. Then washed up on a beach, the base of the fruit weakens, allowing moisture to penetrate. The thick, hard radicle opens the hard fruit wall and the primary root penetrates deeply into the soil. Fruits of other *Heritiera* species with large wings (e.g., *H. Javanica*, *H. simpliciflora*) are wind-dispersed.

f. Ecology

H. littoralis grows in swamps on rocky and sandy coasts, often in drier sites and in the transition zone from mangrove to freshwater swamp. It is typically a tree of the banks of the rivers. Sometimes *H. littoralis* may make up 40% of the total stand, e.g., in Sarawak. It is often accompanied by *Bruguiera parviflora* (Roxb.) Wight & Arn. Ex Griffith, *Xylocarpus granatum* Koenig, and *Excoecaria agallocha* L. like *H. littoralis*,

H. globosa grows behind the tidal zone of the mangrove belt, whereas some other species, e.g., *H. novoguineensis*, apparently prefer sites inundated by fresh water. Other species are found in inland forest, usually scattered and at low and medium altitudes (up to 600m) in mixed dipterocarp forest. The different wood types may partially be determined by ecological conditions; mengkulang comes from inland forest species.

g. Propagation and planting

H. javanica and *H. simplicifolia* can be propagated by sowing seeds in a nursery or by stump cuttings. Seedlings are transplanted into the fields when 30-50cm high. Spacing is 3m x 4m. The survival rate of planted stump cutting is about 60%.

h. Silviculture and management

Natural regeneration techniques as used in regular management of mixed dipterocarp forest may be successful, but pure stands are probably not a good management target. Moreover, natural regeneration is usually scanty, especially in the inland forest species. In Africa *H. utilis* is artificially regenerated by strip planting.



i. Uses

The timber used as mengkulang. Mengkulang is a very good general-purpose timber. It is not very durable, but is suitable for interior construction, flooring, furniture, ship masts and other ship constructions above the waterline. For the export market mengkulang is recommended for joinery, flooring other purposes, as an alternative to red meranti (from *Shorea* spp.), niangon [from the African *Heriteria utilis* (Sprague)] and African mahogany (from the genus *Khaya*). Mengkuang is suitable for flooring subject to medium or light traffic, and also for purlins, ceiling joists, window frames, and even foundation piling (but must then be treated with preservative). It is particularly suited for staircase construction. It makes high quality veneer for core and outer layers of plywood. The wood can be used to make strong and stable particle board.

j. Diseases and pests

Moth larvae and beetles of the families *Curculionidae* and *Scolytidae* may damage seeds of *H. littoralis*. High percentages of *H. littoralis* seeds may show evidence of borers. Research in Australia showed that very few seeds contain an intact embryo. There may be significant amount of pre-dispersal predation by insects on developing seeds of *H. littoralis*. Moreover, crabs may damage seedlings.

Basal trunk



Bark



78. *Heritiera littoralis* Aiton

Heritiera littoralis is a member of Sterculiaceae family. The vernacular names of this species are Indonesia: dungon (general). Philippines: dungon, dungon late. Burma: kanazo, pinle-kanazo. Thailand: ngonkai-thale (central, Surat Thani), duhun (Trang). Vietnam: c[aa]y cui. Trade groups of this species are: Dungun: heavy hardwood, e.g., *Heritiera littoralis* Aiton, *H. sylvatica* S. Vidal. The synonym of *Heritiera littoralis* is *Heritiera minor* (Gaertner) Lamk. Detailed descriptions of *Heritiera littoralis* are as follows:



a. Origin and geographic distribution

Heritiera consist of about 35 species and is distributed over a large area comprising tropical Africa (2 species), southern Asia from India to New Guinea (the majority of the species), Micronesia (1 species), and tropical Australia (3 species). About 20 species occur in Malesia. *H. littoralis* is the most widespread species, covering almost the entire area of the genus: Eastern Africa, southern Asia from India to southern China and to tropical Australia, Hawaii and New Caledonia; throughout Malesia.

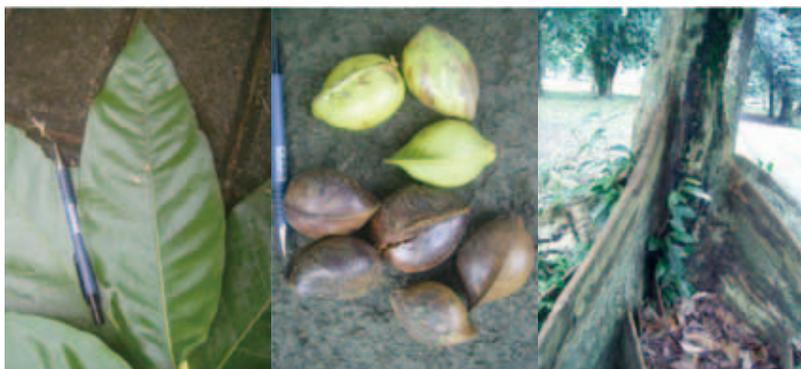
b. Descriptions

Medium-sized to large monoecious trees, up to 50m tall, with usually tall and straight bole (but often stunted and low-branched in *H. littoralis*), branchless up to 20m, and up to 100(-135)cm in diameter; trunk with well developed, but usually thin, buttresses; bark greyish to reddish-brown outside; shallowly fissured and scaly or spotted, inner bark generally pink to red, laminated; twigs usually slender and terete, usually with prominently raised leaf scars, often with clustered or stellate hairs, and scaly. Leaves alternate, principally compound with palmately aranged leaflets, but also unifoliolate, and then seemingly simple; petiole swollen at both ends; leaflets entire, usually finely scaly beneath. Inflorescence axillary, paniculate, pubescent at the base, scaly or stellate-hairy toward tip. Flowers unisexual, very small, with

4-5 lobed calyx and lacking corolla; male flowers much more numerous than female ones, having an androgynophore bearing 8-10 sessile anthers and with or without minute sterile ovaries; female flowers slightly larger than male ones, having 4-5 sessile small ovaries with short styles, alternating with small groups of sterile anthers. Fruit an ellipsoid to globose (often oblique) nut with woody wall, provided with a ridge often apically enlarging into a wing (i.e. a samara). Seed with a fairly thin testa, lacking albumen. Seedling of *H. littoralis* with hypogeal germination; first 2 leaves opposite or sub-opposite, often scale-shaped, subsequent leaves arranged spirally.

Tree





Leaf

Fruits

Basal trunk

c. Observations

A medium-sized evergreen tree, up to 25m tall, but usually much less, with usually twisted and stunted bole up to 40(-60)cm in diameter, buttresses thin, wavy, extending far out; leaves simple, silvery scaly beneath, petioles 0.5-1cm long, stout; panicles lax, up to 18cm long; fruit ellipsoid, with a rudder-like ridge, glabrous and glossy. *H. littoralis* grows in the inland zone of mangrove swamps, and it is common in many places. The wood often smells like leather. The density of the wood is 830-1,040 kg/m³ at 15% moisture content.

d. Growth and development

The fruits are either dispersed by water (mangrove species) or wind (inland forest species). The fruit of *H. littoralis* floats in water with the ridge upwards, and is impermeable to water. Then washed up on a beach, the base of the fruit weakens, allowing moisture to penetrate. The thick, hard radicle opens the hard fruit wall and the primary root penetrates deeply into the soil. In *H. littoralis* the growth of the branches is rhythmic and the shoots are distinctly articulate. Usually flowers at intervals throughout the year.

e. Ecology

H. littoralis grows in swamps on rocky and sandy coasts, often in drier sites and in the transition zone from mangrove to freshwater swamp. It is typically a tree of the banks of the rivers. Sometimes *H. littoralis* may make up 40% of the total stand, e.g., in Sarawak. It is often accompanied by *Bruguiera parviflora* (Roxb.) Wight & Arn. Ex Griffith, *Xylocarpus granatum* Koenig, and *Excoecaria agallocha* L. like *H. littoralis*, *H. globosa* grows behind the tidal zone of the mangrove belt, whereas some other species, e.g., *H. novoguineensis*, apparently prefer sites inundated by fresh water. Other species are found in inland forest, usually scattered and at low and medium altitudes (up to 600m) in mixed dipterocarp forest. The different wood types may partially be determined by ecological conditions; Dungun generally from mangrove swamp species.

f. Propagation and planting

H. javanica and *H. simplicifolia* can be propagated by sowing seeds in a nursery or by stump cuttings. Seedlings are transplanted into the fields when 30-50cm high. Spacing is 3m x 4m. The survival rate of planted stump cutting is about 60%.



g. Silviculture and management

Natural regeneration techniques as used in regular management of mixed dipterocarp forest may be successful, but pure stands are probably not a good management target. Moreover, natural regeneration is usually scanty, especially in the inland forest species. In Africa *H. utilis* is artificially regenerated by strip planting.

h. Uses

The timber is used as dungun. Dungun wood is of good quality, but it is not used so commonly because of the often twisted and stunted form and low branching of the bole; moreover, the timber is difficult to work. It is particularly used for rice pounder and other domestic articles, but sometimes also for piling, bridges and ship building. In the Philippines it is recommended for steamed bentwork and when strength and durability are required. Dungun was formerly valued for bullet-proof shields because of its toughness.

H. littoralis is excellent firewood, having a high energy value. Moreover, the wood is suitable for the production of wrapping, writing, and printing paper. The bark contains tannin and is used for

toughening fishing nets. An extract from the seeds is used medicinally in cases of diarrhoea and dysentery. The seeds are occasionally edible. In the Philippines the roots are used as a fish poison.

i. Diseases and pests

Moth larvae and beetles of the families *Curculionidae* and *Scolytidae* may damage seeds of *H. littoralis*. High percentages of *H. littoralis* seeds may show evidence of borers. Research in Australia showed that very few seeds contain an intact embryo. There may be significant amount of pre-dispersal predation by insects on developing seeds of *H. littoralis*. Moreover, crabs may damage seedlings.

Bark



79. *Pterygota alata* (Roxb) R. Br.

Pterygota alata is a member of Sterculiaceae family. The vernacular names of this species are: Malaysia: kangsar, menuang (Peninsular). Burma (Myanmar): sin-kadet, taung-letkok. Laos: po dêng. Thailand: huaka (peninsular), mabin (northern). The synonym of this species is *Sterculia alata* Roxb. Detailed descriptions of *Pterygota alata* are as follows:



a. Origin and geographic distribution

Pterygota comprises about 20 species. The distribution of this species is from Bangladesh (Chittagong) to Burma (Myanmar), Indo-China, Thailand and Peninsular Malaysia.

b. Uses

When treated, the wood of *Pterygota* is suitable for general construction, bridge and wharf superstructure, railway sleepers and poles. It is used for flooring, interior finish, furniture and cabinet work, joinery, mouldings, paneling, cladding, lining, steps, hand rails, tool handles. It is also suitable for manufacture of cement-bonded.

c. Properties

Pterygota yield a medium-weight to heavy hardwood with a density of 460-980 kg/m³ at 15% moisture content. Heartwood pale yellow-white to pale brown. Texture medium to coarse and uneven. Growth rings indistinct. The wood is fairly easy to saw, plane and finish, but has a tendency to tear when quarter-sawing boards with interlocked grain. The sapwood and heartwood are permeable when treated with preservatives under pressure. Logs are very susceptible to blue stain, termites, and pinhole borer attack unless rapidly removed from the forest and treated with appropriate prophylactic preservatives.

d. Descriptions

Medium-sized to large trees up to 50m tall, bole cylindrical to tapering, up to 120cm in diameter and branchless for up to 36m. Bark surface smooth to shallowly fissured. Seedlings with epigeal germination. In trials in West Java and East Java with *Pterygota alata* at 19-31 years of age, the mean annual increment was 0.9-1.9cm in diameter and 0.8-1.1m in height.

e. Ecology

Pterygota is found scattered or rarely gregarious in primary, lowland rain forest, up to 1,000m altitude, in areas with a short but pronounced dry period. It occurs on fertile soils and apparently tolerates periodic droughts. *P. alata* prefers flat alluvial soils and periodically inundated localities.

f. Propagation and planting

Pterygota can be propagated by seed. There are about 1,250 seeds without wings per kg. Seeds should be sown in the shade and those of *P. alata* have 80-85% germination in 7-203 days.

g. Silviculture and management

In trial in West Java *P. alata* regenerated naturally with an average of 19 seedlings/m².

Leaf



Seeds



Basal trunk



80. *Sterculia foetida* L.

Sterculia foetida is a member of Sterculiaceae family. The synonym of this species is *Sterculia polyphylla* R.Br. (1844). The local names of this species are; Indonesia: kepoh, kabu-kabu, kalupat. Malaysia: kelumpang jari. Philippines: kalumpang. Burma: letpan-saw. Cambodia: samrong. Thailand: samrong, homrong, chammahong. Detailed descriptions of *Sterculia foetida* are as follows:



a. Origin and geographic distribution

Eastern Africa, India, Sri Lanka, Burma, Indo-China, Thailand, throughout the Malaysian region (but not reported for Sarawak and Papua New Guinea), northern Australia and Hawaii.



Tree

b. Uses

The wood is used for temporary construction, packing cases, concrete shuttering and similar uses. The wood is stronger and more durable than most other *Sterculia* wood. The seeds are eaten as nuts (although they may be slightly poisonous when fresh), and they are 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.

c. Observations

A medium-sized to fairly large deciduous tree up to 40m tall, with bole up to 90(-120)cm in diameter. Bark surface sparsely cracked and peeling off into large pieces or slightly fissured and diphled. *S. foetida* is found in primary and secondary forest, often in river banks and on coral sandstone rocks along the coast, up to 1,000m altitude. The heartwood is pinkish and has a pungent smell. The density is 495-760 kg/m³ at 15% moisture content.

d. Properties

Sterculia yield a light weight and comparatively soft wood. The heartwood is straw-coloured.

e. Descriptions

A medium-sized to fairly large deciduous tree up to 40m tall, with bole up to 90(-120)cm in diameter, with buttresses up to 1.5m high, bark surface sparsely cracked and peeling off into large pieces or slight fissured and diphled, lenticellate, whitish-grey to greysish-brown, inner bark fibrous, brown or reddish brown, twigs stout, 25mm in diameter; leaves palmately compound with (5-)6-10 leaflets. The heartwood is pinkish and has a pungent smell.

f. Wood anatomy

Macroscopic character:

Heartwood yellowish-white, pale yellowish or grayish-white. Growth rings sometimes fairly distinct.

Microscopic character:

Tangential diameter is 200-350µm. Prismatic crystals present, usually in chambered axial parenchyma cells.

g. Ecology

Sterculia grows in lowland forest, from dryland to swampy forest, and usually not above 1,500m altitude. *Sterculia* trees usually are found scattered, apparently as distantly separated individuals in the understory, but some species reach the canopy of the forest or rare even emergent.



Flowers

Leaf

Fruits

Bark

h. Growth and development

The mean annual growth in a 15 years old plantation of *S. foetida* in Java was 0.8m in height and 1.1-1.3cm in diameter. The tree architecture of *S. foetida* is according to Aubreville's model, a monopodial trunk with rhythmic growth and spiral phyllotaxis, and plagiotropic branches in tiers.

i. Propagation and planting

S. foetida has 460-640 dry seeds/kg. Seed germinates rapidly; germination is 80-100% in 8-19 days. Seeds should be sown no deeper than 1cm 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.

Seedlings



j. Silviculture and management

As light demanding species, *Sterculia* should be given ample space to develop and a spacing of 1m x 6m proves better diameter growth than one of 1m x 3m. The self pruning capacity of the lower, heavy branches of *S. foetida* is satisfactory. Due to its open crown, weeds easily develop underneath.

k. Yield

In a 15-year-old trial of *S. foetida*, mean annual increment is 2.6-3.9 m³/ha. The wood volume of a clear log (60cm in diameter at breast height).



FAMILY **THEACEAE**



Tropical trees of Indonesia

81. *Schima wallichii* (DC.) Korth.

Schima wallichii is a member of Theaceae family. The vernacular names of this species are; Indonesia: puspa, madang gatal, seru. Malaysia: medang gatal, gatal-gatal, samak. Papua New Guinea: schima. Burma: laukya. Laos: boun nak, 'mi. Thailand: bunnak, champa dong, thalo. Detailed descriptions of *Schima wallichii* are as follows:





Seed pods

a. Origin and geographic distribution

Schima is a wide-ranging monotypic genus found from northeastern India throughout Indo-China, southern China, the Ryuku Islands and the Bonin Islands to Thailand, Peninsular Malaysia, Sumatra, Java, Borneo and the Philippines. The only species, *Schima wallichii* (DC.) Korth., is widely grown in South-East Asia and locally naturalized.

b. Uses

The wood of *S. wallichii* is used for medium-heavy construction under-cover, flooring, interior fitting, paneling, door and window frames, joinery, utility furniture, ship and boat building (ribs, decks), vehicle bodies, agricultural implements, pallets, boxes and crates, poles, toys, turnery and, when treated, for railway sleepers. It has been used for bridge building in mountain areas and young trees have been applied as rafters. It is also useful for reforestation, also in relation to water conservation in catchments areas.

c. Properties

S. wallichii yield a medium-weight to heavy hard wood with a density of 450-920 kg/m³ at 15% moisture content.

d. Descriptions

An evergreen, medium-sized to large tree up to 47m tall; bole cylindrical, branchless for up to 25m, up to 125(-250)cm in diameter, rarely with up to 1.8m high steep buttresses; bark surface ruggedly cracked into small thick angular pieces, red brown to dark grey, inner bark with irritating fibers, bright red. Seedling with epigeal germination; cotyledons emergent, leafy; hypocotyl elongated; all leaves arranged spirally; in-volute to almost con-duplicate.

e. Wood anatomy

Macroscopic character:

Heartwood pinkish-brown, red-brown or grey-brown, sometimes dark red-brown. Texture moderately fine or fine and even.

Microscopic character:

Growth rings distinct to indistinct. The energy value of the sapwood is about 19,980 kJ/kg.

f. Ecology

S. wallichii is a common tree that can grow in a wide range of climates, habitats, and soil. It is found in perhumid to seasonal climates. It often occurs gregariously in primary lowland to montane forest, up to 2,400(-3,900)m altitude.



Flower

g. Growth and development

A 28-year-old plantation of *S. wallichii* in West Java had an average diameter of 24cm and an average height of 22m. Tree may flower and fruit already after four years.

h. Propagation and planting

Schima wallichii can be raised from seed; the use of cuttings has not been successful. There are 196,000-267,000 dry seeds/kg. Dried seeds or fruits can be stored for up to three months, although one record from Nepal shows that they can be stored for a long time without problems. In general, germination percentage is 25-55%.

i. Silviculture and management

Wildlings have been collected from natural regeneration in plantations. Seeds are sown under shade and only lightly covered with soil. It usually considered a moderate light demander and regenerates abundantly where sufficient light is admitted for the development of the seedlings, but it also stated to be a shade-bearing species which hardly regenerates even in small gaps.

Leaf



Bark



FAMILY
THYMELAEACEAE



Tropical trees of Indonesia

82. *Aquilaria mallacensis* Lam.

Aquilaria mallacensis is one of important non timber forest product named "gaharu" agar wood. Detailed descriptions of *Aquilaria mallacensis* are as follows:





Leaf

Branch

Seeds

Bark

a. Origin and geographic distribution

A. malacensis grow in India, Burma, Malaysia, Philippines and Indonesia. In Indonesia mainly in Sumatra (Sibolangit, Bangka, Jambi, Riau and South Sumatra), Kalimantan, Sulawesi, Moluccas and Papua.

b. Uses

The agar wood is highly appreciated and priced fragrant wood caused by accumulation of scented resin. Agar wood contains more than 12 chemical components that can be extracted. They have a wide use in medicine (general pain reducer, dental pain, kidney and rheumatism medicine), as venom repellent, in perfume and as incense raw material. Wood without or with low content of resin can be used for boxes, interior or veneer. The inner fibrous bark has occasionally been used locally as raw material for clothing and ropes.

c. Descriptions

Up to 20-40m tall and 60cm in diameter. Young bark is light brown with fine hairs, older bark is smooth and whitish in colour. Wood without resin is white, light and soft, while wood with resin is hard, dark and heavy. Leaves alternate, elliptic or lanceolate, inflorescence a terminal or axillary umbel.

d. Propagation and planting

A. malacensis can be propagated by seed. Seeds are recalcitrant. Viability drops when the seeds are dried to a moisture content between 35% and 20% mc, with rapid loss in viability occurring below 20% mc and total loss at 7-11% mc. The seed cannot be stored for long and it is recommended to sow shortly after harvest. Storing in open sacks in a dry room may prolong viability. Vegetative propagation is relatively easy. Mass propagation can be done by rooting of cuttings after treatment with rooting hormones. Other types of vegetative propagation are air-layering, occultation and tissue culture.

e. Silviculture and management

Seeds are sown on top of the seedbed, then pressed lightly into the medium and covered with a layer of 1-2cm fine compost. Nursery beds, and later transplant beds, should be kept under shade. When the seedlings have three leaves they are transplanted into polybags. Before planting out, the shade should be gradually reduced.

Seedlings



FAMILY **VEBENACEAE**



Tropical trees of Indonesia

83. *Gonistylus bancanus* (Miq.) Kurz

Gonistylus bancanus is included in family of Verbenaceae. The local name of this species is ramin. Detailed descriptions of *Gonistylus bancanus* are as follows:





Leaf

a. Origin and geographic distribution

Native to Indonesia (western and central Kalimantan, south-eastern Sumatra and Bangka), Malaysia (south-western Peninsular and Sarawak) and Brunei Darussalam. It is a lowland species that is rarely found above 100m altitude. It grows in freshwater coastal peat-swamp forest, occasionally forming pure stands.

b. Uses

The timber of ramin has white to light yellowish white heartwood, moderately fine with even texture, and density of 0.54-0.75 g/m³ (moisture content 15%). It is very suitable for veneer and plywood, and highly valued for light construction and numerous uses where a clean, whitish timber is wanted. Among other things it is used for decorative cabinets, furniture, interior decoration, wall panelling, light flooring, toys, turnery, broom handles and other non-impact handles, venetian blind slats, dowels, rulers, picture frames, and drawing boards. Uses for general light construction include door and window frames, moulding, skirting, ceilings and partitions. Various other applications comprise planks, barrels, boxes and shipboards.

c. Descriptions

Tree up to 40-45m tall with straight and cylindrical bole, branchless up to 21m. Stem diameter at breast height up to 120cm. Observations under natural conditions in Kapuas, Central Kalimantan, indicated that *G. bancanus* together with bintangur (*Calophyllum kunstlerii*), jangkang (*Xylopia malacensis*), pisangpisang (*Mezzetia parvifolia*), and meranti bunga (*Shorea pauciflora*) belong to the top layer of the vegetation with tree heights of about 33m.

d. Propagation and planting

The seeds are sown in sand or a mixture of sawdust and soil (2:1) in shady conditions and the seedbed should be covered with transparent material (e.g., plastic) to avoid excessive moisture loss. Germination is hypogeal. The radicle begins to emerge after about 5 days, and nursery germination is completed after about 30 days. The germinated seeds are then transferred to containers with peat or peat + charcoal powder as growing medium. In the nursery the seedlings should be placed under shade.

Seedlings



84. *Gmelina arborea* Roxb.

Gmelina arborea belongs to the family of Verbenaceae. The trade group of this species is Yemane: lightweight hard wood, *Gmelina arborea* Roxb. White beech: lightweight hard wood, e.g. *G. moluccana* (Blume) Backer ex K. Heyne. The vernacular name of *Gmelina arborea* is Yemane (Trade name). Detailed descriptions of *Gmelina arborea* are as follows:





Flowers



Leaf



Fruits



Trunk

a. Origin and geographic distribution

Gmelina consists of about 33 species of trees and shrubs and is distributed from Pakistan and India, Srilanka and southern China through the Malaysian Archipelago towards northern and western Australia, Fiji, New Zealand and New Caledonia. About 12 species are found in Malaysia. *G. arborea* is the best known species of the genus.

b. Uses

The wood is used mainly for light construction and for pulping. Several parts of the plant are used medicinally. Leaves are good cattle fodder.

c. Production and international trade

The majority of Yemane timber is consumed locally in South-East Asia, mainly for construction purposes and ship building. Until 1990 it was not exported much.

d. Properties

Yemane is a light weight hard wood. The colour is uniformly cream to light yellowish-brown, turning reddish-brown with age.

e. Descriptions

Small to medium-sized trees or shrubs, up to 30m, rarely 40m tall with cylindrical bole having a

diameter of up to 100(-250)cm, without buttresses but sometimes flanged; barksmooth or scaly, pale brown to grey; twigs glabrous or pubescent, spinous or unarmed.

f. Wood anatomy

Macroscopic characters:

Demarcation between heartwood and sapwood indistinct, heartwood light-brown to yellowish-brown, sometimes with a pinkish tinge, sapwood whitish, sometimes with a greenish or yellowish tinge.

Microscopic characters:

Growth rings indistinct, if present, marked by smaller size of latewood pores. Vessels diffuse, 3-6(-12)mm² solitary and in radial multiples of 2-4, occasionally with narrow vessels between the larger ones, 130-240mm in tangential diameter.

g. Growth development

Yemane seeds germinated to become epigeal seedlings with the stony endocarp opening by lateral valves. The ridicule then appears, followed by the cotyledons. The primary root is long and slender at the initial stage but then thickens, producing a moderate number of lateral roots. The depth of the root system varies.

h. Ecology

Yemane is rather common in its natural distribution area where it occurs in habitats varying from rain forest to drier deciduous forest. It reaches its maximum size in the more humid forests of Burma, especially in humid fertile valleys. It can grow up to 1,300m altitude but is then usually stunted. It thrives in climates with mean annual temperature of 21-28°C, with mean maximum temperature of the hottest month 24-35°C, and mean minimum temperature of the coldest month 18-24°C. In its natural range the annual rainfall varies from 750-5,000mm. Its optimum lies at an annual rainfall of 1,800-2,300mm in areas with a dry period of 3-5 months and a relative humidity of at least 40%.

i. Propagation and planting

The species is normally propagated by seed. The weight of 1,000 seeds is approximately 400g. Freshly collected seeds (stones) of yemane yield the best germination results. The germination rate is 65-80%. The fruit wall should still be yellow-green to yellow.

j. Silviculture and management

It is important to balance the spacing with the development of good stem forms. Narrow spacing combined with early and regular thinning improves the stem form and reduces heavy branching and forking. Pruning is essential to produce long clear boles. Cutting off all leaves of the sapling except for the upper 2-3 pairs has been recommended in order to get a straight bole. As yemane has a high light requirement and is sensitive to competition,

good site preparation and clearing by weeding or fire is required to ensure good growth and establishment.

k. Diseases and pests

Serious fungal infestation has been observed in various locations. *Armillaria mellea*, *Ceratocystis fimbriata*, *Ganoderma colossus*, *Gnomonia* sp. and *Poria rhizomorpha* are some of the fungi found to cause serious damage to planted trees of yemane. Additionally, a parasitic plant, *Loranthus scurrula* L. can also cause damage. The latter is controlled by spraying herbicides.

l. Yield

Under favourable conditions yemane is capable of reaching an annual increment of 20-25 m³/ha with impressive exceptions of over 30 m³/ha with a maximum of 38 m³/ha.

m. Genetic resources and breeding

The various species of *Gmelina* are usually widely distributed, and although they are not abundant (except on favorable sites), none of them seems to be threatened with extinction.

Tree



Seeds



85. *Peronema canescens* Jack

Peronema canescens is a member of Verbenaceae family. The vernacular names of this species are; Indonesia: jati sabrang, jati londo, kurus, sungkai. Malaysia: sukai, cherek. Thailand: sangkae, khoeilai, sakae. Detailed descriptions of *Peronema canescens* are as follows:



a. Origin and geographic distribution

Peronema is a monotypic genus and is native to Peninsular Malaysia, Sumatra, the Riau Archipelago, West Java and Kalimantan.

b. Uses

The light weight, non-durable timber is used for pillars in houses, interior finishes, and especially for roof trusses on account of its lightness and strength. It has been used to make carts, and bridges for light traffic. The tree is often planted in hedges. In traditional medicine the bitter juice of the leaves and a decoction of the bark are used against fever. Boiled leaves are used in a poultice against ringworm, and in a mouthwash against toothache.

c. Properties

Sungkai is a light to medium-weight and moderately hard wood, with some resemblance to teak. The heartwood is cream-coloured to light yellow or light brown. The density of this species is (360-520-730 kg/m³ at 15% moisture content.

d. Descriptions

An evergreen or deciduous shrub or small to medium-sized tree up to 20(-30)m tall; bole straight or slightly flexuous, branchless for up to 9(-15)m, up to 70cm in diameter, usually with a small buttresses; root system superficial, with a short taproot; bark surface dirty grey or light buff, smooth to fissured and fibrous or scaly; crown ovoid,, densely short-hairy. Seedling with epigeal germination; cotyledons equal, petiolate, ovate with an emarginate apex; first leaves pinnately

lobed, subsequent ones imparipinnate.

e. Wood anatomy

Macroscopic character:

The heartwood is cream-coloured to light yellow or light brown, often with light red tinge. Texture moderately fine and even or moderately coarse and uneven.

Microscopic character:

Growth rings boundaries marked by difference in vessel frequency and vessel size. Fibres 900-1,600µm and tangential diameter is 100-170µm .

f. Ecology

Sungkai is common in secondary forest, forest clearings, river banks, along roads and railways, and in open country. It does not grow in primary forest and it grows best in moist to wet sites. Sungkai is found naturally from sea-level up to 600(-900)m altitude.

g. Growth and development

Sungkai trees need much light for optimal growth. At first, growth is reasonably rapid in full fill light, but slows down later, even on fertile soil. Seedlings grow fast when fully exposed, but when shaded, even lightly, the stems become very slender and brittle. Mean annual growth increments in trial plots in logged over area in East Kalimantan were 120cm in height and 0.8cm in diameter for saplings, and 114cm in height and 1.5cm in diameter for pole sized trees. First flowering occurs when trees are about 5m high. Flowering season in Java is in June/July. Fruiting occurs about months after flowering.



Leaf (adaxial and abaxial)

h. Propagation and planting

Seeds germinate soon under full light, but collected seeds do not germinate well. The weight of 1,000 seeds is 3.5-4g. The common method of propagation is by stem cuttings taken from straight trees. Trees from stem cuttings will finally develop a superficial root system similar to that of trees grown from seed.

i. Silviculture and management

Sungkai is unsuitable for planting in mixtures with other species, but it may be used as first cover for the planting of dipterocarp species. Self-pruning does not occur sufficiently. Artificial pruning is necessary.

j. Diseases and pests

Seedlings under shade are often attacked by leaf rust. Shoot-boring insects that tend to attack the tops may deform trees, the damage is not serious.

k. Harvesting

In Palembang it has been found that long-term storage of the wood in running water is beneficial, and petrifies the wood in 6 years. Sungkai is usually clear felled when the trees reach an average diameter of 20cm or more.

l. Yield

Mean annual volume increment was about 10 m³/ha in a 15-year-old stand, planted at spacing of 3m x 1 m in Gadungan (Indonesia).

Pinnatisect leaf



Basal trunk



86. *Tectona grandis* Linn.

Teak (*Tectona grandis* L. F., a member of the Verbenaceae family), is a large deciduous tree, which in favourable locations develops a tall, straight, (fairly) clean cylindrical bole. As it grows older it becomes moderately fluted and buttressed. Teak provides a valuable, versatile, tropical timber. Teak is probably the most widely cultivated high value hard wood (HVH) in the world and the decline of its natural resource in India, Myanmar, Thailand and Lao, as well as the desire to develop a valuable resource, has turned attention to its artificial cultivation in plantations. The trade groups of teak are: medium-weight hard wood, *Tectona grandis* L.f. and *T. philippinensis* Benth. & Hook. F. The vernacular names of this species are; Indonesia: jati (general), deleg, kulidawa (Java). Burma: kyun. Laos: sak. Thailand: sak (general), mai-sak. Detailed descriptions of *Tectona grandis* are as follows:





Leaf

a. Origin and geographic distribution

Teak (*Tectona grandis*) has been grown for more than 100 years, so it is a mainstay for many plantations. It is considered a very valuable wood because of its ability to withstand weather. It even prevents any metal used in it from rusting. Teak is very stable, which means that it does not warp when subjected to variations in humidity and temperature.

Teak occupies two areas of native range: the western portion includes most of peninsular India and the eastern portion includes parts of Burma, Laos, and Thailand. It has been cultivated since ancient times in Asia and today the species is planted in much of the moist tropics. *Tectona grandis* has naturalized in at least the Philippines, Java and Puerto Rico.

Teak is not native to Costa Rica but grows very well there. There are many monoculture plantations of teak in Costa Rica. It is a pioneer species; in other words, it prefers no competition, so for the first few years, it has to be cleared of weeds and kept from being shaded. After about three years, the trees are large enough to shade out competing vegetation. Teak requires very good drainage and rich soil. It prefers a dry season of about three months.

India, Myanmar, Muangthai, Vietnam, Sabah,

Philiphina, Brunei, Trinidad, Puertorico, Ceylon, China.

b. Uses

Medicinal Uses:

According to Ayurveda, wood is acrid, cooling, laxative, sedative to gravid uterus and useful for treatment of piles, leucoderma and dysentery. Flowers are acrid, bitter and dry and useful for bronchitis, biliousness, urinary discharges etc. Roots are useful for treatment of urinary system related troubles. According to Unani system of medicine, the oil from flower is hair promoter and useful for scabies. Wood is good for headache, biliousness, burning sensation and pain and liver related troubles. It allays thirst and possess anthelmintic and expectorant properties.

Other uses

Wood is used for ship building, railways, piles in harbour, bridge-building, construction work, furniture and cabinet work. Bolster, furniture, pillar, log, house building, bridge, roof frame, door cushion, window and tool wood.

c. Properties

Teak is a medium-weight timber which is rather soft and has a very characteristic appearance. The heartwood is often dull yellowish when freshly cut but it turns golden brown or sometimes dark grayish-brown after exposure.



Fruits

Basal trunk

d. Descriptions

Stem: woody and branchout. Stem is brown in color.

Leaf arrangement: alternate. Produces red tint when rubbed.

Leaf blade: green in color and a pinnate venation.

Flower: A zygomorphic symmetry with three anthers. Corolla: six, stamens: three.

Fruit: green, hairy and round, seed: surrounded by the fruit. Big tree, 25-50m at height of 100 years old tree; big and straight stem when it is grown at fertile land. Trees grown at infertile land has more significant response on fire/burning, pasturing, and/or pest diseases.

e. Wood anatomy

Macroscopic character:

Sapwood white, yellowish-white to pale yellowish-brown. Heartwood golden brown, dark golden brown, sometimes ageing to dark brown or dark grayish-brown.

Microscopic character:

Growth rings distinct, marked by thick-walled latewood fibres and differences in vessel diameter.

f. Ecology

Teak is a large deciduous tree that reaches maximum heights of 30 to 40m and diameters of 2m. Although varying considerably by habitat, the trees individually and by stands demonstrate a

moderate growth rate. The tree has large, yellow-green leaves, a medium-dense foliage, a medium-to-narrow crown, and a straight trunk covered by tan-to-gray scaly bark. It grows in a wide variety of soils if they are well drained, are not compacted or have a shallow hardpan, and are not seriously depleted of nutrients. *Tectona grandis* tolerates a wide range of climates, but grows best in a warm, moist, tropical climate (1,250 to 3,000mm of mean annual precipitation) with a marked dry season of 3 to 6 months. Trees of the species are not harmed by infrequent light frosts. Although *T. grandis* is not divided into subspecies or varieties, a number of different habitat-correlated populations can be distinguished by both morphological characteristics and adaptability.

g. Growth and development

The fruit splits open on one or two sides when germination starts. The radicle emerges first, and soon afterwards the cotyledons emerge. The root system is superficial, often not deeper than 50cm, and roots may extend laterally up to 15m from the stem. The optimum for its growth lies at 75-100% of full sunlight. The initial growth of teak is rapid. At an age of 5 years an average height of 13m and stem diameter of 10cm is not unusual.

h. Propagation and planting

Planting can be done generatively (seeds) and vegetatively (shoot cutting and grafting). The fruits



Seedlings

retain their viability for about 2 years in sacks in dry warehouses. High seed moisture content or high atmospheric humidity will shorten the storage life considerably. Long periods of storage are not been necessary in most areas because *T. grandis* produces good seed crops almost every year. Cut tests of fruit from 56 collections across the range of *T. grandis* revealed a potential mean viability of 71 percent with a range of 40 to 96 percent (Danish/Food and Agriculture Organization Forest Tree Seed Centre 1973). Germination percentage of fruits in nursery beds in various parts of the world varied from 0 to 96 percent in periods varying from 10 days to 3 months. Seeds extracted from fruits and treated with fungicide gave a germination rate of 54 percent in 12 days. But because seed extraction is difficult, and untreated *T. grandis* seeds have protracted, often low and unpredictable germination, some fruit pregermination treatment is usually applied to the fruit. A number of pretreatments have been effective:

Soaking the fruits in water for several days or alternately wetting and drying have proven effective. In one test, clean fruits pretreated by five cycles of alternately soaking in water for 24 hours and drying in the sun for 48 hours, were sowed. Germination began 18 days after sowing, increased for 15 days, and gradually decreased. The germination rate 68 days after sowing was 61 percent. Weathering of the epicarp and mesocarp helped germination.

In inoculating seeds with *Scytalidium* sp., a cellulolytic fungus isolated from teak litter, and keeping them moist for 21 days resulted in 96 percent germination compared to 20% for uninoculated controls.

Treating with indoleacetic acid and gibberellic acid, alone and in combination at various concentrations, increased germination 5 to 12% over controls (21% germination).

Soaking fruits from 11 Indian provenances in a nutrient solution resulted in a higher seedling yield (34%) than control (18%), water soaking (30%), or scarification (28%). Gupta and Pattanath (1975) felt that nutrient deficiencies in some of the sources resulted in lower germination or early seedling failure.

Storing seeds for several months improves germination. Some seed lots that were stored for several months germinated better than fresh seeds, probably because they needed a period of after ripening.

Size of fruit and region of origin also affect germination rates. Because large fruits tend to have a greater number of seeds than smaller fruits, they yield a significantly higher number of seedlings per fruit. Banik (1977) recommended that fruits smaller than 14mm in diameter be culled. Seeds from dry regions are frequently more difficult to germinate. Germination is epigeal. Teak fruits are usually broadcast in nursery beds and covered with 1.2 to

2.5cm of sand, soil, or sawdust.

A temperature of 30°C during germination appears to be optimal for the seeds. A seedling yield of about 25% can be expected from good seed. The beds should be kept moist.

Once the seedlings have become established, watering should gradually be reduced. Stump plants (seedlings with the tops removed) or potted plants grown in plastic nursery bags are usually used in field plantings. Direct seeding is also practiced but requires prepared seed spots. Early growth is slow and mortality is often high. The stump plants are grown in the nursery until they reach 1.2 to 2.5cm in diameter at the root collar; the top is cut back to about 2.5cm, and the tap root cut back to 18 or 20cm in length. Ideally, plants of suitable size can be grown in 6 to 9 months. In Thailand and India, some nurseries undercut the beds and remove seedlings large enough for stump plants after 1 year, allowing the remaining seedlings to grow an additional year after which the whole bed is harvested. Sowing of the nursery beds should be timed to ensure the proper size for planting at the start of the rainy season. Another approach involves harvesting in the dry season, storing the dormant stumps in beds of dry sand for 3 months, and planting at the start of the wet season. After outplanting, seedlings must be weeded for 1 to 2 years until they are well above weeds, grasses, and vines.

i. Silviculture and management

Clear cutting-artificial regeneration. Naturally found at various geological formation such as tertiary limestone and sandy limestone. Grow better

in good soil condition with good aeration and drainage. In Indonesia, Teak found on lowlands to hilly areas from 0-700m a.s.l. In India, teak is found on areas at 1,300m a.s.l, and 1,000m a.s.l. in Myanmar. Teak grows fast at humid tropical climate with annual rainfall 1,200-2,500mm. Teak is intolerant as it require more light for better growth

j. Diseases and pests

Disease can be conveyed by bacteria such as *Pseudomonas solanacearum* and fungi such as *Corticium salmonicolor*. Termite such as *Neotermes tectonae* may damage the tree. Seeds can be infested by larvae of Lepidoptera and Coleoptera.

k. Harvesting

Stems are usually girdled two years before logging. This practice kills the trees, and makes felling and transport easier.

l. Yield

Teak produces between 12 to 26m³ in volume of wood per year. Based on the observed growth on Finca Leola, we appear to be close to, if not at, the high-end growth rate of 26m³ (the trees in the photo at left are only one year old). The price for teak has been going up steadily for many years, at a rate consistently over 6% per year. Currently, teak buyers from other parts of the world are having difficulty to find as many teak logs as they would like to buy from Costa Rican plantations.

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팩스 [02]967-5101, 961-2559

전화 원장실 [02]961-2500 / 연구지원과장실 [02]961-2511 / 민원실 [02]961-2522-63

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Tropical trees of Indonesia

A Field Guide to Tropical Trees

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Publisher **Koo Gil-Bon**, Ph.D (Director General of KFRI, Republic of Korea)

Authors **Moon Heung-Kyu**, Ph.D (Division Director of KFRI, Republic of Korea)

&Editors **Ujang Susep Irawan**, MSi (Coordinator of Operation Wallacea Trust, Indonesia)

Park So-Young, Ph.D (Research Scientist of KFRI, Republic of Korea)

Park Chong-Ho, Ph.D (Director of Bureau of Forest Resources, KFS, Republic of Korea)

Yi Jae-Seon, Ph.D (Professor of Kwangwon Nat. Univ., Republic of Korea)

Photos **Moon Heung-Kyu, Ujang Susep Irawan**

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Address : 57, Hoegi-ro, Dongdaemun-gu, Seoul, Republic of Korea

Tel. 82-31-290-1161 Fax. 82-31-290-1020 www.kfri.go.kr

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