treatment of seeds before sowing is not necessary. Wildlings are sometimes used for planting.

Management *Diospyros abyssinica* trees can be managed by pruning, pollarding and coppicing.

Diseases and pests In mature trees, butt rot seems common. The fruits of *Diospyros abyssinica* are susceptible to attacks by the Mediterranean fruit fly (*Ceratitis capitata*), which is a pest of many fruit crops.

Genetic resources In view of its wide distribution in tropical Africa and its occurrence in various habitats, *Diospyros abyssinica* does not seem to be threatened by genetic erosion. However, in many regions in West Africa it is uncommon. There are no indications of overexploitation or unsustainable usage.

Prospects The wood of *Diospyros abyssinica* is presently not commercially important. The heartwood has not the dark colour and high durability of other *Diospyros* spp., but the wood is locally important for domestic uses. The medicinal properties are promising and more research is recommended on pharmacological activities in relation to drug development.

Major references Beentje, 1994; Bolza & Keating, 1972; Dale & Greenway, 1961; Katende, Birnie & Tengnäs, 1995; Keay, 1989; Maiga et al., 2006; Noad & Birnie, 1989; Coates Palgrave, 1983; White, 1983; White, 1988.

Other references Aubréville, 1959c; Bekele-Tesemma, 2007; Burkill, 1994; Bussmann, 2000; Chikamai et al., undated; Dakora, 1995; Duncan & Duncan, 2000; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Irvine, 1961; Lieberman & Li, 1992; Maundu et al., 2001; Neuwinger, 2000; Odlo, 2009; Swaine, Lieberman & Hall, 1990; Takahashi, 1978; White, 1956; White, 1987.

Sources of illustration Hawthorne & Jongkind, 2006; Noad & Birnie, 1989; White, 1987.

Authors E.A. Obeng

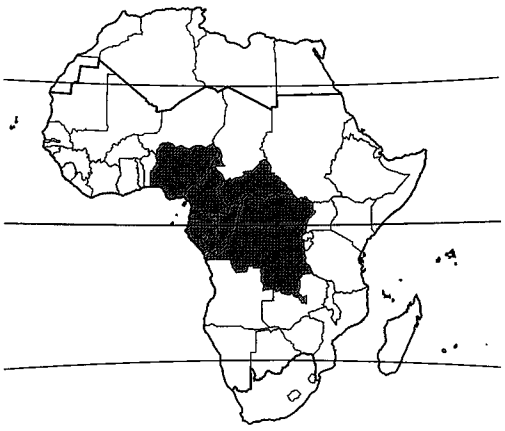
DIOSPYROS CRASSIFLORA Hiern

Protologue Monogr. Eben.: 260 (1873); Trans. Camb. Phil. Soc. 12: 260 (1873).

Family Ebenaceae

Vernacular names African ebony, West African ebony, Benin ebony (En). Ebène d'Afrique, ébène noir, ébénier véritable du Gabon (Fr).

Origin and geographic distribution *Diospyros crassiflora* occurs from southern Nigeria east to the Central African Republic, and south to Gabon and DR Congo.



Diospyros crassiflora – wild

Uses The black heartwood (traded from Cameroon as 'mevini', from Equatorial Guinea as 'ébano' and from Gabon as 'evila') is used for heavy flooring, interior trim, ship building, vehicle bodies, furniture, cabinet making, musical instruments (especially the black keys of pianos, but also guitar fingerboards), precision equipment, turnery, carvings, knife-handles and brush backs. The sapwood and sometimes also the heartwood is used for poles, posts, vehicle bodies, agricultural implements, toys, novelties, sporting goods, combs, ladders, boxes, crates, crossbows, veneer and plywood. The wood is also used as firewood.

In traditional medicine, a bark decoction is drunk and used as a wash to treat ovarian problems, and the bark powder is applied to heal sores and wounds. The leaf sap is applied as eye drops to treat eye inflammations. In Gabon the bark is used in a mixture with the heartwood of *Pterocarpus soyauxii* Taub. to treat yaws.

Production and international trade The wood of *Diospyros crassiflora* is considered the true ebony of commerce from Africa and has been for a long time an important export product from Nigeria, Cameroon and Gabon. The total volumes exported from these countries are unknown, but are low at present because of dwindling stands. In the 1960s around 70 m^3 of wood were exported annually from Cameroon and 56 m^3 in 1972, and in 1960 Gabon exported 130 m^3 and in 1994 35 m^3. Currently, export and utilization of the wood requires special permission in Cameroon. DR Congo is consid-

ered the major exporter at present. The high-quality carvings are in great demand by tourists.

Properties The heartwood is jet-black to black-brown or dark brown with black streaks. It is distinctly demarcated from the sapwood, which is pinkish to pale red after cutting darkening to pale reddish brown upon exposure, and up to 12 cm thick. The grain is straight, occasionally interlocked or curly, texture fine.

The wood is heavy with a density of 900–1010 kg/m^3 at 12% moisture content. It air dries slowly, with high risks of distortion and checking, but in small dimensions it may dry fairly rapidly and with little degrade. The rates of shrinkage are high, from green to 12% moisture content about 5.5% radial and 6.5% tangential and from green to oven dry 7.0% radial and 11.0% tangential. Once dried, the wood is often poorly stable in service.

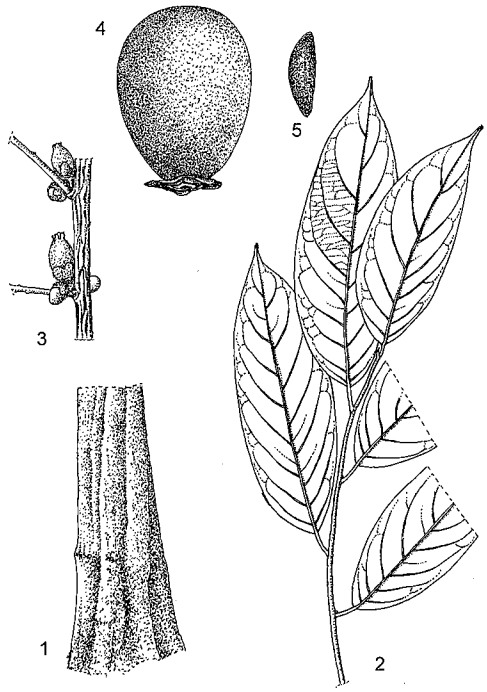
At 12% moisture content, the modulus of rupture is 130–179 N/mm^2, modulus of elasticity 15,500–18,900 N/mm^2, compression parallel to grain 58–88 N/mm^2, shear 17 N/mm, Janka side hardness 14,320 N and Monnin hardness 7.0.

The wood is difficult to saw and work, with serious dulling effect on saws and cutting edges. Stellite-tipped sawteeth and tungsten-carbide cutting tools are recommended, and powerful machines are needed for machining. The wood surfaces take an excellent polish, but picking up of interlocked or curly grain may occur in planing and a reduced cutting angle is recommended. The wood has a tendency to split upon nailing, and pre-boring is advised. It has good slicing properties, but powerful machines are needed. The gluing properties are satisfactory. A preliminary surface treatment with alcohol is recommended for coatings. The wood is moderately durable, being moderately resistant to termite attack, but susceptible to pinhole borers and marine borers attacks. It is extremely resistant to preservative treatment. Saw dust may cause allergic contact dermatitis in wood workers.

The stem bark showed significant in-vitro antibacterial and antifungal activities. Plumbagin, cyclocanaliculatin, gerberinol, lupeol, lupenone and betulinic acid have been isolated from the stem bark, and the naphthoquinone crassiflorone has also been isolated. Some of these compounds have also shown antibacterial and antifungal properties.

Adulterations and substitutes The wood of *Diospyros crassiflora* is often mixed with that of other African *Diospyros* spp. with blackish heartwood such as *Diospyros mespiliformis* Hochst. ex A.DC. African blackwood (from *Dalbergia melanoxylon* Guill. & Perr.) resembles the wood of *Diospyros crassiflora* and is used for similar purposes.

Description Dioecious medium-sized tree up to 25 m tall; bole cylindrical or fluted, branchless for up to 15 m, up to 120 cm in diameter, without buttresses; bark surface with fine longitudinal fissures, exfoliating in rather thick scales, blackish grey to black, inner bark black and brittle in outer layer, pale salmon pink with creamy streaks in inner layer; branches reddish grey-brown, with longitudinal cracks; young twigs glabrous. Leaves alternate, simple and entire; stipules absent; petiole up to 1.5 cm long, grooved above, nearly glabrous; blade lanceolate-elliptical to oblong-elliptical, 10–21 cm × 4–10 cm, cuneate to rounded and slightly asymmetrical at base, abruptly acuminate at apex, thin-leathery, nearly glabrous, glossy dark green above, paler below, pinnately veined with 5–8 pairs of lateral veins, finest veins perpendicular to lateral veins. Inflorescence an axillary fascicle, often



Diospyros crassiflora – 1, base of bole; 2, leafy twig; 3, flowering branch; 4, fruit; 5, seed. Redrawn and adapted by Iskak Syamsudin

on older branches, 3–6-flowered for male inflorescence, 1–2-flowered for female one. Flowers unisexual, regular, nearly sessile; calyx fleshy, up to 10 mm long, pinkish red, with tube slightly longer than the (4–)5 lobes; corolla 2.5–3 cm long, fleshy, short-hairy, pinkish white, with ellipsoid tube and 4–6 short lobes; male flowers with numerous stamens up to 1.5 cm long, with very short filaments, ovary rudimentary; female flowers with rudimentary stamens, ovary superior, globose, c. 5 mm in diameter, 8–10-celled, styles 4–5. Fruit an ellipsoid to obovoid berry, up to 10 cm × 6.5 cm, sparsely hairy to glabrous, yellowish when ripe, enclosed at base by enlarged calyx up to 4 cm in diameter, up to 10-seeded. Seeds oblong, up to 5 cm × 2 cm × 1.5 cm, glossy brown to black.

Other botanical information *Diospyros* is a large pantropical genus of about 500 species; in tropical Africa about 90 species occur and several produce valuable timber or edible fruits.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; (10: vessels in radial multiples of 4 or more common); 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 25: intervessel pits small (4–7 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 μm; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 86: axial parenchyma in narrow bands or lines up to three cells wide; 87: axial parenchyma reticulate; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 96: rays exclusively uniseriate; 97: ray width 1–3 cells; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; (109: rays with procumbent, square and upright cells mixed throughout the ray); (113: disjunctive ray parenchyma cell walls present); 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E.E. Mwakalukwa, P.E. Gasson & E.A. Wheeler)

Growth and development *Diospyros crassiflora* is slow growing. In natural forest in Cameroon the mean diameter growth was 4.5 mm/year for trees with a mean height of 14.5 m and a mean age of 50 years. However, two trees measured over a period of 10 years in central Gabon had an average annual growth rate of only 1 mm in diameter. In a 50-years-old plantation in Cameroon, dominant trees were on average 24 m tall and 22 cm in bole diameter, whereas the standing volume was estimated at 320 m^3/ha.
In Cameroon flowering of trees has been recorded from February to May, in Gabon from September to October. Fruits ripen about 6 months later. They are eaten by animals, which probably serve as seed dispersers.

Ecology *Diospyros crassiflora* occurs in lowland semi-deciduous and evergreen forest up to 1000 m altitude, but usually avoids the most humid forest types.

Management *Diospyros crassiflora* is in general uncommon in the forest, usually occurring as isolated trees or in small groups of 2–3. In western Cameroon the average wood volume of boles of more than 15 cm diameter was recorded as 0.25 m^3/ha. Trees coppice well.

Diseases and pests In Cameroon attacks of jumping plant-lice and other leaf-defoliating insects on *Diospyros crassiflora* have been recorded.

Harvesting Trees are harvested by the selective logging system. Some caution is needed during harvesting operations because logs may have brittle heart. In Gabon and the Central African Republic the minimum bole diameter allowed for felling is 40 cm, in DR Congo and Cameroon 60 cm.

Handling after harvest Due to the high density of the wood logs do not float in water and cannot be transported by river.

Genetic resources Nearly all big trees of *Diospyros crassiflora* have been heavily overexploited with few remaining stands in the most remote areas of its range, and the species seems to have poor natural regeneration. Therefore, *Diospyros crassiflora* is classified as endangered in the IUCN Red List of threatened species.

Prospects In spite of the fact that *Diospyros crassiflora* is highly demanded for its commer-

cial ebony wood, very little research has been carried out on its propagation and management in natural forest. Therefore, requirements for sustainable exploitation are still unclear, but the long time needed for the production of black heartwood of sufficient diameter to be interesting for the timber market and the scarcity of large trees seem to preclude sustainable commercial exploitation. More research is recommended in natural regeneration measures to protect the species.

Major references Bolza & Keating, 1972; Burkill, 1994; Dalziel, 1937; Dzoyem et al., 2006; Keay, 1989; Kennedy, 1936; Letouzey & White, 1970a; Neuwinger, 2000; White, 1978b; White, 1987.

Other references African Regional Workshop, 1998; ATIBT, 1986; Burkhardt & Lebel, undated; CIRAD Forestry Department, 2008; Foahom, 2003; Maisonneuve & Manfredini (Editors), 1988b; Meier, 2009; Owona Ndongo et al., 2009; Raponda-Walker & Sillans, 1961; Takahashi, 1978; UNEP-WCMC, 2006; Vivien & Faure, 1985; White, 1963; White & Abernethy, 1997; Wilks & Issembé, 2000; Worbes et al., 2003.

Sources of illustration Vivien & Faure, 1985; White, 1987.

Authors E.A. Obeng

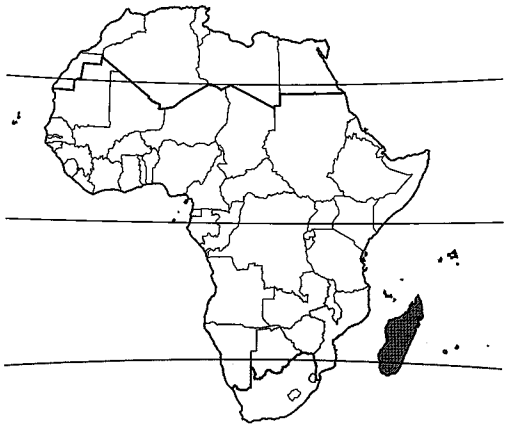
DIOSPYROS GRACILIPES Hiern

Protologue Monogr. Eben.: 191 (1873).

Family Ebenaceae

Vernacular names Madagascar ebony (En). Ebène de Madagascar (Fr).

Origin and geographic distribution *Diospyros gracilipes* is endemic to Madagascar, where it is widespread in the northern and eastern parts of the island.



Diospyros gracilipes – wild

Uses The black heartwood, known as 'hazomainty', is used for high-quality joinery, furniture, musical instruments, pegs, ornaments, inlay work, handles, carvings and turnery. The bark, leaves and fruits are used in mixtures to stimulate contractions of the uterus during childbirth, and as an abortive. This practice is not without danger; fatal cases have been reported.

Production and international trade Export of Madagascar ebony started in the 16th century by the Portuguese. Together with rosewood (from *Dalbergia* spp.), ebony from some *Diospyros* spp., of which *Diospyros gracilipes* is one of the most important, is considered the most precious and valuable wood in Madagascar. It fetches extremely high prices, even when traded in smaller dimensions. In recent years, the export of Madagascar ebony, as well as that of rosewood, is nearly entirely to China.

Properties Distinction between *Diospyros* spp. of Madagascar producing black ebony is usually not made, and the wood properties are said to be quite similar. The heartwood near the centre and base of old boles is black, sometimes with whitish streaks, and distinctly demarcated from the whitish sapwood which becomes yellowish upon exposure. The grain is usually straight, sometimes wavy to slightly interlocked, texture very fine. The wood is heavy, with a density of 900–1100 kg/m³ at 12% moisture content. It dries rather slowly, with little tendency to distort. It takes about 4 months to air dry boards of 2.5 cm thick. The rates of shrinkage are moderately high, from green to oven dry about 4.5% radial and 9.2% tangential. Once dry, the wood is stable in service. At 12% moisture content, the modulus of rupture is about 190 N/mm², modulus of elasticity 22,700 N/mm², compression parallel to grain 63 N/mm² and Chalais-Meudon side hardness 12.

The wood is fairly easy to saw and work, but needs high-power tools because of its high density, abrasiveness and presence of silica (about 0.1%). It takes a smooth and nice finish without the use of a filler. It has a tendency to split upon nailing and screwing, and pre-boring is recommended. The wood is durable; it is resistant to impregnation with preservatives.

The exudate from the bark may cause black marks and vesicles on the skin.

Botany Evergreen small tree up to 15 m

tall; bole usually low-branching, up to 30(–40) cm in diameter; bark surface smooth to more or less rough, blackish brown, inner bark thin; crown with spreading branches; twigs usually glabrous. Leaves alternate, simple and entire; stipules absent; petiole 3–10 mm long; blade elliptical-lanceolate to ovate-lanceolate, (3–)6–12 cm × (1.5–)2–6 cm, cuneate to rounded at base, short-acuminate at apex, wavy at margins, thin-leathery, pinnately veined with 4–7 pairs of lateral veins. Inflorescence an axillary fascicle, often on older branches or on the bole, up to 20-flowered. Flowers unisexual, regular; pedicel slender, up to 5 cm long, strongly elongating in fruit; calyx cup-shaped, 3–8 mm long, short-hairy, with tube about as long as the 4 lobes, strongly enlarging in fruit; corolla slightly longer than calyx, with long tube and 4–6 rounded lobes; male flowers with 8–16 stamens, filaments very short; female flowers larger than male ones, with c. 6 rudimentary stamens, ovary superior, ovoid, reddish brown hairy, 8–10-celled, styles 8–10, fused at base. Fruit an ovoid to oblong berry c. 3 cm long, brownish green, covered by a whitish powder, up to 8-seeded. Seeds elongate, flattened, c. 12 mm long, blackish. Seedling with epigeal germination.

Diospyros gracilipes is variable and some varieties have been distinguished. It grows slowly and tolerates shade. It usually flowers in May–June and September–December and fruits ripen 3–6 months later. Ripe fruits are eaten by lemurs, which may disperse the seeds.

Diospyros is a large pantropical genus of about 500 species; in mainland tropical Africa about 90 species occur and several produce valuable timber or edible fruits. Over 100 species have been recorded for Madagascar, several of which provide valuable ebony wood, and possibly the total number of species is around 200. About 14 species are endemic to the Mascarene islands.

Diospyros perrieri Jum. is the main producer of ebony wood in western Madagascar; it has black heartwood similar to that of *Diospyros gracilipes*. However, nearly all larger trees of *Diospyros perrieri* have disappeared.

Diospyros platycalyx Hiern is also reported to provide blackish heartwood, but is also under high pressure caused by exploitation in its distribution area in western Madagascar.

Diospyros tessellaria Poiret is as small to medium-sized tree up to 20 m tall, with slender, straight bole, endemic to Mauritius. It provided the ebony of commerce of Mauritius ('bois d'ébène noir'), but larger trees have nearly all disappeared from the forests.

Ecology *Diospyros gracilipes* occurs mainly in humid evergreen forest, from sea-level up to 1350(–1650) m altitude. The mean annual rainfall is (500–)1000–2500(–3000) mm, with 1–7 dry months, and the mean annual temperature is 20–24°C. It occurs on a variety of soils, from sandy to limestone and rocky soils.

Management The 1000-seed weight is 600–650 g. Germination starts 3–7 weeks after sowing and the germination rate of fresh seed is about 65%. The seeds are extracted from the fruit and usually sown in pots or polythene sacs. Propagation by root suckers is possible. The tree coppices well. Enrichment planting of natural forest with *Diospyros gracilipes* is sometimes practised.

Genetic resources and breeding Large-scale unauthorized logging of Madagascar ebony occurs in the forests of Madagascar. In 2009 large amounts of ebony trees were logged in Madagascar, together with even larger amounts of rosewood (*Dalbergia* spp.) trees, and the export was mainly to China. Only small quantities were shipped to Germany and Mauritius.

Several *Diospyros* spp. in Madagascar are being considered for inclusion in the CITES Appendix II list, including *Diospyros gracilipes*, *Diospyros perrieri* and *Diospyros platycalyx*.

Prospects Most *Diospyros* spp. providing valuable black ebony wood in Madagascar and the Mascarene islands are under strong pressure caused by over-exploitation. Sustainable production of this type of timber is unlikely on a commercial basis because the black heartwood is only available in the bole core of old trees; moreover, the trees grow slowly. Enrichment planting might be an option, but will require very long rotation cycles. Because of the high value of the wood, studies on optimal management could be useful, but for the time being protection measures are needed.

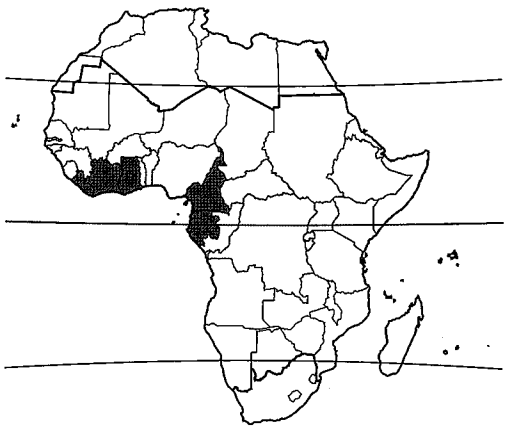
Major references Blaser et al., 1993; Debray, Jacquemin & Razafindrambao, 1971; Normand, Sallenave & Rothe, 1960; Perrier de la Bâthie, 1952; Rakotovao et al., en préparation.

Other references Ballet, Lopez & Rahaga, 2010; Innes, 2010; Richardson, 1981; Schuurman & Lowry, 2009.

Authors R.H.M.J. Lemmens & D. Louppe

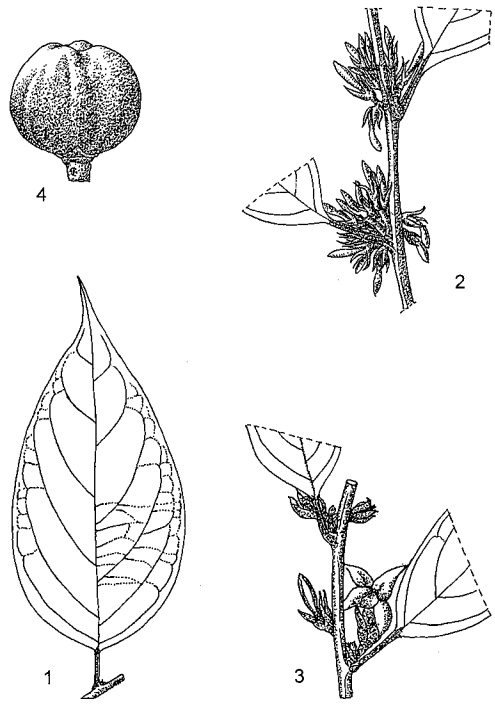
DIOSPYROS KAMERUNENSIS Gürke

Protologue Engl. Bot. Jahrb. 26: 69 (1898).
Family Ebenaceae
Vernacular names Cameroon ebony, African ebony (En).
Origin and geographic distribution *Diospyros kamerunensis* is distributed from Liberia to Ghana and from Cameroon to Gabon.
Uses The wood of *Diospyros kamerunensis* is used for posts in house construction, poles, implements, handles, household utensils and drums. It is suitable for heavy flooring, joinery, mine props, ship building, vehicle bodies, sporting goods, toys, novelties, draining boards, carvings, turnery and sliced veneer. The tough stem of saplings is sometimes used as rope. The fruit pulp of fully ripe fruits is edible.
Production and international trade The wood of *Diospyros kamerunensis* is mainly used locally and occasionally traded on the international market in mixtures with other ebony woods, often as 'Cameroon ebony'.
Properties The heartwood is pinkish when freshly cut, often becoming grey to grey-brown upon drying, and indistinctly demarcated from the paler and wide sapwood. Near the centre of the bole the wood is sometimes blackish. The grain is generally straight, sometimes interlocked, texture usually fine.
The wood is heavy, with a density of about 990 kg/m³ at 12% moisture content, hard and tough. During air drying, it is liable to splitting and twisting, and it is recommended to dry the wood in smaller dimensions. The rates of shrinkage are high. At 12% moisture content, the modulus of rupture is 169 N/mm², modulus of elasticity 15,580 N/mm² and Janka side hardness 14,850 N.
The wood is relatively easy to work in spite of its high density, but the dulling effect on saw teeth and cutting edges may be serious. It planes to a good finish and takes a high polish. Pre-boring is needed for nailing and screwing; the wood holds nails and screws well. The heartwood is quite durable, being resistant to termite attack, but less resistant to pinhole borers and marine borers. The sapwood is not durable and susceptible to *Lyctus* attack, but it is moderately permeable for preservatives by impregnation. The wood dust may cause dermatitis and irritation to mucous membranes in wood workers.



Diospyros kamerunensis – wild

Description Evergreen, dioecious shrub or small tree up to 15(–20) m tall; bole usually straight and slender, up to 30 cm in diameter; bark surface rough, finely fissured, greenish grey, inner bark thin; twigs golden-brownish hairy when young, becoming glabrous. Leaves alternate, simple and entire; stipules absent; petiole 1–2 cm long, grooved above, short-hairy; blade lanceolate-elliptical to ovate or oblong-elliptical, 15–20 cm × 5–9 cm, obtuse at base, acuminate at apex, papery or thin-leathery, yellowish short-hairy below especially when young, pinnately veined with 3–7(–8) pairs of lateral veins. Inflorescence an axillary fascicle, 3–6(–20)-flowered for male inflorescence, 1–2(–3)-flowered for female one. Flowers unisexual, regular; pedicel up to 3 mm long; calyx up to 8 mm long, yellowish red hairy, with tube slightly shorter than the 4 lobes; corolla salver-shaped, c. 2 cm long, fleshy, short-hairy, white or yellowish, with c. 1 cm long tube and 4(–5) lobes c. 1 cm long; male flowers with 12 stamens c. 6 mm long, with very short filaments, hairy at base of anthers; female flowers with 8–12 rudimentary stamens, ovary superior, ovoid, c. 5 mm long, 8(–10)-celled, styles 4(–5). Fruit a depressed-globose to ellipsoid berry, up to 4 cm long, sparsely hairy to glabrous, yellow-orange to orange-red when ripe, up to 8(–10)-seeded. Seeds c. 3 cm × 2 cm × 1 cm. Seedling with epigeal germination.
Other botanical information *Diospyros* is a large pantropical genus of about 500 species; in mainland tropical Africa about 90 species occur and several produce valuable timber or edible fruits.
Diospyros monbuttensis Gürke is a shrub or small tree up to 10 m tall with bole up to 40 cm in diameter. It occurs in semi-evergreen forest and gallery forest from Côte d'Ivoire east to the Central African Republic and northern DR



Diospyros kamerunensis – 1, leaf; 2, part of twig with male flowers; 3, part of twig with female flowers; 4, fruit.
Redrawn and adapted by Iskak Syamsudin

Congo. The whitish yellow wood is used for similar purposes as that of *Diospyros kamerunensis*, but mainly for implements, utensils and handles. The flexible branches are used for game traps. In traditional medicine decoctions of bark and leafy twigs are administered, often in mixtures with other medicinal plants, to treat leprosy, skin affections caused by fungi, jaundice, excessive uterine bleeding and chickenpox.

Diospyros thomasii Hutch. & Dalziel is a small tree up to 10 m tall, occurring in humid forest in Guinea, Sierra Leone and Liberia, particularly in secondary forest. The wood, which is pinkish when freshly cut, is used for drums and oars. The flexible branches are used for game traps. The sweet fruit pulp is edible. The bark is used to treat diarrhoea.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; (10: vessels in radial multiples of 4 or more common); 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 25: intervessel pits small (4–7 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 μm; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled; 70: fibres very thick-walled. Axial parenchyma: 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 86: axial parenchyma in narrow bands or lines up to three cells wide; 87: axial parenchyma reticulate; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 96: rays exclusively uniseriate; 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; 109: rays with procumbent, square and upright cells mixed throughout the ray; (113: disjunctive ray parenchyma cell walls present); 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 138: prismatic crystals in procumbent ray cells; 142: prismatic crystals in chambered axial parenchyma cells.
(E.A. Obeng, P.E. Gasson & H. Beeckman)

Growth and development *Diospyros kamerunensis* is a shade bearer with slow but steady growth. In West Africa, flowering of trees usually occurs in September–October. Fruits ripen about 3 months after flowering.

Ecology *Diospyros kamerunensis* is most common in moister evergreen forest, but it can also be found in more dry forest types. It is characteristic for the understorey of undisturbed forest, usually on acid, well-drained soils, but has also been reported from secondary forest.

Propagation and planting *Diospyros kamerunensis* may regenerate well under shady conditions in the forest.

Harvesting Some caution is needed during harvesting operations because logs may have brittle heart.

Handling after harvest Freshly harvested boles do not float in water and thus cannot be transported by river.

Genetic resources Although *Diospyros kamerunensis* does not seem to be abundant in most of its geographical distribution area, it is unlikely to be under threat of genetic erosion. There are no indications of overexploitation.

Prospects *Diospyros kamerunensis* will remain useful as a source of wood for local applications, e.g. for poles, implements and utensils. However, prospects as a timber tree of commercial importance for export are poor because of the small size of boles. Chemical and nutritional analyses of the fruits are recommended.

Major references Aubréville, 1959; Bolza & Keating, 1972; Burkill, 1994; Irvine, 1961; Letouzey & White, 1970a; Oteng-Amoako (Editor), 2006; Vivien & Faure, 1996.

Other references Cooper & Record, 1931; Hall & Swaine, 1981; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Letouzey & White, 1970b; Takahashi, 1978; White, 1963; White, 1978b.

Sources of illustration Letouzey & White, 1970a.

Authors A.A. Oteng-Amoako & E.A. Obeng

DIOSPYROS MESPILIFORMIS Hochst. ex A.DC.

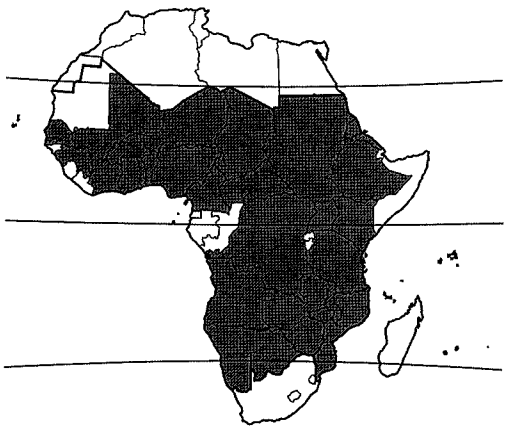
Protologue Prodr. 8: 672 (1844).

Family Ebenaceae

Chromosome number $2n = 30$

Vernacular names African ebony, wild African ebony, West African ebony, swamp ebony, Transvaal ebony, ebony diospyros, monkey guava, jackal berry (En). Ebène d'Afrique, ébène de Mozambique, kaki de brousse (Fr). Ebano africano (Po). Mgiriti, mjoho, mgombe, msindi, mpweke, mkadi (Sw).

Origin and geographic distribution *Diospyros mespiliformis* is extremely widespread, occurring from Senegal east to Eritrea, Ethiopia and Kenya, and south to Namibia, northern South Africa and Swaziland, but it is nearly absent in the more humid forest zones of West and Central Africa. It is also found in Yemen. Trial plantings for fruit production exist in Israel, and *Diospyros mespiliformis* has also been planted in the southern parts of the United States.



Diospyros mespiliformis – wild

Uses The wood is used for posts in house construction, flooring, joinery, furniture, ship building, vehicle bodies, musical instruments such as drums, household utensils such as cups, spoons, pestles and mortars, tool handles, walking sticks, combs, agricultural implements such as ploughs, boxes, carvings and turnery. The heartwood is sometimes blackish and is then used as a substitute for *Diospyros crassiflora* Hiern, e.g. for decorative flooring and interior trim. The bole is used traditionally for dug-out canoes. The wood is also used as firewood, and is valued for charcoal production.

The fruit is sweet but acidulous with a slight lemon-like taste. It is often eaten raw when fully ripe, particularly by children, but sometimes also dried and kept for later use when food is scarce at the end of the dry season. The fruits are also used in the production of fruit juice and alcoholic drinks. They can be ground into a flour, which is sometimes an ingredient of porridge. The seeds are also eaten; they have a nut-like flavour. The leaves are occasionally eaten as vegetable, and the foliage is browsed by livestock. The gum from the bark is used to mend broken pottery, and fruit pulp to glaze and varnish pottery. *Diospyros mespiliformis* is planted for re-afforestation, as ornamental shade tree and as windbreak. The flowers serve as source of nectar for honey bees.

Various parts of the tree are used in traditional medicine. Roasted and pulverized roots are taken to treat jaundice, and root decoctions as anthelmintic, to ease childbirth, and to treat malaria, pneumonia and syphilis. Bark preparations are administered to treat cough, bronchial diseases, tuberculosis, syphilis and leprosy, and applied externally to wounds, ulcers, bruises and furuncles. The bark is also used in veterinary medicine as vermifuge. Leaf decoctions or infusions are taken to treat fever, diarrhoea, dysentery, trypanosomiasis, menorrhagia, whooping cough, hiccough and poisoning. Leaf preparations are externally applied to treat fever, pneumonia, conjunctivitis and otitis, and as haemostatic and antiseptic to wounds, yaws and furuncles. Fruit decoctions or infusions are taken to treat dysentery, diarrhoea and menorrhagia. Fruit ash is applied to fungal skin infections and fruit powder to ul-

cers, whereas seed decoctions are administered against headache. Twigs are chewed to clean the teeth. Various parts of the tree are used in ritual ceremonies.

Production and international trade The wood of *Diospyros mespiliformis* is only traded in very small amounts on the international timber market, and then usually together with the wood of more important ebony producers such as *Diospyros crassiflora*. It is available in local markets, e.g. in Sudan.

In Gambia *Diospyros mespiliformis* is classified amongst the 20 most important timber species. Locally high-quality carvings are in great demand by tourists. The fruits are traded on local markets and may provide vital supplementary income for poor households.

Properties The heartwood is pinkish grey to pinkish brown, darkening to dark brown upon exposure. Some boles have a blackish core up to 25 cm wide. The heartwood is indistinctly demarcated from the slightly paler sapwood. The grain is wavy to interlocked, texture fine and even.

The wood is heavy with a density of (640–)800–900 kg/m^3 at 12% moisture content. It air dries slowly, with some risk of distortion and checking. It takes about 8 weeks to air dry boards of 2.5 cm thick from 60% to 12% moisture content. Kiln drying should be done with care because of a severe risk of case-hardening. The rates of shrinkage are moderate, from green to 12% moisture content 2.5–2.9% radial and 3.9–5.1% tangential, and from green to oven dry about 3.6% radial and 7.3% tangential. Once dried, the wood is stable in service. At 12% moisture content, the modulus of rupture is 93–111 N/mm^2, modulus of elasticity 11,100–11,960 N/mm^2, compression parallel to grain 51–57 N/mm^2, shear 15–19 N/mm^2, Janka side hardness 6750–9470 N and Janka end hardness 10,400 N.

The wood is moderately difficult to saw and work, particularly with hand tools. It may cause serious blunting of saw teeth and cutting edges. The wood surfaces take an excellent polish, but picking up of interlocked grain may occur in planning; a reduced cutting angle of 20° is recommended. The wood finishes well without the use of a filler. It has a tendency to split upon nailing, and pre-boring is advised. The heartwood is durable, being resistant to termite attack, but sometimes susceptible to boring beetles such as *Anobium* spp. The sapwood is liable to attack by blue stain fungi, brown and white rot fungi and *Lyctus*, but it is moderately easily to treat with preservatives by impregnation. Saw dust may cause allergic contact dermatitis and irritation of mucous membranes in wood workers.

The composition of fruits per 100 g edible portion is: water 69 g, energy 404 kJ (97 kcal), protein 1.1 g, fat 0.4 g, carbohydrate 22 g, fibre 6.2 g, Ca 96 mg, Mg 28 mg, P 46 mg, Fe 1 mg, thiamin 0.01 mg, riboflavin 0.04 mg, niacin 0.24 mg and ascorbic acid 24.6 mg. Analysis of the fruits in northern Nigeria showed that only low amounts of antinutritional factors such as oxalate, phytate, saponin and tannin are present. The seeds contain about 9% water and their protein content is 4.9 g per 100 g fresh weight. Fruit extracts showed high radical-scavenging capacity.

The results of tests with mice and rats suggested that stem bark extracts contain an agent with neuropharmacological activity that may be sedative in nature, and the extracts showed antipyretic, analgesic and anti-inflammatory activities, supporting the applications in traditional medicine for relieving pain and fever. Tests with rat skeletal muscle cells showed that bark extracts inhibited intracellular calcium release, which could explain the use of the bark as antihypertensive and anti-diarrhoeal agents. Root, bark and leaf extracts showed antimicrobial activities against bacteria and fungi. The naphthoquinone epoxide diosquinone has been isolated from the root bark. It showed pronounced in-vitro antibacterial as well as cytotoxic activity against several human cancer cell lines. Plumbagin has also been isolated from the roots; this compound also has antibacterial activity.

Adulterations and substitutes The wood of *Diospyros mespiliformis* is sometimes mixed with that of *Diospyros crassiflora* Hiern, which is a more highly valued ebony with blackish heartwood.

Description Evergreen or semi-deciduous, dioecious, small to medium-sized tree up to 25(–40) m tall; bole usually straight and cylindrical, branchless for up to 18 m, up to 150(–200) cm in diameter, sometimes fluted at base or with buttresses; bark surface with longitudinal fissures, exfoliating in rather thin rectangular scales, blackish grey, inner bark black in outer layer, pinkish in inner layer; crown rounded, dense; branches often knobby, grey, young twigs short-hairy. Leaves alternate, simple and entire; stipules absent; petiole 0.5–1 cm long; blade narrowly elliptical to oblong-elliptical or narrowly obovate, 3.5–19 cm × 1.5–

Diospyros mespiliformis – 1, male flower; 2, female flower; 3, part of fruiting branch. Redrawn and adapted by Iskak Syamsudin

7.5 cm, cuneate to rounded at base, acute to slightly acuminate or rounded at apex, thin-leathery, minutely hairy below, pinnately veined with 12–20 pairs of indistinct lateral veins. Flowers axillary, unisexual, regular, 4–5-merous, nearly sessile; calyx with tube about as long as lobes, woolly hairy outside; corolla short-hairy, white to greenish yellow, with narrowly urn-shaped tube and short lobes; male flowers 3 together on a 4–6 mm long peduncle, with c. 3 mm long calyx and c. 6 mm long corolla, stamens c. 14, 4 mm long, with short filaments, ovary rudimentary; female flowers usually solitary, with c. 8 mm long calyx having large lobes with wavy margins and 10–12 mm long corolla, stamens rudimentary, ovary superior, ovoid-conical, c. 3 mm long, 4–6-celled, stigma sessile, 2–3-lobed. Fruit a globose berry up to 2.5 cm in diameter, warty, hairy but becoming glabrous, yellowish and finally purplish when ripe, enclosed at base by calyx, 3–6-seeded. Seeds compressed oblong-ellipsoid, up to 1 cm long, reddish brown to dark brown. Seedling with epigeal germination; hypocotyl c. 6 cm long, thick, epicotyl c. 1 cm long, flattened; cotyledons leafy but slightly fleshy, elliptical, c. 1.5 cm long, early caducous; first two leaves opposite.

Other botanical information *Diospyros* is a large pantropical genus of about 500 species; in mainland tropical Africa about 90 species occur and several produce valuable timber or edible fruits.

Diospyros bussei Gürke (synonym: *Diospyros cornii* Chiov.) is a small evergreen tree up to 15(–18) m tall, occurring in open woodland and wooded grassland in Somalia, eastern Kenya and eastern Tanzania. Its dark brown heartwood is used in ship building and for poles and walking sticks. The fruit is edible.

Diospyros ferrea (Willd.) Bakh. is a small tree up to 15 m tall, with bole up to 30 cm in diameter. It is even more widespread than *Diospyros mespiliformis*, occurring in a wide variety of habitats from Senegal east to Kenya and south to Angola, Zimbabwe, Mozambique and Madagascar, but also in tropical Asia, Australia, Melanesia and Polynesia. In tropical Asia, where *Diospyros ferrea* trees can reach larger dimensions, the heavy wood is used for joinery, furniture, musical instruments, sporting goods, utensils, carvings and turnery. The heartwood can be blackish, often with yellowish streaks, and is sometimes traded as a substitute of *Diospyros ebenum* J.König, which is considered to produce the best commercial black ebony and is native to southern India and Sri Lanka, but has occasionally been planted in botanical gardens in Africa. The fruit pulp of *Diospyros ferrea* is edible. In Madagascar leaf decoctions are used to treat stomach-ache.

Diospyros greenwayi F.White is a shrub or small tree up to 15 m tall, endemic to eastern Kenya and eastern Tanzania. Its wood is occasionally used for poles in house building.

Diospyros kabuyeana F.White is an evergreen small tree up to 15(–25) m tall, endemic to moister forest and riverine forest in eastern Kenya and Tanzania. Its wood is used in house construction, especially for posts, and has been used for making bows.

Diospyros quiloensis (Hiern) F.White is a small deciduous tree up to 10 m tall, native to Tanzania, Malawi, Zambia, Zimbabwe and Mozambique. The black heartwood is distinctly demarcated from the yellowish sapwood and is in great demand for carvings, e.g. for masks and animals for the tourist industry. The wood is sometimes also used in construction because of its great durability. The fruit pulp is edible.

Diospyros senensis Klotzsch is a spiny shrub or

small tree up to 12 m tall, occurring in dry deciduous forest and thickets in southern DR Congo, Malawi, Zambia, Zimbabwe and Mozambique. Its tough wood is used in construction and for tool handles. Root infusions are applied to the chest of children to treat colds.
Diospyros squarrosa Klotzsch is a shrub or small tree up to 12 m tall, occurring from southern DR Congo, Somalia and Kenya south to Zimbabwe and Mozambique. The wood is used for poles and tool handles. The fruit pulp is edible. Decoctions of roots, bark and leaves are administered to treat malaria.
Diospyros verrucosa Hiern is a shrub or small tree up to 15(–18) m tall, endemic to southern Tanzania and northern Mozambique. Its wood is used for poles in house construction and for utensils. The fruit pulp is edible.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; (10: vessels in radial multiples of 4 or more common); 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 24: intervessel pits minute (≤ 4 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 μm; 42: mean tangential diameter of vessel lumina 100–200 μm; 46: ≤ 5 vessels per square millimetre; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 86: axial parenchyma in narrow bands or lines up to three cells wide; (87: axial parenchyma reticulate); 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: (96: rays exclusively uniseriate); (97: ray width 1–3 cells); 109: rays with procumbent, square and upright cells mixed throughout the ray; 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells; 138: prismatic crystals in procumbent ray cells; (154: more than one crystal of about the same size per cell or chamber).
(E. Ebanyenle, A.A. Oteng-Amoako & P. Baas)

Growth and development *Diospyros mespiliformis* grows quite slowly. Seedlings reach about 10 cm tall 2.5 months after germination and 20–30 cm tall after 6 months, and young trees are often only 1–1.5 m tall after 5 years. In northern Cameroon in a region with a mean annual rainfall of 800 mm, the survival rate was 54% and the mean height only 2.4 m 18 years after planting, but in a region with a mean annual rainfall of 1000 mm trees reached an average height of 4.0 m after 12 years. In natural forest in Côte d'Ivoire, the diameter growth was estimated at 5 mm/year over a period of 60 years, and in Benin at 6 mm/year. Young foliage is pinkish to reddish brown, and old leaves become yellow before they fall. The foliage is commonly eaten by elephants, antelopes and buffaloes. The flowers are pollinated by insects such as bees. In West Africa trees usually flower in the second part of the dry season, but elsewhere flowering usually takes place in the rainy season. In southern Africa flowers are most common in October–November. Fruits ripen about 6 months later. They are eaten by baboons, which serve as seed dispersers, although tests in Ghana showed that the germination rate of seeds that passed the digestive organs of baboons was not improved. The fruits are also eaten by other monkeys, antelopes, elephants, jackals, birds such as hornbills, pigeons, parrots and turacos, and fruit bats, which all may disperse seeds. It is said that the tree can live for more than 200 years.

Ecology *Diospyros mespiliformis* occurs in woodland and wooded savanna, sometimes also in fringes of more humid forest, up to 1350 m altitude, rarely up to 2000 m. In many drier regions it is commonly found in riparian forest. The mean annual rainfall in the area of distribution is 300–2000 mm, with a dry season of up to 8 months. *Diospyros mespiliformis* is usually found on more fertile, deep soils, often on alluvial soils and termite mounds, but it is occasionally found on rocky hill slopes. Young trees have been recorded to be sensitive to fire.

Propagation and planting In natural forest in northern Benin, natural regeneration has been reported to be quite good, with about 290 seedlings and 60 saplings per ha. In central Côte d'Ivoire about 280 seedlings and saplings were counted per ha. *Diospyros mespiliformis* often regenerates abundantly in dry secondary forest.
Diospyros mespiliformis is usually propagated by seeds. Fruits should be collected from the tree when they start to become yellow, to avoid competition by animals such as birds. Seeds

should be depulped and cleaned in running water, and subsequently dried in the sun before storage. There are 2400–3200 seeds per kg. The seeds usually germinate within 6 weeks. They can be stored for several years in airtight containers at 3°C and about 5% moisture content, but at room temperature for not more than one year. Scalding the seeds for 3–7 minutes accelerates germination, as well as partial removal of the seed coat by nicking. However, in Malawi a germination rate of more than 80% was achieved by simply cleaning and soaking the seeds. In Burkina Faso grafting experiments showed promising results. Root suckers can also be used for propagation. Young trees are difficult to transplant; sowing on the permanent site is recommended.

Management In most parts of its distribution area, *Diospyros mespiliformis* is neither particularly rare nor particularly abundant. Only very locally it is abundant or dominant. In the Sudano-Sahelian zone, *Diospyros mespiliformis* is characteristic for terrace sites in agroforestry landscapes with millet and maize cultivation. In southern Africa trees are often left when clearing land for agricultural fields so that fruits can be harvested. Tests in Côte d'Ivoire and Ghana showed that the application of an inorganic NPK fertilizer may have significant effect on the height and diameter growth of seedlings. Trees can be coppiced and pruned.

Diseases and pests Fruits are eaten by numerous animals, often already before they are fully ripe. Seeds are commonly attacked by boring insects and should be protected when stored.

Harvesting Some caution is needed during harvesting operations because logs of large trees may have brittle heart or may be hollow. In Benin a minimum bole diameter of 35 cm and a cutting cycle of 25 years have been recommended for harvesting, but this seems to be inadequate for sustainable harvesting.

Yield A bole of 50 cm in diameter harvested in northern Côte d'Ivoire was estimated to yield 1 m^3 of wood.

Handling after harvest Due to the high density of the wood logs do not float in water and cannot be transported by river. After cutting, the heartwood of logs slowly becomes darker, sometimes to black, and burying has been reported to accelerate the process of darkening.

Genetic resources *Diospyros mespiliformis* is extremely widespread and there is no reason to consider it as threatened by genetic erosion. However, it is locally extensively exploited for timber and firewood and may be under pressure in some regions.

Prospects *Diospyros mespiliformis* is a true multipurpose tree, which is of great importance to local communities of African people. It does not only provide wood, but also edible fruits, traditional medicines and forage. Moreover, it plays an important role in the ecosystem, providing food to numerous animals. More research on this species is therefore warranted, particularly on propagation and planting, and on growth rates under different circumstances. More detailed pharmacological studies are recommended because the interesting medicinal properties found in research might be developed into new drugs.

Major references Bolza & Keating, 1972; Burkill, 1994; CAB International, 2010; Chilufya & Tengnäs, 1996; Janick & Paull (Editors), 2006; Maundu & Tengnäs (Editors), 2005; Neuwinger, 2000; Orwa et al., 2009; White, 1987; White, 1988.

Other references Adeniyi et al., 2003; Adzu et al., 2002a; Adzu et al., 2002b; Ahawaadong, 2006; Arbonnier, 2004; Chikamai et al., undated; CIRAD Forestry Department, 2008; Coates Palgrave, 1983; de la Mensbruge, 1966; Dupriez & De Leener, 1989; Keay, 1989; Lajubutu et al., 1995; Osei-Begyina, 2007; Palmer & Pitman, 1972–1974; Prins & Maghembe, 1994; Takahashi, 1978; Umaru et al., 2007; van Wyk & Gericke, 2000; White, 1983; White & Verdcourt, 1996.

Sources of illustration White, 1963; White, 1987.

Authors H.H. El-Kamali

DIOSPYROS SANZA-MINIKA A.Chev.

Protologue Veg. Ut. Afr. Trop. Franç. 5: 155 (1909).

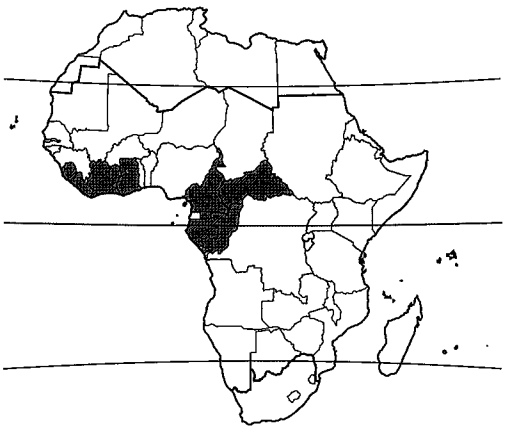
Family Ebenaceae

Chromosome number $2n = 30$

Vernacular names African ebony, Liberia ebony (En).

Origin and geographic distribution *Diospyros sanza-minika* occurs from Sierra Leone to Ghana, and from Cameroon to Gabon and Congo.

Uses The wood of *Diospyros sanza-minika* is used for poles and wattles in house construction, mine props, implements, utensils, handles, game traps, cages, shafts of spears and



Diospyros sanza-minika – wild

harpoons, and turnery. It is suitable for heavy flooring, joinery, ship building, vehicle bodies, sporting goods, toys, novelties, draining boards and carvings. The wood is also used as firewood. In traditional medicine, a poultice of pulped leaves is applied as anodyne.

Production and international trade The wood of *Diospyros sanza-minika* is rarely exported and almost exclusively used domestically. There is no information available on trade statistics.

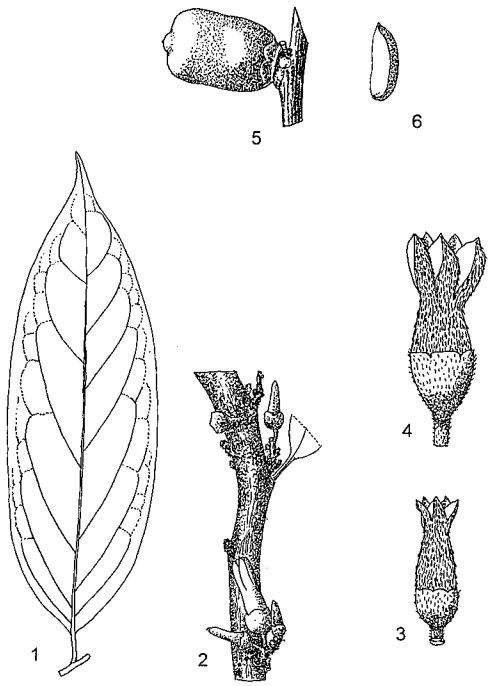
Properties The heartwood is greyish white to pinkish when freshly cut, darkening to brownish with black streaks or occasionally black near the centre of the log; it is indistinctly demarcated from the sapwood. The grain is straight to interlocked, texture fine.

The wood is medium-weight to heavy, with a density of 630–980 kg/m^3 at 12% moisture content, and hard. The rates of shrinkage are quite high. Once dry, the wood is unstable in service. At 12% moisture content, the modulus of rupture is 132–180 N/mm^2, modulus of elasticity 13,130–15,880 N/mm^2, compression parallel to grain 54–72 N/mm^2, cleavage 15–19 N/mm, Janka side hardness 10,850 N and Chalais-Meudon side hardness 8.1–8.8.

The wood is rather difficult to saw and work with both hand and machine tools; it causes a serious dulling effect on saw teeth and cutting edges. The wood planes to a good finish and takes a high polish, but some picking up may occur when interlocked grain is present; a reduced cutting angle is recommended. The wood holds nails moderately well, but pre-boring is advised. The wood is liable to attacks by sap stain fungi. It is moderately durable, being hardly attacked by termites but susceptible to marine borers and occasionally to pinhole borers. The sapwood is permeable to preservatives by impregnation. Saw dust may cause irritation of skin and throat in wood workers.

Several norbergenin derivatives have been isolated from the bark, some of which showed radical scavenging properties and in-vitro antimalarial activity against *Plasmodium falciparum*.

Description Evergreen small to medium-sized tree up to 25(–40) m tall; bole branchless for up to 20 m, straight, cylindrical, up to 60(–100) cm in diameter, usually without buttresses; bark surface deeply fissured, blackish, very hard, inner bark thin, pinkish; crown usually small, narrow to rounded, with horizontal branches; young twigs nearly glabrous. Leaves alternate, simple and entire; stipules absent; petiole 0.5–1(–1.5) cm long, grooved above, glabrous; blade lanceolate-elliptical to oblong-elliptical, 12–27 cm × 3–10 cm, cuneate at base, short-acuminate at apex, leathery, dark short-hairy below when young, pinnately veined with 7–12 pairs of lateral veins. Inflorescence an axillary fascicle, often on older branches, (1–)



Diospyros sanza-minika – 1, leaf; 2, part of branch with male flowers; 3, male flower; 4, female flower; 5, fruit; 6, seed.
Redrawn and adapted by Iskak Syamsudin

3–5-flowered. Flowers unisexual, regular; pedicel up to 3(–5) mm long; calyx cup-shaped, up to 8 mm long, yellowish brown short-hairy, entire or indistinctly lobed at apex; corolla c. 2 cm long, fleshy, densely appressed brownish hairy outside, white or pinkish inside, with c. 1 cm long tube and (3–)4–5 lobes up to 1 cm long; male flowers with corolla lobes about as long as tube, stamens 20–24, c. 5 mm long, with very short filaments, usually glabrous; female flowers with corolla lobes shorter than tube, rudimentary stamens 5–6, ovary superior, ovoid, c. 4 mm long, densely hairy, 6–8-celled, styles 3–4. Fruit an ellipsoid-cylindrical to slightly 4-angled berry, up to 5 cm × 4.5 cm, reddish brown hairy but becoming glabrous, yellow when ripe, 4–8-seeded. Seeds oblong-cylindrical, 2–3 cm long, brown to blackish. Seedling with epigeal germination; hypocotyl 4–7 cm long, thick, epicotyl 3–5 cm long, hairy; cotyledons staying within the seed coat, leafy, c. 3 cm long, early caducous; first 2 leaves opposite, dark red.

Other botanical information *Diospyros* is a large pantropical genus of about 500 species; in mainland tropical Africa about 90 species occur and several produce valuable timber or edible fruits.

Diospyros boala De Wild. is a small to medium-sized tree up to 25 m tall, occurring in Cameroon, Gabon and DR Congo. Its wood is locally used for implement handles.

Diospyros conocarpa Gürke & K.Schum. is a small tree up to 10 m tall, occurring from Nigeria to DR Congo and Cabinda (Angola). Its wood is locally used in house building.

Diospyros cooperi (Hutch. & Dalziel) F.White is a shrub or small tree up to 13 m tall, occurring from Sierra Leone to Ghana. The slender boles are used for posts and rafters in house construction. A leaf decoction produces a black dye.

Diospyros elliotii (Hiern) F.White is a small tree up to 11 m tall with short bole up to 40 cm in diameter, characteristic for gallery forest in savanna regions and the inner edges of mangroves from Senegal to Nigeria. The wood is used for implements and handles, and branches for game traps. The tree is a source of firewood. Twigs serve as chew sticks and the fruit pulp is edible.

Diospyros iturensis (Gürke) Letouzey & F.White is a small to medium-sized tree up to 20 m tall, occurring from Nigeria east to the Central African Republic and south to DR Congo and northern Angola. Its wood is locally used for poles, utensils and handles. Bark infusions are administered in local medicine to treat bronchitis.

Diospyros mannii Hiern is a small to medium-sized tree up to 20(–30) m tall, with bole up to 30(–60) cm in diameter. Its distribution area is quite similar to that of *Diospyros sanza-minika*, from Sierra Leone east to the Central African Republic and south to Cabinda (Angola). The blackish heartwood with greyish streaks which is present in the core of the bole of old trees is heavy, with a density of about 950 kg/m^3 at 12% moisture content, and is locally used for utensils and handles. The wood is suitable for similar purposes as the wood of *Diospyros sanza-minika*, but is rarely available in larger dimensions. The large fruits, which are up to 10 cm long and have irritating hairs, provide edible pulp and seed arils, which are said to have an excellent taste similar to muskmelon. In traditional medicine, pulped bark is applied to fractures and used in mixtures to treat intestinal complaints.

Diospyros polystemon Gürke is an evergreen small to medium-sized tree up to 20(–30) m tall, occurring from Cameroon to DR Congo and northern Angola. Its wood is locally used for implement handles.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 24: intervessel pits minute (≤ 4 µm); 25: intervessel pits small (4–7 µm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 µm; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 86: axial parenchyma in narrow bands or lines up to three cells wide; 87: axial parenchyma reticulate; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 96: rays exclusively uniseriate; (97: ray width 1–3 cells); 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square mar-

ginal cells; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; (137: prismatic crystals in upright and/or square ray cells); 142: prismatic crystals in chambered axial parenchyma cells.
(L. Awoyemi, A.A. Oteng-Amoako & P. Baas)

Growth and development *Diospyros sanza-minika* grows slowly. Young foliage of trees is red. In West Africa flowering is usually from March to July, but in Côte d'Ivoire sometimes also in November–December. Fruits ripen about 3 months later, often towards the end of the rainy season, but they may persist for more than 6 months. They are eaten by animals such as chimpanzees, which probably serve as seed dispersers.

Ecology *Diospyros sanza-minika* occurs in humid evergreen forest up to 500 m altitude, preferring well-drained, base-poor and acidic soils and avoiding swamps and rocky sites.

Propagation and planting Although *Diospyros sanza-minika* is considered a shade bearer, vigorous saplings are most common in small to medium-sized gaps in the forest. In forest in Ghana germination of seeds is usually recorded in May–June.

Harvesting Caution is needed during harvesting operations because logs may have brittle heart.

Genetic resources *Diospyros sanza-minika* is locally common in West Africa, e.g. in some regions in Côte d'Ivoire and Ghana, but it seems to be less common in Central Africa. It may become endangered by genetic erosion as a result of on-going deforestation.

Prospects Although *Diospyros sanza-minika* does not produce the blackish ebony wood which is in high demand on the international market, its wood is valued for domestic uses. It seems to have little prospects as commercial timber tree, but research on its propagation and sustainable management in natural forest is recommended. The antimalarial properties of the bark deserve more research attention because they may offer possibilities for the development of new drugs.

Major references Bolza & Keating, 1972; Burkill, 1994; de Koning, 1983; Irvine, 1961; Kryn & Fobes, 1959; Kunkel, 1965; Letouzey & White, 1978c; Sallenave, 1955.

Other references Aubréville, 1959c; Cooper & Record, 1931; Danforth & Noren, 1997; de la Mensbruge, 1966; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Letouzey & White, 1970b; Neuwinger, 2000; Raponda-Walker & Sillans, 1961; Savill & Fox, 1967; Takahashi, 1978; Tangmouo et al., 2009; Tangmouo et al., 2010; Taylor, 1960; Vivien & Faure, 1985; White, 1963; White, 1978b; White, 1987.

Sources of illustration Letouzey & White, 1978c.

Authors E.A. Obeng & A.A. Oteng-Amoako

DISTEMONANTHUS BENTHAMIANUS Baill.

Protologue Hist. pl. 2: 135 (1870).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 24$

Vernacular names African satinwood, yellow satinwood (En). Movingui (Fr).

Origin and geographic distribution *Distemonanthus benthamianus* occurs from Guinea and Sierra Leone eastward to Cameroon, and southward to Gabon and southern Congo.

Uses The wood, traded as 'movingui', 'African satinwood' and 'yellow satinwood', is used for a variety of purposes such as heavy construction including hydraulic works, heavy flooring, carpentry, mine props, ship building, vehicle bodies, railway sleepers, furniture for interior as well as exterior use, cabinet making, sporting goods, musical instruments, crates, boxes, agricultural implements, tool handles, vats for chemical products, shingles, carvings, turnery, veneer and plywood. It is also used as firewood and for charcoal production.
The bark is used in traditional medicine. Pounded bark is applied to skin complaints including furuncles and abscesses, used as a sniff against epilepsy, taken to treat palpitation and used as an enema to treat hepatitis. Bark decoctions are used in a bath or as a va-

Distemonanthus benthamianus – wild

pour bath to treat bronchitis, rheumatism, and fever including malaria. In Nigeria twigs are used as chewing sticks. The yellow dye from the roots has been used for body decoration. The tree is used in many local ritual ceremonies.

Production and international trade In 1983 Côte d'Ivoire exported 38,000 m³ of 'movingui' logs, but only 180 m³ in 1996. In 1999 'movingui' timber ranked 10th on the list of most important export timbers of Gabon, with 28,000 m³ of logs exported. In 2000 Gabon exported 36,000 m³ of logs, but the amount decreased to 12,000 m³ in 2009. In 2004 Congo exported 4000 m³ of sawn *Distemonanthus benthamianus* wood at an average price of US$ 134/m³, and 1200 m³ in 2009. In 2005 export of sawn wood from Cameroon was 14,000 m³ at an average price of US$ 340/m³, and in 2006 12,000 m³ at an average price of 514/m³. In 2009 Cameroon exported 5000 m³ of logs and 5500 m³ of sawn wood. The bark is sold in local markets in Gabon for medicinal purposes. In Ghana considerable volumes of *Distemonanthus benthamianus* wood are exported, mainly as sliced veneer and mouldings.

Properties The heartwood is yellow to golden yellow, darkening to orange-brown upon exposure, sometimes with pinkish brown streaks, and distinctly demarcated from the whitish to greyish or straw-coloured, up to 4 cm wide sapwood. The grain is wavy to interlocked, texture medium to fine and even. The wood is slightly lustrous and quite decorative. Radial surfaces show a ribbon figure. The wood is not recommended for the manufacture of laundry and kitchen equipment because it often contains a yellow, water-soluble extractive.

The wood is medium-weight to fairly heavy, with a density of 570–860 kg/m³ at 12% moisture content, and fairly hard. It air dries well but quite slowly, with little degrade, but with a slight tendency of developing end checks and surface checks. The rates of shrinkage are low to medium, from green to oven dry 3.0–4.4% radial and 5.0–7.2% tangential. Once dry, the wood is moderately stable to stable in service.

At 12% moisture content, the modulus of rupture is (103–)140–207 N/mm², modulus of elasticity 8400–12,950(–14,740) N/mm², compression parallel to grain 45–69(–85) N/mm², shear 12.5–14.5 N/mm², cleavage 12.5–21.5 N/mm, Janka side hardness 5470–6290 N, Janka end hardness 7330 N and Chalais-Meudon side hardness (2.9–)4.3–7.7.

The sawing and working characteristics are variable depending on the amounts of silica and exudate in the wood. Fresh wood is quite easy to saw, but dry wood more difficult and may cause over-heating of saw blades. When the silica content is high, stellite-tipped saw teeth and tungsten-carbide cutting edges are recommended; the wood may contain up to 1.3% silica. Quarter-sawn surfaces may show picking up of grain in moulding and planing operations, and a reduced cutting angle of 20° is recommended. The wood can take a nice finish and polishes well when a filler is used. The nailing and screwing characteristics are variable; splitting may be a problem and pre-boring is advised, but the wood holds nails and screws well. It glues satisfactorily. The use of a filler is recommended before painting. The steam bending properties are good. The wood can be sliced for the production of good-quality veneer. It can also be peeled, but this is rarely done because the veneer is not nicely figured. Steaming of the wood for 48 hours before slicing or peeling is needed to obtain veneer with a good flexibility. Tests showed that the wood is well suited for the production of glued laminated elements.

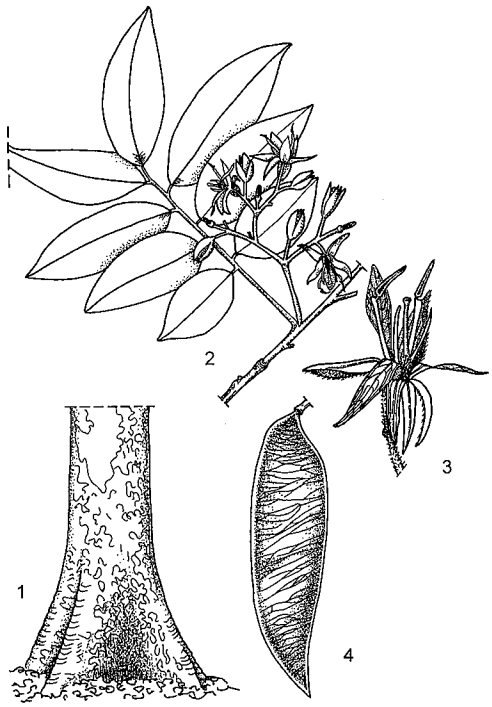
The heartwood is moderately durable, being moderately resistant to fungal and termite attacks, and quite resistant to dry-wood borer attack. In tests in Turkey, the wood showed good durability against marine borers, but this may depend on the silica content. The heartwood is resistant to impregnation with preservatives. The saw dust may cause dermatitis in wood workers.

The wood contains 37% cellulose, 27% lignin, 12.5% pentosan, 2.7% ash and (0.2–)0.4–0.8 (–1.3)% silica. The solubility is 13.0% in alcohol-benzene, 1.3% in hot water and 16.1% in a 1% NaOH solution.

Aqueous and chloroform extracts of the bark showed in-vitro antibacterial activity against several bacteria implicated in oral and dental infections. The extract contained tannins, steroids, saponins and alkaloids.

Adulterations and substitutes In Ghana the wood of *Distemonanthus benthamianus* is considered a substitute for the woods of *Sterculia oblonga* Mast., *Nauclea diderrichii* (De Wild. & T.Durand) Merr. and *Piptadeniastrum africanum* (Hook.f.) Brenan. The wood properties are comparable to European beech and oak.

Description Deciduous medium-sized to large tree up to 40 m tall; bole branchless for up to 25 m, usually straight and cylindrical, up to



Distemonanthus benthamianus – 1, base of bole; 2, flowering twig; 3, flower; 4, fruit. Redrawn and adapted by G.W.E. van den Berg

130 cm in diameter, often with short, rounded buttresses; bark surface smooth, orange to red, becoming pale green to yellowish, peeling off in large, irregular patches, inner bark thin, fibrous, cream-coloured to orange or pink-brown, sticky; crown umbrella-shaped, fairly open; twigs short-hairy but soon glabrous, purplish. Leaves alternate, imparipinnately compound with (4–)7–11(–13) leaflets; stipules narrowly oblong, c. 7 mm long, caducous; petiole (1–)2–4 cm long, rachis 6–18 cm long; petiolules 3–6 mm long; leaflets alternate, ovate to elliptical, (3.5–)5–10 cm × (1.5–)2.5–5 cm, rounded at base, usually short-acuminate at apex, thick-papery, slightly hairy below, pinnately veined with 8–13 pairs of lateral veins. Inflorescence an axillary panicle-like cyme up to 10(–30) cm long, short-hairy. Flowers bisexual, slightly zygomorphic, showy; pedicel slender, up to 1 cm long, hairy; sepals 5, free, lanceolate, c. 1 cm long, 2 broader than other 3, recurved, reddish brown; petals 3, free, narrowly elliptical, slightly longer than sepals, 1 slightly broader than other 2, white; stamens 2, up to 1.5 cm long, rudimentary stamens 3; ovary superior, c. 0.5 cm long, brown hairy, 1-celled, style c. 0.5 cm long, glabrous. Fruit a flattened elliptical pod 7–13 cm × 2.5–3.5 cm, papery, reticulately veined, indehiscent, 2–5-seeded. Seeds flattened elliptical, c. 1 cm × 0.5 cm, glossy brown. Seedling with epigeal germination; hypocotyl 4–5 cm long, quadrangular, epicotyl c. 0.5 cm long; cotyledons leafy, obovate, up to 2 cm long; first 2 leaves opposite, simple.

Other botanical information *Distemonanthus* comprises a single species and seems to have a rather isolated position.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 25: intervessel pits small (4–7 μm); 26: intervessel pits medium (7–10 μm); (27: intervessel pits large (≥ 10 μm)); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 80: axial parenchyma aliform; 82: axial parenchyma winged-aliform; 83: axial parenchyma confluent; (85: axial parenchyma bands more than three cells wide); (89: axial parenchyma in marginal or in seemingly marginal bands); 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 113: disjunctive ray parenchyma cell walls present; 115: 4–12 rays per mm. Storied structure: 118: all rays storied; 120: axial parenchyma and/or vessel elements storied. Mineral inclusions: 136: prismatic crystals present; 140: prismatic crystals in chambered upright and/or square ray cells; 142: prismatic crystals in chambered axial parenchyma cells; 159: silica bodies present; 160: silica bodies in ray cells; 161: silica bodies in axial parenchyma cells.
(R. Shanda, P.E. Gasson & E.A. Wheeler)

Growth and development Growth of seedlings in the nursery is slow; they reach 10–25 cm in height after 5 months. In Guinea they were on average 100 cm tall when planted in

moderate shade and 160 cm in full sun 2 years after planting. The survival rate of seedlings planted at 625 plants/ha in Gabon was 100% after one year when planted in the open as well as in opened-up forest, and after 6 years it was 80% and 60%, respectively. After 6 years the mean height was 11 m and the mean bole diameter 10 cm when planted in the open and 6.5 m and 4.5 cm, respectively, when planted in the forest. After 11 years the mean height was 16.5 m and the mean bole diameter 11.5 cm in the open and 11 m and 6 cm, respectively, in the shade. The mean annual diameter growth of the bole in natural forest is estimated at 3–4 mm. In an arboretum in Cameroon, the mean annual diameter growth of planted trees without thinning was 5 mm, but it varied widely from 1 mm to 11 mm.

Trees may start to fruit when the bole is only 20 cm in diameter, but only trees with a bole diameter of more than 40 cm fruit regularly. The tree is leafless for a short period. New foliage is coppery red and followed by the quite conspicuous flowers. In Liberia flowering is in January–February and in Ghana usually in February–July, and fruits ripen about 6 months later. Fruiting is reported to be sparse and not annually. In Central Africa fruiting usually occurs at the end of the short dry season. The fruits are dispersed by wind up to 50 m from the mother tree. Monkeys and parrots feed on the seeds. The roots are associated with mycorrhizae.

Ecology *Distemonanthus benthamianus* occurs in evergreen and moister types of semi-deciduous forest, also in disturbed forest but not in swampy locations. In West Africa it is more common in moist semi-deciduous forest than in evergreen forest. It prefers regions with a mean annual rainfall of 2000 mm. It does not appear to have any soil preference.

Propagation and planting *Distemonanthus benthamianus* is classified as a non-pioneer light demander, and natural regeneration is limited in mature forest; few saplings are found in forest with a closed canopy. However, seedlings and saplings can be found in the understorey of the forest and tolerate shade. Regeneration in disturbed forest may occur, but is neither abundant. However, in Gabon seedlings have been reported to be locally abundant in secondary and planted forests. To promote regeneration, it was proposed to open the forest canopy just before the trees fruit.

The seeds are difficult to collect, mainly because fruiting is irregular. There are about 2500 seeds per kg. The seeds take 2–6.5 weeks, sometimes to 5 months, to germinate after sowing and the germination rate is generally moderate, in Guinea 13–26%, although it has also been reported to be 90%. Soaking the seeds in water for 24 hours or in sulphuric acid for 30 minutes promotes germination. The fastest growing seedlings are about 40 cm tall and ready for planting when 4–5 months old, but generally they need to stay in the nursery for at least one year. Wildlings are occasionally collected for planting. A spacing of 3 m × 3 m is recommended for planting in the field. *Distemonanthus benthamianus* is sometimes planted in mixtures with other species having similar growth rates, such as *Nauclea diderrichii* (De Wild. & T.Durand) Merr., *Afzelia bella* Harms, *Bussea occidentalis* Hutch. and *Paramacrolobium coeruleum* (Taub.) J.Léonard.

Management *Distemonanthus benthamianus* usually occurs scattered in the forest, occasionally in small groups. In Ghana the average wood volume has been estimated at 0.6 m³/ha and the total exploitable volume of trees with a bole diameter of more than 70 cm at 250,000 m³; the annual allowable cut volume is 6300 m³. In Cameroon the average density is up to 0.3 trees with a bole diameter of more than 60 cm per ha, with a mean wood volume of up to 2 m³/ha. In Gabon the average wood volume has been estimated at 0.3 m³/ha.

Harvesting Some caution is needed at felling because the bole may have internal stresses and wind shakes. The minimum bole diameter allowed for harvesting is 60 cm in Côte d'Ivoire and Cameroon and 70 cm in Ghana and Gabon.

Yield One large tree may yield 8–15 m³ of wood.

Handling after harvest Logs are fairly durable and can be left in the forest for some time after felling without serious deterioration. However, the sapwood is susceptible to fungal and borer attacks, and deep splits may develop in the logs if they are left too long. Logs sink in water and cannot be transported by river.

Genetic resources *Distemonanthus benthamianus* is widespread, but usually occurs scattered in the forest in low densities. In general, it does not seem to suffer from genetic erosion at present, also because it is commonly found in secondary forest and is exploited on a moderate level, but locally it may be vulnerable, e.g. in southern Cameroon where it is considered to be susceptible to genetic erosion due to logging activities. Monitoring of the popula-

tions is recommended.
An analysis of the spatial genetic structure of *Distemonanthus benthamianus* in Cameroon and Gabon showed the existence of 3 clearly differentiated gene pools, probably as a result of forest fragmentation in cool and dry periods in the past when the species survived in some relict populations, from which it expanded again when the climate became warmer and wetter.

Prospects There is an export market for the durable and multipurpose timber of *Distemonanthus benthamianus*. In Ghana it has been suggested as a substitute of similar timbers which have become rare due to over-exploitation, whereas in several Central African countries it already has established a position amongst the more important export timbers. Natural regeneration is sparse, and this may hamper sustainable exploitation from the forest. Research is needed on appropriate methods of silvicultural management.

Major references Bolza & Keating, 1972; Burkill, 1995; CIRAD Forestry Department, 2008; CTFT, 1947; Debout, Doucet & Hardy, 2011; Guiscafre & Sales, 1975; Koumba Zaou et al., 1998; Oteng-Amoako (Editor), 2006; Takahashi, 1978; Voorhoeve, 1979.

Other references Adjanohoun et al. (Editors), 1988; Aiyegoro et al., 2008; ATIBT, 1986; Aubréville, 1968; Aubréville, 1970; Christy et al., 2003; de la Mensbruge, 1966; de Saint-Aubin, 1963; Gassita et al. (Editors), 1982; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Irvine, 1961; Keay, 1989; Neuwinger, 2000; Ngavoura, 1990; Raponda-Walker & Sillans, 1961; Siepel, Poorter & Hawthorne, 2004; Tailfer, 1989; Vivien & Faure, 1985; White & Abernethy, 1997.

Sources of illustration Voorhoeve, 1979; Wilks & Issembé, 2000.

Authors F.W. Owusu & D. Louppe

DRYPETES GERRARDII Hutch.

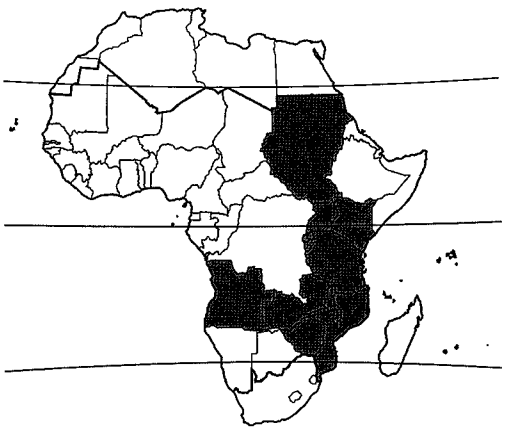
Protologue Dyer, Fl. cap. 5(2): 405 (1920).

Family Euphorbiaceae (APG: Putranjivaceae)

Synonyms *Drypetes battiscombei* Hutch. (1924).

Vernacular names Bastard white ironwood, forest ironwood, forest ironplum, hairy drypetes (En). Kihambie (Sw).

Origin and geographic distribution *Drypetes gerrardii* is widespread from southern Sudan, Uganda and Kenya south to Angola, Zimbabwe, Mozambique, eastern South Africa and Swaziland.



Drypetes gerrardii – wild

Uses The wood known in Kenya as 'munyenye' and in southern Africa as 'white bastard wood' is locally used, mainly for poles in construction, and for joinery, furniture, tool handles and utensils. It is suitable for flooring, mine props, ship building, vehicle bodies, sporting goods, boxes, crates, agricultural implements and turnery. Locally in South Africa small *Drypetes gerrardii* trees with a bole diameter of 3–10 cm are popular for poles in house building and fencing. The wood is also used as firewood and for charcoal production.
In traditional medicine, a root decoction is taken to treat stomach-ache, and ground roots and leaves are administered with water to treat gonorrhoea. The flowers provide nectar for honey bees.

Properties The heartwood is whitish, turning pale yellowish to greyish upon exposure, with occasional brownish streaks, and indistinctly demarcated from the wide sapwood. The grain is straight, occasionally slightly interlocked, texture fine and even.
The wood is medium-weight to heavy, with a density of 710–815 kg/m^3 at 12% moisture content, and hard. It air dries slowly but well, with only slight end-checking and warping. The rates of shrinkage during drying are quite high. Once dry, the wood is stable in service. At 12% moisture content, the modulus of rupture is 147 N/mm^2, modulus of elasticity 18,230 N/mm^2 and compression parallel to grain 68 N/mm^2.
The wood saws and works moderately well with machine tools. It planes to a smooth sur-

face. It has a tendency to split upon nailing and screwing, and pre-boring is advised. The peeling and slicing characteristics are not favourable. The wood is moderately durable. It is liable to termite attack, but in South Africa it has been recorded to be resistant to termites. The sapwood is liable to *Lyctus* attack, and the wood is susceptible to marine borers. The heartwood is resistant to treatment with preservatives, the sapwood is moderately resistant.

Several triterpenoids, a steroid and a flavone dimer have been isolated from the leaves.

Description Evergreen, dioecious shrub or small to medium-sized tree up to 20(–35) m tall; bole branchless for up to 10 m, straight, up to 40(–50) cm in diameter, often fluted at base or with sharp buttresses; bark surface grey or greyish brown, usually smooth, sometimes flaking in rounded scales, inner bark yellowish white to orange with white flecks; crown dense and narrow with more or less horizontal branches; twigs drooping, greyish, finely hairy. Leaves alternate, simple; stipules triangular, c. 1 mm long, soon caducous; petiole 3–10 mm long; blade ovate to rhombic-elliptical or lanceolate, 2–14(–17) cm × 1–7(–9) cm, cuneate to rounded and asymmetrical at base, acute to acuminate at apex, margins toothed to nearly entire, thin-leathery, yellowish hairy along midrib or nearly glabrous, pinnately veined with 5–9 pairs of lateral veins. Flowers unisexual, regular, 4-merous; pedicel up to 4 mm long; sepals rounded, c. 3 mm in diameter, whitish yellow, densely yellowish hairy; petals absent; male flowers in an axillary few-flowered fascicle, with 4 stamens c. 3 mm long, disk 4-lobed; female flowers solitary, with shallowly cup-shaped disk, ovary superior, densely hairy, 2-celled, styles 2, free, reflexed, up to 1.5 mm long. Fruit an obovoid to nearly globose, slightly 2-lobed, fleshy drupe 1–1.5 cm long, short-hairy, yellowish to reddish-orange when ripe, indehiscent, 1–2-seeded. Seeds compressed-ovoid, c. 1 mm long, brownish with whitish streaks.

Drypetes gerrardii – 1, tree habit; 2, twig with male fowers; 3, twig with fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Drypetes gerrardii* is variable and some varieties have been distinguished, mainly based on leaf sizes and hairiness of young shoots and petioles.

Drypetes comprises about 210 species and is distributed throughout the tropics and subtropics. About 60 species occur in continental Africa and about 15 in the Indian Ocean islands. The wood of several other *Drypetes* spp. is used locally in tropical Africa.

Drypetes afzelii (Pax) Hutch. is a shrub or small tree up to 10 m tall, occurring in West Africa, from Sierra Leone to Ghana. Its greyish to pale brown wood is hard, durable and quite resistant to termites and probably used for construction. The gum from the bole is rubbed on the body because of its aromatic scent. *Drypetes afzelii* is classified as vulnerable in the IUCN Red List because it is uncommon and suffered from decline of its habitat, i.e. wet evergreen forest.

Drypetes arguta (Müll.Arg.) Hutch. is a shrub or small tree up to 8 m tall, occurring from Tanzania south to eastern South Africa. In South Africa small logs, with a mean length of 150 cm and mean diameter of 22 cm, are used for wall laths in building traditional houses, and the wood is used for sticks. The fruits are edible and used to make an intoxicating drink.

Drypetes aubrevillei Leandri is a small to medium-sized tree up to 25 m tall with bole up to 50 cm in diameter. It is found in West Africa, from Sierra Leone to Ghana. Its pale yellow wood is heavy, with a density of about 960 kg/m^3 at 12% moisture content, and hard. It is

used in house construction. The bark is used in traditional medicine; it is applied externally to treat bronchitis, lumbago, rheumatism and kidney pain, and is taken as expectorant.

Drypetes aylmeri Hutch. & Dalziel is a small tree up to 13 m tall, with bole up to 25 cm in diameter. It is also found in West Africa, from Sierra Leone to Ghana. Its whitish wood is hard, durable and quite resistant to termites, and used in house construction.

Drypetes bathiei Capuron & Leandri is a shrub up to 4 m tall, occurring in northern and eastern Madagascar. Its hard wood is used for construction, tool handles and sticks.

Drypetes caustica (Frapp. ex Cordem.) Airy Shaw is a small to medium-sized tree up to 20 m tall, endemic to Réunion and Mauritius. The wood has been used for construction, but *Drypetes caustica* has become rare and exploitation should be discouraged.

Drypetes floribunda (Müll.Arg.) Hutch. is a small tree up to 10 m tall, occurring from Senegal east to DR Congo in dry forest and savanna. Its whitish wood is hard and used in house construction and for poles, and also as firewood. The pulp of the orange-red fruits is edible, and twigs are used as chew-sticks for cleaning the teeth.

Drypetes gilgiana (Pax) Pax & K.Hoffm. is a shrub or small tree up to 10(–15) m tall, with bole up to 25 cm in diameter. It occurs from Senegal east to Cameroon in various forest types. Its pale brown wood is hard, and used in traps for animals and probably also for construction. The pulp of the orange-red fruits is sweet and edible, but not commonly consumed.

Drypetes gossweileri S.Moore is a medium-sized tree up to 30(–40) m tall, with bole up to 100(–120) cm in diameter, occurring from Nigeria east to the Central African Republic and DR Congo. Its pale yellowish brown wood, with a density of 760–800 kg/m^3 at 12% moisture content, is commonly used in house building and for joinery. However, the applications of the bark in traditional medicine are more important.

Drypetes mossambicensis Hutch. is a shrub or small to medium-sized tree up to 20 m tall, with bole up to 60 cm in diameter. It is found in woodland, often along rivers, in Malawi, Zambia, Zimbabwe, Mozambique and northern South Africa. The pale brown to yellowish brown wood, which has a density of about 970 kg/m^3 at 12% moisture content, is used for household utensils and ornaments. The fruits are edible and locally popular.

Drypetes parvifolia (Müll.Arg.) Pax & K.Hoffm. is a shrub or small tree up to 6 m tall. It occurs in West Africa from Sierra Leone to Nigeria, and in East Africa in Kenya and Tanzania. Its wood is locally used in house construction, mainly for poles.

Drypetes roxburghii (Wall.) Hurus. originates from tropical Asia and has been introduced in some regions of West and East Africa, where it is mainly planted as ornamental shade tree. In tropical Asia its wood is used for construction and turnery, whereas the leaves and fruits are used in traditional medicine and the leaves as forage.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; (10: vessels in radial multiples of 4 or more common); 13: simple perforation plates; 22: intervessel pits alternate; 25: intervessel pits small (4–7 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 μm; 47: 5–20 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; (86: axial parenchyma in narrow bands or lines up to three cells wide); 87: axial parenchyma reticulate; (93: eight (5–8) cells per parenchyma strand); 94: over eight cells per parenchyma strand. Rays: 97: ray width 1–3 cells; (100: rays with multiseriate portion(s) as wide as uniseriate portions); 102: ray height > 1 mm; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 116: ≥ 12 rays per mm. Mineral inclusions: (136: prismatic crystals present); (137: prismatic crystals in upright and/or square ray cells); (138: prismatic crystals in procumbent ray cells).

(P. Mugabi, P.E. Gasson & E.A. Wheeler)

Growth and development Young leaves of *Drypetes gerrardii* are reddish. Larvae of the butterfly *Coeliades libeon* feed on the leaves. In southern Africa, flowering trees have been recorded from September to November, and ripe fruits from October to April. The fruits are eaten by animals such as birds and monkeys, which serve as seed dispersers.

Ecology *Drypetes gerrardii* occurs in ever-

green forest and riverine forest, sometimes also in scrub vegetation, at 600–2300 m altitude. It is usually found in more dry forest types, but occasionally also in more humid rainforest.

Propagation and planting The 1000-seed weight is about 12 g. In an experiment in Uganda, seeds germinated on average 39 days after sowing at a low germination rate of 17.5%.

Management Small-sized *Drypetes gerrardii* trees (up to 10 cm in bole diameter) are locally common in the forest understory in South Africa, with recorded average densities of 130 stems per ha, of which an average of 18 stems per ha are harvested to serve as poles. Trees can be coppiced. In South Africa nearly 50% of cut stems showed coppice regeneration.

Genetic resources *Drypetes gerrardii* is not only widespread but also locally common; its exploitation seems to be moderate, and therefore it is not threatened by genetic erosion, although locally over-exploitation for poles and firewood may occur.

Prospects *Drypetes gerrardii* and other *Drypetes* spp. do not play a role on the international timber market, and in view of their usually small bole size it is unlikely that this will change. However, the usually quite heavy, hard and fairly durable wood is locally important for construction, especially for poles, and research on growth rates and regeneration is recommended to draw up directives for proper management practices to ensure sustainable production.

Major references Beentje, 1994; Bolza & Keating, 1972; Boudreau et al., 2005; Burkill, 1994; Chikamai et al., undated; Coates Palgrave, 1983; Hyde & Wursten, 2010b; Palmer & Pitman, 1972–1974; Radcliffe-Smith, 1996; Takahashi, 1978.

Other references Coode, 1982; de Boer et al., 2005; Dowsett-Lemaire & White, 1990; Gaugris et al., 2007; Grace et al., 2002a; Ichikawa, 1987; Liu et al., 2008d; Long, 2005; Lovett et al., 2007; Neuwinger, 2000; Ng'ang'a et al., 2008; Obiri & Lawes, 2003; Obiri, Lawes & Mukolwe, 2002; Radcliffe-Smith, 1987a; Schmidt, Lötter & McCleland, 2002; Sharam, Sinclair & Turkington, 2006; Tchinda & Sob, 2008; van Wyk, 1972–1974; Vivien & Faure, 1996; Zanne, Chapman & Kitajima, 2005.

Sources of illustration Noad & Birnie, 1989; Troupin, 1983.

Authors E.A. Obeng

DUGUETIA STAUDTII (Engl. & Diels) Chatrou

Protologue Changing Gen.: 70 (1998).

Family Annonaceae

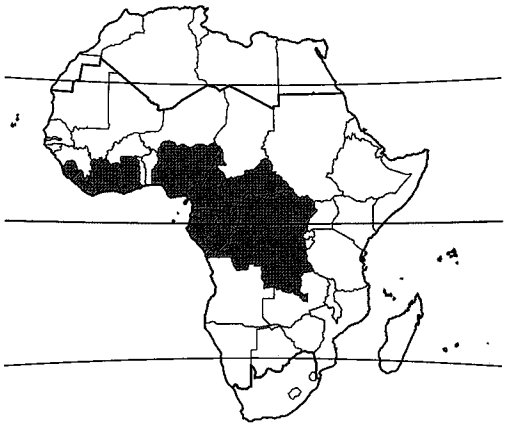
Synonyms *Pachypodanthium staudtii* (Engl. & Diels) Engl. & Diels (1900).

Origin and geographic distribution *Duguetia staudtii* occurs from Sierra Leone east to the Central African Republic and south to Gabon and DR Congo.

Uses The wood of *Duguetia staudtii*, known as 'ntom' in Central Africa and as 'aniouketi' in Côte d'Ivoire, is locally used, especially in house construction for poles and planks, but also for carpentry and utensils; it is suitable for flooring, joinery, interior trim, mine props, furniture, cabinet making, toys, novelties, boxes, crates, vats, food containers, turnery, veneer and plywood.

The bark is used in hut construction for walls, partitions and doors. It is commonly used in traditional medicine. Bark decoctions are taken to treat colds, cough and other complaints of the respiratory tracts, and as anodyne, purgative, anthelmintic and aphrodisiac. They are used as mouth wash against toothache, and to wash the hair to get rid of lice. A paste of pounded bark is applied externally to treat smallpox and measles. The bark is also used to treat tumours, oedema, leprosy and gonorrhoea. Pulped bark with cola nut is taken against gastro-intestinal problems. Leaf decoctions are applied in mixtures to wash the body to treat measles. In Côte d'Ivoire stem bark is used as an ingredient in the preparation of arrow poison.

Production and international trade The wood of *Duguetia staudtii* is only used locally



Duguetia staudtii – wild

and not or rarely traded on the international market.

Properties The heartwood is pale yellow to yellowish brown or greenish brown, indistinctly demarcated from the slightly paler, up to 8 cm wide sapwood. The wood is susceptible to discolouration to a greyish tinge. The grain is straight, texture moderately coarse.

The wood is medium-weight to fairly heavy, with a density of 670–830 kg/m^3 at 12% moisture content, moderately hard and tough. It air dries well without serious degrade, except occasional end checking. The rates of shrinkage are rather high, from green to oven dry 3.4–5.9% radial and 8.2–10.6% tangential. In Liberia boards of 2.5 cm thick could be air dried from green to 20% moisture content in 6 weeks. No defects were observed in kiln drying the wood from 60% to 20% moisture content in 72 hours.

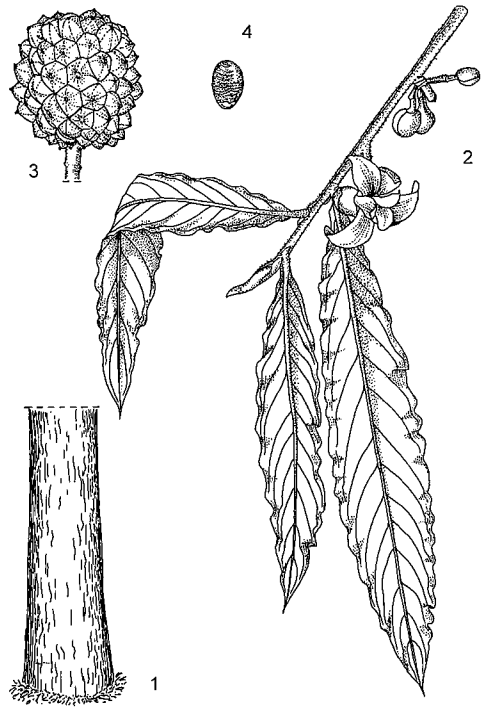
At 12% moisture content, the modulus of rupture is 139–168 N/mm^2, modulus of elasticity 8530–19,600 N/mm^2, compression parallel to grain 59–88 N/mm^2, shear 8 N/mm^2, cleavage 16–18 N/mm, Janka side hardness 9050 N and Chalais-Meudon side hardness 4.0–4.2.

The wood works easily with both hand and machine tools, and has little dulling effect on cutting edges. It can be planed to an attractive lustrous surface, and finishes smoothly. The nailing and screwing properties are satisfactorily, and the wood glues well. It takes paints and vanish well. The peeling and slicing characteristics are good. The wood is not durable, being susceptible to attacks by fungi and termites, although it has also been reported to be quite resistant to termite attack; the sapwood is liable to *Lyctus* attack. The wood is moderately easy to treat with preservatives.

The wood contains about 42% cellulose, 29.5% lignin, 16% pentosan, 1.7% ash and less than 0.02% silica. The solubility is 1.2% in alcohol-benzene, 3.4% in hot water and 17.1% in a 1% NaOH solution.

The bark and leaves contain alkaloids, mainly isoquinoline alkaloids, and the presence of tannins has been reported in the bark and roots. Some bisnorlignans have been isolated from the bark, as well as the flavonol pachypodol, which has potent antiviral activity against poliovirus. Crude bark extracts killed microfilariae and adult females of *Onchocerca volvulus*, the causal organism of river blindness; oliverine was identified as active compound. 2,4,5-Trimethoxystyrene has been isolated in larger amounts from the bark. This compound is toxic to brine shrimp, but showed only weak cytotoxic activity. It showed significant insecticidal activity against *Callosobruchus maculatus*, a pest in stored cowpea, and *Sitophilus zeamais*, a pest of stored maize. The essential oil from the bark contained more than 70% of 2,4,5-trimethoxystyrene, and the oil showed in-vitro activity against *Plasmodium falciparum*. Ethanol bark extracts showed high toxicity in tests with rats. Bark extracts showed antifungal activity against *Candida albicans* and *Cladosporium cucumerinum*.

Description Evergreen, medium-sized to fairly large tree up to 35(–50) m tall; bole branchless for up to 20 m, straight and cylindrical, up to 70(–90) cm in diameter, without buttresses but sometimes slightly swollen at base; bark surface smooth to slightly rough, shallowly longitudinally fissured, yellowish to greenish grey, inner bark thick, fibrous, with thick granular to gritty stripes, yellow to orange-brown, turning darker upon exposure, strongly scented; crown small, with horizontal branches; twigs drooping, slightly hairy, becoming glabrous. Leaves alternate, simple; stipules absent; petiole up to 1 cm long, flat-



Duguetia staudtii – 1, base of bole; 2, flowering twig; 3, fruit; 4, seed.
Redrawn and adapted by J.M. de Vries

tened above; blade narrowly elliptical to narrowly obovate, 13–34 cm × 3–8 cm, cuneate to rounded at base, sometimes slightly cordate, acute to short-acuminate at apex, margins wavy, leathery, sparsely appressed stellate hairy below, pinnately veined with 10–22 pairs of lateral veins. Inflorescence an axillary fascicle on a short peduncle up to 4(–6) mm long, 2–4-flowered, densely stellate hairy; bracts up to 12 mm long. Flowers bisexual, regular, 3-merous; pedicel up to 12 mm long, elongating in fruit; sepals free, ovate, 1–1.5 cm long, densely stellate hairy outside; petals free, in 2 whorls, 0.5–2.5 cm long, creamy white, nearly glabrous; stamens numerous, arranged spirally, 1–1.5 mm long, anthers nearly sessile; carpels free, numerous, arranged spirally, ovaries 1–1.5 mm long, hairy, stigmas sessile, up to 1 mm long. Fruit globose to depressed ovoid, 2–7 cm in diameter, pinkish to reddish when ripe, consisting of numerous pyramidal fruiting carpels fused at base; each fruiting carpel with woody wall, fleshy reddish pulp and 1 seed. Seeds obovoid, 1–1.5 cm long, glossy brown, with up to 4 mm long, whitish aril at base. Seedling with epigeal germination; hypocotyl 5–7 cm long, epicotyl very short, 1–2 mm long; cotyledons leafy, sessile, rounded, up to 2 cm in diameter, soon caducous; first 2 leaves nearly opposite.

Other botanical information *Duguetia* comprises about 90 species, with the majority in tropical America and 4 species in West and Central Africa. The African species have been considered to belong to a separate genus *Pachypodanthium*, but the results of a cladistic analysis based on morphological and anatomical data published in 1998 led to inclusion in *Duguetia*.

Duguetia confinis (Engl. & Diels) Chatrou (synonym: *Pachypodanthium confine* Engl. & Diels) is a medium-sized to fairly large tree up to 35(–40) m tall with bole up to 85 cm in diameter, occurring in Cameroon, Equatorial Guinea, Gabon and Congo. It differs from *Duguetia staudtii* in its densely hairy lower leaf surface with erect stellate hairs and in its ellipsoid fruits consisting of nearly entirely fused carpels. Its wood, with a density of about 710 kg/m³ at 12% moisture content, is similar to that of *Duguetia staudtii* and used for similar purposes, especially in house construction.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 1: growth ring boundaries distinct. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; (24: intervessel pits minute (≤ 4 μm)); 25: intervessel pits small (4–7 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 46: ≤ 5 vessels per square millimetre; (58: gums and other deposits in heartwood vessels). Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled; 70: fibres very thick-walled. Axial parenchyma: 86: axial parenchyma in narrow bands or lines up to three cells wide; 88: axial parenchyma scalariform; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; 102: ray height > 1 mm; (103: rays of two distinct sizes); 104: all ray cells procumbent; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 115: 4–12 rays per mm. Secretory elements and cambial variants: (124: oil and/or mucilage cells associated with ray parenchyma).

(C. Essien, P.E. Gasson & E.A. Wheeler)

Growth and development In West Africa flowering is most common from February to May and fruits usually appear in July–September, but flowers and especially fruits can be found nearly throughout the year. Ripe fruits fall apart in separate carpels and are eaten by monkeys and birds, which may serve as seed dispersers.

Ecology *Duguetia staudtii* usually occurs rather scattered in closed evergreen and dense riparian forest, up to 900 m altitude. It can be found in primary as well as secondary forest. It prefers sandy localities. In Gabon it has been reported to form occasionally nearly pure stands in seasonally flooded sites.

Propagation and planting There are about 4500 seeds per kg. Seeds start germinating 2–4 weeks after sowing. The germination rate is generally high. Natural regeneration of *Duguetia staudtii* occurs in not too dense shade; the species is considered to be a non-pioneer light demander.

Management In general, *Duguetia staudtii* occurs scattered in the forest, or in small groups. In Liberia the average wood volume of trees with a bole diameter of more than 50 cm has been estimated at 0.3 m³/ha. In forest in Cameroon, the average number of trees with a bole diameter of more than 15 cm is 0.3 per ha

with a mean wood volume of 0.5 m³/ha. In Gabon the mean wood volume has been estimated at 0.6 m³/ha.

Handling after harvest Logs should be removed rapidly from the forest after felling because they are susceptible to attacks by fungi and insects, and the wood is liable to discolouration.

Genetic resources *Duguetia staudtii* is fairly widespread and there are no indications of over-exploitation, and therefore it does not seem to be threatened by genetic erosion.

Prospects *Duguetia staudtii* provides a good-quality timber that can be used for various purposes, and that could be interesting for the international market. Its usually straight and cylindrical bole may offer good possibilities for veneer production by peeling. However, more information is needed on its natural regeneration and growth rates to ensure sustainable exploitation. Further research with regards to potential drug development is warranted because several of the uses of the bark in traditional medicine have been supported by pharmacological screening.

Major references Bolza & Keating, 1972; Burkill, 1985; Chatrou, 1998; Dudek, Förster & Klissenbauer, 1981; Neuwinger, 1998a; Oteng-Amoako (Editor), 2006; Takahashi, 1978; Titanji et al., 1990; Vivien & Faure, 1985; Voorhoeve, 1979.

Other references Agnaniet, Menut & Bessière, 2004; Atindehou et al., 2002; Aubréville, 1959b; Chatrou, Koek-Noorman & Maas, 2000; Cooper & Record, 1931; de la Mensbruge, 1966; de Saint-Aubin, 1963; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Irvine, 1961; Koona & Bouda, 2004; Kryn & Fobes, 1959; Kunkel, 1965; Neuwinger, 2000; Normand & Paquis, 1976; Raponda-Walker & Sillans, 1961; Savill & Fox, 1967; Tailfer, 1989; White & Abernethy, 1997; Wilks & Issembé, 2000.

Sources of illustration Voorhoeve, 1979; Wilks & Issembé, 2000.

Authors R.B. Jiofack Tafokou & S. Konsala

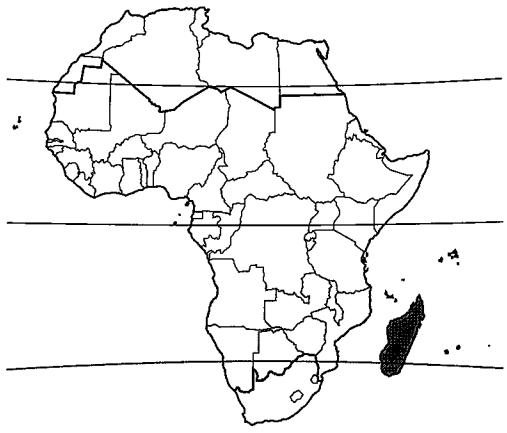
DUPUYA MADAGASCARIENSIS (R.Vig.) J.H.Kirkbr.

Protologue Novon 15(2): 310 (2005).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Cordyla madagascariensis* R.Vig. (1949).

Origin and geographic distribution *Dupuya madagascariensis* is endemic to Madagascar, where it is widespread from the northern to the south-western parts.



Dupuya madagascariensis – *wild*

Uses The wood, known and locally traded as 'anakaraka', is in demand because of its durability for beams, posts, frames and planks in house construction, for parquet flooring, carpentry, naval construction and shingles, and in boat building. It is suitable for mine props, vehicle bodies, sporting goods, agricultural implements, railway sleepers and turnery. *Dupuya madagascariensis* is traditionally used as fish poison.

Production and international trade The wood of *Dupuya madagascariensis* is probably not traded on the international timber market.

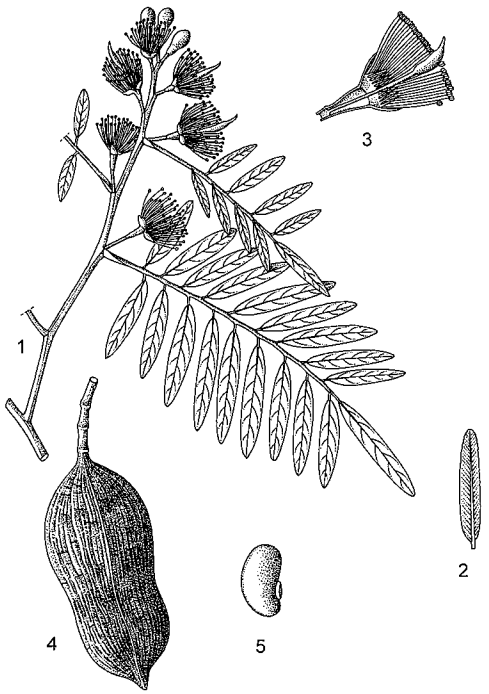
Properties The heartwood is yellowish brown to dark brown and distinctly demarcated from the yellow-white, up to 6 cm wide sapwood. The grain is usually straight, texture rather coarse. The wood is slightly oily to the touch.

The wood is heavy, with a density of 870–1050 kg/m³ at 12% moisture content, and hard. It air dries fairly well, but slowly. The rates of shrinkage are moderate, from green to oven dry 2.7–4.7% radial and 4.1–6.5% tangential. Once dry, the wood is stable to moderately stable in service. At 12% moisture content, the modulus of rupture is 140–208 N/mm², modulus of elasticity 10,700–19,800 N/mm², compression parallel to grain 65–85 N/mm² and Chalais-Meudon side hardness 8–12.5. The wood is fissile and low resistance to shocks.

The wood saws and works well, but the dulling effect on saw teeth can be considerable because the wood may contain silica. It can be finished

to a smooth but dull surface. Pre-boring is needed for nailing, but the holding capacity for nails and screws is good. The wood polishes well. The wood is durable, being resistant to fungi, termites and moderately resistant to borers, including marine borers. It is resistant to impregnation with preservatives.

Description Deciduous medium-sized tree up to 20(–25) m tall; bole usually straight and cylindrical, up to 60(–90) cm in diameter; bark surface fissured and scaly with elongate scales, greyish brown to dark grey; crown rounded, large, dense; twigs glabrous. Leaves arranged spirally, imparipinnately compound with 15–43 leaflets; stipules curved, up to 4 mm long, caducous; petiole and rachis together up to 18.5 cm long, with 2 narrow ridges; petiolules up to 1 mm long; leaflets usually alternate, narrowly obovate to narrowly elliptical or oblong, (1–) 1.5–4 cm × 0.5–1(–1.5) cm, oblique at base, rounded to notched at apex, margins entire to slightly crenate, nearly glabrous, with translucent dots and streaks, pinnately veined. Inflorescence a terminal raceme up to 18 cm long, sparsely hairy; bracts small. Flowers bisexual, regular; pedicel c. 0.5 cm long; hypanthium cup-shaped, c. 2 mm long, greenish; calyx initially entire but splitting into 2(–4) lobes; petals absent; stamens numerous, inserted at rim of hypanthium, 1–1.5 cm long, white, with inner row of rudimentary stamens up to 2.5 mm long; ovary superior, ellipsoid, 1-celled, on a long stipe, style short. Fruit an ellipsoid to cylindrical, indehiscent, berry-like pod 3.5–6.5(–10) cm × 2–3.5 cm, reddish brown to dark brown, with stipe of up to 3.5 cm long, with 1–3 seeds embedded in whitish pulp. Seeds oblong-ellipsoid, 1.5–2 cm long, with reddish brown seed coat and thick endosperm. Seedling with hypogeal germination.



Dupuya madagascariensis – 1, flowering twig; 2, leaflet; 3, flower in longitudinal section; 4, fruit; 5, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Dupuya* comprises 2 species and is endemic to Madagascar. It has recently been separated from *Cordyla* based on the presence of staminodes and on differences in seed morphology, but this was not supported by a study on the distribution of flavonol pentaglycosides in the leaves of *Cordyla*, *Dupuya* and the closely related *Mildbraediodendron*. Traditionally, these genera have been placed in *Caesalpiniaceae* (*Leguminosae - Caesalpinioideae*), but chemistry, cytology, palynology and wood anatomy support the inclusion in *Papilionaceae* (*Leguminosae - Papilionoideae*), and this is also supported by molecular studies.

Dupuya haraka (Capuron) J.H.Kirkbr. (synonym: *Cordyla haraka* Capuron) is a medium-sized to fairly large tree up to 35 m tall, with bole up to 80(–100) cm in diameter, occurring in evergreen rainforest in northern and eastern Madagascar, where it is considered vulnerable. It differs from *Dupuya madagascariensis* in its leaves with 6–13 obovate to elliptical leaflets. The reddish brown wood is used in house construction and for boats.

Dupuya madagascariensis is subdivided into two subspecies; subsp. *madagascariensis* is widespread, subsp. *tamarindoides* (Capuron) J.H.Kirkbr., which has more numerous leaflets, is restricted to northern Madagascar.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: (1: growth ring boundaries distinct); (2: growth ring boundaries indistinct or absent). Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 26: intervessel pits medium (7–10 μm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and

shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 µm; 46: ≤ 5 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present. Axial parenchyma: 80: axial parenchyma aliform; 82: axial parenchyma winged-aliform; 83: axial parenchyma confluent; 89: axial parenchyma in marginal or in seemingly marginal bands; 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 104: all ray cells procumbent; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(P. Détienne)

Growth and development Seedlings prefer much sunlight, and *Dupuya madagascariensis* is considered a pioneer. The average annual growth is about 40 cm. Trees flower in September–November. Fruits ripen 6–8 months later, in May–June. They are eaten by sifaka (*Propithecus*) lemurs, which may disperse the seeds.

Ecology *Dupuya madagascariensis* occurs in dry forest up to 600(–900) m altitude, often together with *Commiphora* spp. The mean annual rainfall in the area of distribution is 500–1200 mm, with 5–7 dry months. The mean annual temperature is 24°C. *Dupuya madagascariensis* occurs on well-drained, sandy, sandy-loamy or calcareous soils. Near Morondava it is usually found on medium-fertile to infertile soils.

Propagation and planting Ripe fruits, characterized by a hard and brown wall, can be collected from the tree or from the ground, but it is recommended to pick them from the trees to avoid insect attack. They are often beaten in a bag to extract the seeds, which are dried in the sun for 1–2 days. The 1000-seed weight is 1200–1300 g. Dried seeds stored in a cool and dry locality still have a fair germination rate after 1.5–2 years, up to 84%. However, seeds stored for only 6 months showed a germination rate of only 30–40%, which may be a result of partial seed dormancy. Seeds are immersed in water for 24–48 hours to promote germination. They are sown in a seed bed in the nursery at a distance of 10 cm × 10 cm in the shade, and are covered by 2–3 cm of soil. Germination starts 9 days after sowing and it may continue for over 50 days. The seedlings are pricked out and planted in nursery beds at the same spacing. The seedlings can be planted into the field after 12 months, when they have reached a height of about 50 cm with a stem diameter of 1 cm. However, direct seeding into the field is also practised. Seedlings should be protected from rodents and wild pigs. Propagation by cuttings and suckers is possible.

Genetic resources *Dupuya madagascariensis* is widespread and not uncommon, but it occurs in regions with a native vegetation that is highly fragmented. Although several protected areas fall within its distribution, it is found in the IUCN Red List, classified as lower risk / near threatened. *Dupuya haraka* is classified as vulnerable. The wood of both species is highly valued and selective logging results in more pressure on the populations.

Prospects *Dupuya madagascariensis* and *Dupuya haraka* are both subject to more or less uncontrolled harvesting. Much more information is needed on standing stocks, growth rates, propagation and adequate management measures to give recommendations for sustainable harvesting.

Major references Blaser et al., 1993; Bolza & Keating, 1972; CFPF, 2008; du Puy & Labat, 1998; du Puy et al., 2002; Guéneau, Bedel & Thiel, 1970–1975; Kirkbride, 2005; Parant, Chichignoud & Rakotovao, 1985; Takahashi, 1978.

Other references Bezzola, Schroff & Michaud, 1985; Boiteau, Boiteau & Allorge-Boiteau, 1999; Guéneau & Guéneau, 1969; Schatz, 2001; Veitch, Kite & Lewis, 2008.

Sources of illustration du Puy et al., 2002.

Authors S. Rakotonandrasana

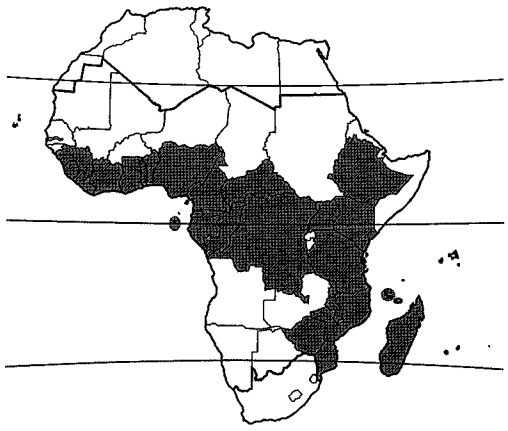
EHRETIA CYMOSA Thonn.

Protologue Schumach., Beskr. Guin. pl.: 129 (1827).

Family Boraginaceae

Origin and geographic distribution *Ehretia cymosa* is very widespread, from Sierra Leone east to Ethiopia and Kenya, and south to Zimbabwe and Mozambique; also in Comoros, Mayotte and Madagascar.

Uses The wood is used for furniture, cabinet work, poles, tool handles and yokes. It is also used as firewood and for making charcoal.
The twigs serve as chewing-sticks for maintaining tooth and gum hygiene. Many plant parts are used in traditional medicine. A leaf infusion is taken and used as a wash to treat



Ehretia cymosa – wild

fever and convulsions. Leaf sap is reportedly a mild laxative and is applied as a haemostatic. Leaf decoctions serve as a treatment for stiffness, toothache and hyperthermia. In Ghana leaf poultices are applied to fractured bones to promote healing. Leafy twigs are used in mixtures with parts of other plants to treat gastric ulcers. Root and leaf decoctions are administered to treat tetanus and dysentery. Roots and leaves are considered to be aphrodisiac. Bark and root decoctions are taken as a treatment for menstruation problems, and a bark decoction is applied externally against skin diseases. The Maasai people use the roots to treat brucellosis. In Ethiopia crushed roots in water are taken against stomach complaints. Root juice is applied to wounds.

The leaves serve as fodder. *Ehretia cymosa* is locally important as livestock feed in agroforestry systems in Ethiopia. The leaves make a good mulch. The fruits are edible. The flowers are a source of nectar and pollen for honey bees. *Ehretia cymosa* is planted as an ornamental tree, e.g. in Kenya and Uganda.

Properties The wood is greyish brown with alternate darker and lighter bands, and lustrous. The texture is moderately fine and even. The wood is moderately lightweight, with a density of 480–550 kg/m^3 at 12% moisture content, and not durable.

In an in-vitro test utilizing rat calvarial bone, aqueous leaf extracts showed stimulation of bone remodelling. Roots and leaves are reportedly toxic, but livestock browse on the leaves apparently without adverse effects. Analyses of the leaves even showed good nutritional values for ruminants, except the micronutrient levels of Na and Cu.

Botany Deciduous shrub or small to medium-sized tree up to 20(–25) m tall; bole often low branching and crooked, up to 30 cm in diameter; bark surface grey to pale brown, with prominent lenticels, inner bark soft, white, spotted with orange-brown, quickly turning brown upon exposure; crown spreading, often with drooping branches; twigs short-hairy but soon becoming glabrous. Leaves arranged spirally, simple and entire; stipules absent; petiole 1–3.5 cm long, slightly grooved; blade elliptical to ovate-oblong, (4–)7.5–20 cm × (2–)3.5–12 cm, cuneate to rounded or slightly cordate at base, acuminate at apex, thinly leathery, nearly glabrous, pinnately veined with 3–8 pairs of lateral veins. Inflorescence an axillary or terminal, strongly branched panicle up to 15 cm × 15 cm, composed of scorpioid cymes, hairy. Flowers bisexual, regular, usually 5-merous, heterostylous, fragrant; pedicel up to 2(–3) mm long, jointed at base; calyx campanulate, 1.5–2.5 mm long, lobes about as long as tube; corolla campanulate, 4–8 mm long, white to yellowish or pinkish white, lobes about as long as tube, often reflexed; stamens inserted at corolla, exserted; ovary superior, ovoid, c. 1 mm long, 2- or 4-celled, style 1–4 mm long, 2-branched at apex. Fruit an ovoid to globose drupe 2–6 mm long, orange to red and eventually turning black, splitting into 4 pyrenes, each 1-seeded.

Some varieties have been distinguished within *Ehretia cymosa*, based on flower size and hairiness of the inflorescence, but there is some disagreement about the usefulness of this division.

Ehretia cymosa grows rapidly. The flowers are commonly visited by bees, which collect nectar and pollen and may serve as pollinator. In Côte d'Ivoire trees flower from January to June. In East and southern Africa fruits mature in October–December. The fruits are eaten by birds, which may disperse the seeds.

Ehretia comprises about 35 species, most of them in tropical Asia (about 20), about 10 in mainland Africa, 7 in Comoros and Madagascar (5 endemic) and 3 in tropical America. The wood of several *Ehretia* spp. is used in tropical Africa in similar ways as that of *Ehretia cymosa*.

Ehretia amoena Klotzsch is a shrub or small tree up to 8 m tall, found from Kenya south to South Africa. It has been much confused with *Ehretia obtusifolia* A.DC., and care is needed to interpret the literature. Its wood is used for

implements and kitchen tools, e.g. pestles. Root decoctions are used in traditional medicine to treat pain, bleedings, swellings, pneumonia, tuberculosis, gonorrhoea, epilepsy, vomiting, diarrhoea, hookworm infections and menstruation problems. Bark powder is administered to skin diseases. Leaf pulp is applied to wounds.

Ehretia rigida (Thunb.) Druce is a shrub or small tree up to 6(–12) m tall, occurring in savanna woodland from Zimbabwe and Mozambique to South Africa. It closely resembles *Ehretia amoena* and *Ehretia obtusifolia*. Its tough and flexible wood is probably used in the same way as that of the 2 latter species. Root powder is externally applied to wounds and burns, and to treat pain. Root decoctions are taken to treat menstruation problems and infertility. *Ehretia rigida* is commonly browsed by livestock.

Ehretia trachyphylla C.H.Wright is a small to medium-sized tree up to 20 m tall and bole up to 30 cm in diameter, occurring in evergreen and riverine forest in Côte d'Ivoire and Ghana. Its speckled wood is used for tool handles. Bark decoctions are used in traditional medicine in the same way as those of *Ehretia cymosa*, to treat menstruation problems and skin diseases.

Ecology *Ehretia cymosa* has a wide ecological range, occurring in the understorey or at edges of evergreen forest and in riverine forest, forest patches, bushland and wooded savanna, up to 2400 m altitude. It is classified as a pioneer and often found in secondary forest.

Management One kg contains 20,000–30,000 seeds. Whole infructescences are usually harvested when about 80% of the fruits have become ripe. Seeds are extracted and usually sown directly into the field. Pre-treatment of the seed is unnecessary. Seeds may start germinating already after 3 days, but germination may continue for 5 weeks. The seeds can be stored for some time.

Locally *Ehretia cymosa* is quite common, e.g. in forest on Mount Elgon in Kenya an average density of 15 boles with a diameter of more than 15 cm per ha has been recorded. Trees can be managed by pruning, pollarding, lopping and coppicing.

Genetic resources and breeding *Ehretia cymosa* is not threatened, being very widely distributed and adapted to a wide variety of habitats. Locally it seems to be threatened by over-exploitation, e.g. in northern Tanzania.

Prospects *Ehretia cymosa* is highly valued as a multipurpose tree, yielding timber, firewood and forage, whereas it is considered important for traditional medicine and mulch, and as ornamental and bee plant. It is certainly of great value for agroforestry systems, and more research on propagation techniques and planting is justified, as well as on phytochemistry and pharmacological activities. The often poor shape of the bole is a serious drawback for increased commercial exploitation of the timber.

Major references Bekele-Tesemma, 2007; Burkill, 1985; Lewis & Avioli, 1991; Maundu & Tengnäs (Editors), 2005; Verdcourt, 1991.

Other references Beentje, 1994; Coates Palgrave, 1983; Latham, 2007; Mamo, 1997; Martins & Brummitt, 1990; Maundu et al., 2001; Miller, 2002; Neuwinger, 2000; Retief & van Wyk, 2001; Wondimu, Asfaw & Kelbessa, 2007.

Authors R.H.M.J. Lemmens

ELAEOCARPUS FLORIBUNDUS Blume

Protologue Bijdr. fl. Ned. Ind. 3: 120 (1825).

Family Elaeocarpaceae

Vernacular names Rugged oil fruit, Indian olive (En).

Origin and geographic distribution *Elaeocarpus floribundus* occurs from India eastward to Vietnam, Peninsular Malaysia, Indonesia (to Borneo) and the Philippines (Palawan). It has been introduced in Madagascar and Mauritius. In Mauritius it is fairly commonly cultivated and occasionally naturalized.

Uses The wood is used for light construction and for indoor uses such as furniture. The acidulous fruits are eaten fresh or pickled in vinegar or brine, whole or as chutney. In Mau-

Elaeocarpus floribundus – planted and naturalized

ritius a leaf decoction is used to treat hypertension and diabetes. An infusion of the bark and leaves is used in Sumatra as a mouthwash against inflamed gums. In Malaysia the bark and leaves are used in a poultice to treat ulcers, and an extract is drunk as a tonic.

Properties The heartwood is whitish to greyish brown or olive-brown, occasionally purplish grey with a pinkish tinge, and not distinctly demarcated from the sapwood. The grain is straight or sometimes wavy, texture fine to medium. The wood is somewhat lustrous. It is lightweight to moderately heavy, with a density of 400–700 kg/m^3 at 12% moisture content, and soft to moderately hard. The wood is generally easy to air dry. It is easy to saw and work, and can be planed to an even surface. It holds nails well, stains and glues satisfactorily, and has excellent bending properties. The wood is fairly durable under cover, but not when exposed to the weather or soil.
Acidic fractions of water-soluble dietary fibre of the fruits contain rhamnose (11%), arabinose (26%), galactose (35%) and uronic acid (27%). The polymeric fraction is composed of α-n-galactopyranosyl uronic acid chains with side chains of arabinose, galactose and rhamnose residues. A skin care product containing extracts from *Elaeocarpus floribundus* showed excellent active-oxygen scavenging actions, and is claimed to have excellent anti-aging and skin-whitening activities. The flavonoid mearnsetin, a rare methyl ester of myricetin, was isolated from the leaves, along with myricetin and myricitrin.

Botany Evergreen small to medium-sized tree up to 30 m tall; bole usually straight and cylindrical, up to 80 cm in diameter; bark surface rough to fissured, brown, inner bark pale yellow to reddish brown; twigs hairy but soon becoming glabrous. Leaves arranged spirally, often crowded at the ends of twigs, simple; stipules minute, early caducous; petiole 1–5.5 cm long, with joint at apex; blade oblong to elliptical or obovate, 6.5–19 cm × 3–8.5 cm, base cuneate to obtuse, apex acuminate, margin slightly toothed, papery, glabrous, with small dots, pinnately veined with 5–7 pairs of lateral veins. Inflorescence an axillary raceme up to 22 cm long, many-flowered. Flowers bisexual, regular, (4–)5-merous, pendulous; pedicel 4–12 mm long; sepals lanceolate or narrowly triangular, c. 6 mm long, often warty; petals free, triangular, 5–7 mm long, finely fringed to the middle, whitish; stamens 25–40, free, c. 4 mm long; disk lobed; ovary superior, conical, 3-celled, short-hairy, style elongate. Fruit an ellipsoid to spindle-shaped drupe up to 4 cm × 2 cm, glabrous, often with yellow dots; stone woody, slightly grooved. Seedling with epigeal germination.
Fruit development shows distinct phases. During 4–9 weeks after flowering fruits grow fast, during 9–17 weeks they grow rather slow, and from 17 weeks onwards growth is again fast until maturity is reached about 26 weeks after flowering. Birds, bats, rodents and pigs eat the fruits and may disperse the seeds.
Elaeocarpus comprises about 300 species occurring from Madagascar to tropical Asia, Polynesia, Australia and New Zealand, with centres of diversity in Borneo and New Guinea. In Madagascar 8 species have been found, all endemic.
Elaeocarpus angustifolius Blume is a medium-sized to large tree up to 40 m tall of the evergreen rainforest of north-eastern India, Myanmar, Peninsular Malaysia, Java and Sulawesi. It has been introduced into West Africa. The wood is suitable for light carpentry. In tropical Asia leaf sap, bark and seeds are occasionally used in traditional medicine. The fruit is edible and the tree is occasionally planted as ornamental or shade tree. In Asia the stones are used as beads.
Elaeocarpus alnifolius Baker is a small to medium-sized tree up to 15(–30) m tall, occurring in eastern Madagascar. Its wood is locally used in construction and as fuel.
Elaeocarpus capuronii Tirel is a small to medium-sized tree up to 15 m tall, occurring in humid forest in eastern Madagascar. Its wood is locally used in construction.
Elaeocarpus subserratus Baker is a small to medium-sized tree up to 25(–40) m tall, occurring in northern, eastern and central Madagascar. Its wood is used locally in construction and carpentry. The flowers yield nectar for honey bees. The bitter bark is used to flavour local rum.

Ecology In its natural area of distribution, *Elaeocarpus floribundus* occurs in lowland rainforest and lower mountain forest, up to 1500 m altitude.

Management *Elaeocarpus floribundus* can be propagated by stones, which should be sown in the shade and have about 15% germination in 4–8 months.

Genetic resources and breeding There are no indications that *Elaeocarpus floribundus* is in danger of genetic erosion in its natural distribution area. There is no information

on the genetic variation in the planted trees in Mauritius.

Prospects *Elaeocarpus floribundus* is likely to remain of limited importance in Mauritius for use as timber and edible fruit, and for medicinal purposes. However, as a multipurpose tree it deserves more research, the more so because other *Elaeocarpus* spp. showed rapid growth in tropical Asia. Not much is known about the endemic species of Madagascar, but most of them are characteristic for humid primary forest in eastern Madagascar, which is a forest type under much pressure because of ongoing deforestation. There seems to be little scope for intensification of timber exploitation of *Elaeocarpus* spp., unless they would show good results in cultivation trials.

Major references Aggarwal, 2001; Chowdhury & Ghosh, 1958; Gurib-Fakim, Guého & Bissoondoyal, 1996; Keating & Sosef, 1998; Tirel, 1985.

Other references Burkill, 1994; Corner, 1988; Decary, 1946; Gasson, 1996; Gurib-Fakim et al., 1994; Janick & Paull (Editors), 2006; Osumi et al., 2003; Pande, 2010; Rahman, Nahar & Mosihuzzaman, 2005; Whitmore & Ng (Editors), 1972–1989.

Authors L.P.A. Oyen

ELAEODENDRON BUCHANANII (Loes.) Loes.

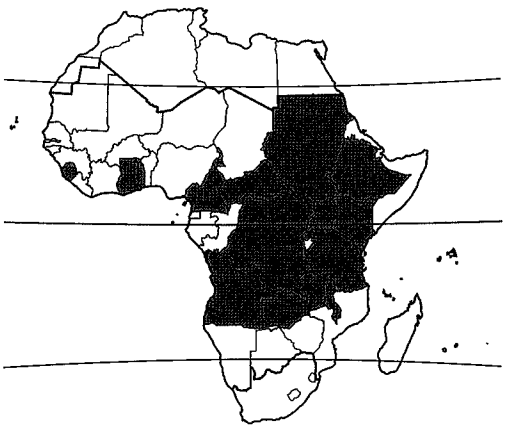
Protologue Engl. & Prantl, Nat. Pflanzenfam., II–IV Nachtr. 1: 223 (1987).

Family Celastraceae

Synonyms *Cassine buchananii* Loes. (1893).

Vernacular names Elaeodendron (En).

Origin and geographic distribution *Elaeodendron buchananii* is widespread, from Sierra Leone east to Kenya and south to Malawi, Zambia and Angola.



Elaeodendron buchananii – wild

Uses The wood is used for joinery and furniture. It is suitable for heavy construction, heavy flooring, interior trim, ship building, vehicle bodies, mine props, handles, ladders, sporting goods, toys, novelties, turnery, pattern making, veneer and plywood. The wood is also used as firewood and for charcoal production.

Leaf extracts are taken as abortifacient, oxytocic, tonic and vermifuge, and to treat fever. Leaves are chewed against diarrhoea. Root decoctions are drunk to treat digestive upsets, coughing with blood, excessive uterine bleeding and infertility. Root powder is taken to treat syphilis, and it is applied to wounds.

Properties The heartwood is pale brown to reddish brown and distinctly demarcated from the whitish sapwood. The grain is straight or interlocked, texture moderately fine.

The wood is heavy, with a density of about 800 kg/m^3 at 12% moisture content. It has a slight tendency of surface and end checking in drying. Once dry, it is stable in service. At 12% moisture content, the modulus of rupture is 128–135 N/mm^2, modulus of elasticity 14,800–15,680 N/mm^2, compression parallel to grain 66–69 N/mm^2, shear 16–18 N/mm^2, cleavage 18 N/mm, Janka side hardness 7650 N and Janka end hardness 9065 N. The wood is fairly easy to saw, although it is hard and tough. It planes well and can be polished to a nice surface. It turns well. The wood is moderately durable. The heartwood is difficult to impregnate with preservatives, the sapwood moderately difficult.

Feeding on the leaves may cause death in livestock after dyspnoea, loss of coordination and diarrhoea. Leaves and fruits are also very poisonous to humans.

A methanol extract of the bark showed cytotoxic activity against L-1210 leukaemic cells, with elabunin, a dammarane-type triterpene, as active principle. A steroidal glycoside, buchaninoside, was isolated from the fruits; it exhibited antifeedant activity against African armyworm (*Spodoptera exempta*) larvae. Mutangin, a sesquiterpene of the eudesmane type, was isolated from unripe fruits and exhibited moderate antifeedant activity against larvae of the stem borer *Chilo partellus*.

Botany Shrub or small to medium-sized tree up to 30 m tall; bole often irregular, up to 60 cm in diameter; bark surface becoming fissured, with many lenticels, dark grey to pur-

plish brown; crown rounded, dense; twigs flattened to quadrangular and pale grey when young, becoming rounded and red-brown, glabrous. Leaves usually opposite, but sometimes alternate, simple; stipules small, free, caducous; petiole 0.5–1.5 cm long; blade elliptical to obovate, (5–)6.5–14(–18) cm × 2–8(–10) cm, cuneate at base, shortly acuminate to acute or obtuse at apex, margins toothed with incurved or appressed teeth, leathery, glabrous, pinnately veined with few lateral veins. Inflorescence an axillary cyme on specialized, 3–5 cm long shoots, glabrous. Flowers unisexual, regular, 4–5-merous, sweet-scented; pedicel c. 1 mm long; sepals rounded, c. 1 mm long; petals free, ovate to oblong, 1.5–2.5 mm long, spreading, white to green or yellow; stamens alternating with petals, c. 1 mm long, free; disk slightly lobed; ovary superior, ovoid-conical, c. 1 mm long, 2–3-celled, style short. Fruit an ellipsoid to globose, fleshy drupe 1.5–2 cm long, usually smooth, pale yellow to pale brown when ripe, 1-seeded.

Elaeodendron buchananii grows slowly. It has been reported that in Kenya young trees are often covered by webs made by caterpillars. The tree is evergreen and may attract livestock in the dry season, which can be problematic because of the risk of poisoning.

Elaeodendron comprises about 40 species and occurs in Asia, Australia, Central America and Africa, where 8 species are found.

The wood of *Elaeodendron matabelicum* Loes. (synonym: *Cassine matabelica* (Loes.) Steedman), a shrub or small tree up to 7(–20) m tall occurring in eastern Botswana, Zimbabwe and southern Mozambique, is used for carving utensils such as spoons. Bark and root infusions or decoctions are taken to treat excessive uterine bleeding, bloody diarrhoea and pains, and as aphrodisiac. The roots produce a yellow dye.

The whitish wood of *Elaeodendron transvaalense* (Burtt Davy) R.H.Archer (synonym: *Cassine transvaalensis* (Burtt Davy) Codd), a shrub or small tree up to 10(–15) m tall from southern Zambia, southern Angola, northern Namibia, Botswana, Zimbabwe, southern Mozambique, eastern South Africa and Swaziland, is used for implements and utensils. Bark infusions and decoctions are popular for the treatment of stomach complaints, fever, venereal diseases, kidney and bladder complaints, skin diseases, swellings, haemorrhoids, and to improve appetite. Root extracts are sometimes used for similar complaints. Leaves are chewed to treat throat problems, and a leaf decoction is drunk against poisoning. The bark has been used for tanning. The fruits are edible. *Elaeodendron transvaalense* is sometimes planted as ornamental tree in gardens. Extracts showed in-vitro activity against *Trichomonas vaginalis*, an important cause of urogenital infections.

In South Africa the brownish wood of *Elaeodendron zeyheri* Spreng. ex Turcz., a small tree up to 13 m tall, is used for beams and furniture. The wood has rather similar properties as that of *Elaeodendron buchananii* and is suitable for similar purposes. The bark has been used for tanning and dyeing, and in traditional medicine to treat snakebites. A root decoction has been used as emetic and ordeal poison. *Elaeodendron zeyheri* has been recorded from southern Mozambique, but is more widespread in eastern South Africa. In the literature it has been much confused with *Elaeodendron croceum* (Thunb.) DC. (synonym: *Cassine papillosa* (Hochst.) Kuntze), a shrub or small tree up to 10 m tall occurring in eastern Zimbabwe and eastern South Africa, of which the wood is probably used for similar purposes. *Elaeodendron croceum* is better known as a medicinal plant.

Ecology *Elaeodendron buchananii* occurs in dry evergreen forest, gallery forest and wooded grassland up to 2250 m altitude.

Management Only seeds are used for propagation. The tree can be managed by pollarding, lopping and pruning.

Genetic resources and breeding *Elaeodendron buchananii* is widespread and locally common, and there are no indications that it is threatened by genetic erosion. However, local collection of the bark for medicinal purposes may threaten populations.

Prospects *Elaeodendron buchananii* will probably remain of some importance for its timber in areas where it is common, e.g. locally in Kenya. It is not well suited for agroforestry systems because of its slow growth and dense foliage that is poisonous to livestock.

Major references Bolza & Keating, 1972; Chikamai et al., undated; Coates Palgrave, 1983; Maundu & Tengnäs (Editors), 2005; Takahashi, 1978.

Other references Beentje, 1994; Burkill, 1985; Fernandes et al., 2008; Kubo & Fukuhara, 1990; Neuwinger, 2000; Palmer & Pitman, 1972–1974; Robson et al., 1994; Tsanuo et al., 1993; Tsujino et al., 1995; van Wyk & van Wyk, 1997.

Authors R.H.M.J. Lemmens

EPHIPPIANDRA MADAGASCARIENSIS (Danguy) Lorence

Protologue Ann. Missouri Bot. Gard. 72(1): 85 (1985).

Family Monimiaceae

Chromosome number $2n = 42$

Synonyms *Hedycaryopsis madagascariensis* Danguy (1928).

Origin and geographic distribution *Ephippiandra madagascariensis* is endemic to Madagascar, where it occurs in the northern and eastern parts of the island.

Uses The timber, known as 'ambora', is used for construction, joinery, furniture, coffins and weatherboards. Boles are often hollow and used for beehives. The bark is used as a mordant in dyeing tissue with indigo; it makes the colour brighter. The leaves are used as a cholagogue.

Properties The heartwood is yellowish white to greenish yellow and distinctly demarcated from the sapwood. It is light, tender and brittle. Shrinkage during drying is moderate. The wood works easily, and the nailing properties are good. It is not durable under humid conditions or in contact with the ground and when used for weatherboards it should be treated. It is extremely difficult to distinguish the wood from that of *Tambourissa* spp., which is much more durable.

Botany Evergreen, monoecious, small to medium-sized tree up to 25 m tall; bole up to 50 cm in diameter; twigs soft-hairy. Leaves opposite, simple; stipules absent; petiole 1–1.5 cm long; blade elliptical to obovate, 3–9 cm × 2–6 cm, cuneate at base, apex obtuse to rounded or notched, margins wavy to toothed, soft-hairy below, pinnately veined with 3–4 pairs of lateral veins. Inflorescence an axillary cyme up to 3 cm long, greyish short-hairy, 3–5-flowered with 1 terminal female flower subtended by 2–4 male flowers. Flowers unisexual, regular; male flowers with 3–4 tepals, stamens 35–50, anthers sessile; female flowers with 8–16 minute deltoid tepals c. 0.5 mm long, implanted on margin of flat discoid receptacle 1–1.5 cm in diameter, ovaries c. 150, superior. Fruit consisting of the enlarged, swollen receptacle 3.5–6 cm in diameter, with 30–50 drupelets up to 1 mm long.

Ephippiandra comprises 7 species and is endemic to Madagascar. It is related to *Tambourissa*, of which the wood is used for similar purposes.

Ephippiandra madagascariensis – wild

Ecology *Ephippiandra madagascariensis* is restricted to humid forest at 700–1000 m altitude.

Genetic resources and breeding Destruction of its habitat is a possible threat to *Ephippiandra madagascariensis*.

Prospects The wood of *Ephippiandra madagascariensis* will remain of some local importance, particularly for inside use, as long as it is available in some quantity.

Major references Cavaco, 1959; Guéneau, Bedel & Thiel, 1970–1975; Lorence, 1985.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Brown et al., 2009; Lorence, 1999; Oginuma & Tobe, 2006; Renner et al., 2010; Schatz, 2001.

Authors C.H. Bosch

ERIOCOELUM MICROSPERMUM Radlk. ex Engl.

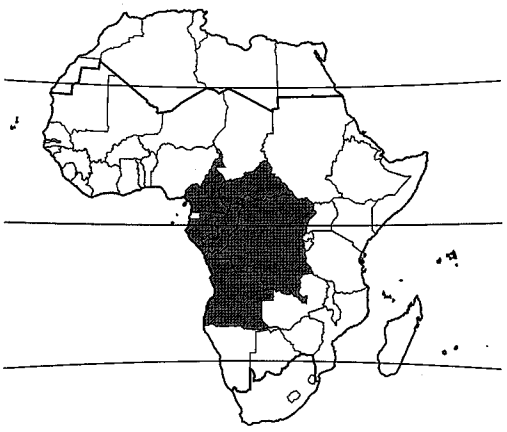
Protologue Engl. & Drude, Veg. Erde 9, III, 2: 282 (1921).

Family Sapindaceae

Origin and geographic distribution *Eriocoelum microspermum* occurs from Cameroon and the Central African Republic south to DR Congo and Angola.

Uses In DR Congo stems are used for poles. The wood is suitable for construction, flooring, joinery, interior trim, ship building, vehicle bodies, furniture, sporting goods, handles, ladders, agricultural implements, boxes, crates, turnery, veneer, plywood, hardboard and particle board. *Eriocoelum microspermum* provides firewood of excellent quality. The bark is used as traditional medicine to treat cough, enteritis and venereal diseases.

Production and international trade The



Eriocoelum microspermum – wild

timber is known under the trade name 'kadiamikani', but trade volumes are probably only small.

Properties The heartwood is pinkish brown to reddish brown, and distinctly demarcated from the pale grey to brownish yellow, up to 7 cm wide sapwood. The grain is usually straight, but with occasional irregular patches, texture medium to fine and even. Radial surfaces show a mottled and ribbon figure, and the wood is lustrous.

The wood is medium-weight, with a density of 560–670 kg/m^3 at 12% moisture content, and very tough and resilient. The shrinkage rates in drying are quite high. At 12% moisture content, the modulus of rupture is 97–139 N/mm^2, modulus of elasticity 12,000 N/mm^2 and compression parallel to grain 53–66 N/mm^2.

The wood is easy to saw. It planes well and usually shows no picking-up of grain. It takes a good finish. The wood has good nailing properties; it does not split and holds nails well. Larger logs are suitable for veneer production by peeling. The wood is moderately durable. It is rarely attacked by termites, the sapwood is not susceptible to *Lyctus* attack, but the wood is liable to marine borer attack.

Botany Monoecious, small to medium-sized tree up to 30(–35) m tall; bole usually straight, branchless for up to 15 m, up to 80 cm in diameter; young twigs reddish brown short-hairy. Leaves alternate, paripinnately compound with 2–3 pairs of leaflets; stipules absent; petiole very short or absent, rachis 8–14 cm long; petiolules stout, up to 8 mm long; leaflets opposite, elliptical, 12–35 cm × 5–13 cm, lowest pair of leaflets smallest and stipule-like, cuneate to rounded at base, acuminate at apex, margins entire, leathery, nearly glabrous, pinnately veined with c. 15 pairs of lateral veins. Inflorescence a terminal or axillary panicle up to 30 cm long, short-hairy. Flowers unisexual, regular, 5-merous; pedicel often recurved, up to 5 mm long; sepals nearly free, c. 1.5 mm long, short-hairy outside; petals free, 3–5.5 mm long, whitish, inside with 2 densely hairy scales at base; stamens 8, free, up to 5 mm long; disk annular, with wavy margin; ovary superior, nearly globose, hairy, 3-celled, style c. 2.5 mm long; male flowers with rudimentary ovary, female flowers with reduced stamens. Fruit a globose capsule 1–2 cm × 1.5–2.5 cm, slightly 3-lobed, orange when fresh, dehiscent with 3 woody valves, inside at base long-hairy, 3-seeded. Seeds ellipsoid, c. 1.5 cm long, smooth, brown, with red cup-shaped aril at base. Seedling with hypogeal germination; epicotyl 3–4 cm long, short-hairy; first leaves alternate, simple.

Eriocoelum comprises about 10 species and is confined to mainland tropical Africa. *Eriocoelum kerstingii* Gilg ex Engl. occurs from Guinea Bissau and Mali east to Sudan and Uganda, and south to Gabon and DR Congo. It is a small tree up to 15 m tall with a bole diameter up to 50 cm. Its pale brown wood is strong and used for construction, furniture, axe-handles and pestles.

Eriocoelum macrocarpum Radlk. ex Engl. is a medium-sized tree up to 30(–35) m tall with bole branchless for up to 20 m and up to 60 cm in diameter. It occurs in Nigeria, Cameroon, Equatorial Guinea, Gabon, Congo and western DR Congo. Its pale brown to pinkish brown wood has properties and uses similar to that of *Eriocoelum microspermum*.

Eriocoelum pungens Radlk. is a shrub or small tree distributed from Liberia to Nigeria. The wood is used in house building and for rafters.

Ecology *Eriocoelum microspermum* is found in humid forest, often in swampy or periodically inundated forest, up to1400 m altitude.

Management Logs have to be processed quickly after felling to avoid serious checking. In DR Congo a bole of 5.6 m long and 43 cm in diameter yielded 0.5 m^3 of wood.

Genetic resources and breeding *Eriocoelum microspermum* is fairly widespread and there are no indications that it is under severe pressure.

Prospects As a timber producer *Eriocoelum microspermum* is not likely to become more important because the bole dimension is often

rather small and the trees usually occur scattered. However, very little is known about this species and other *Eriocoelum* spp.

Major references Bolza & Keating, 1972; Burkill, 2000; Fouarge & Gérard, 1964; Hauman, 1960; Vivien & Faure, 1985.

Other references Bärner & Müller, 1942; Davies & Verdcourt, 1998; Fouilloy & Hallé, 1973a; Hawthorne & Jongkind, 2006.

Authors C.H. Bosch

ERISMADELPHUS EXSUL Mildbr.

Protologue Bot. Jahrb. Syst. 49: 549 (1913).

Family Vochysiaceae

Vernacular names Angoa (Fr).

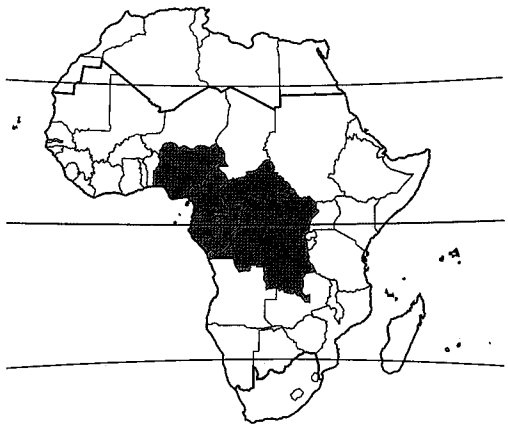
Origin and geographic distribution *Erismadelphus exsul* is distributed from south-eastern Nigeria to DR Congo.

Uses In tropical Africa the wood is locally used for rafters of huts. It is suitable for light construction, furniture, interior trim, joinery and plywood.

In traditional medicine in Cameroon, a decoction prepared from a boiled mixture of the bark of *Erismadelphus exsul* together with the barks of *Albizia adianthifolia* (Schumach.) W.Wight, *Cola lateritia* K.Schum., *Garcinia kola* Heckel, *Ongokea gore* (Hua) Pierre and *Vernonia conferta* Benth. is drunk for the treatment of urinary lithiasis.

Production and international trade The wood is used domestically and hardly or not traded on the international market.

Properties The heartwood is yellowish brown, frequently with greenish brown markings near the centre of the log, and indistinctly demarcated from the yellowish sapwood. The grain is usually straight, sometimes interlocked, texture moderately coarse. The wood is medium-weight, with a density of 630–800 kg/m³ at 12% moisture content. It air dries moderately fast with little tendency of splitting and checking, but twisting or cupping may occur. Thicker boards may be subject to collapse. The shrinkage rates are high, from green to oven dry 4.6–7.6% radial and 8.0–13.9% tangential. Once dry, the wood is moderately stable to unstable in service.

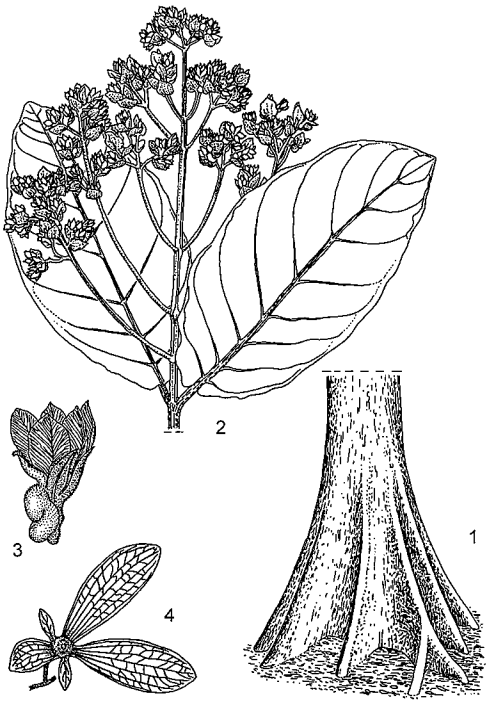


Erismadelphus exsul – *wild*

At 12% moisture content, the modulus of rupture is 117–160 N/mm², modulus of elasticity 11,000–17,700 N/mm², compression parallel to grain 44–67 N/mm², shear 5.5–9 N/mm², cleavage 5–17 N/mm and Chalais-Meudon side hardness 3.1–6.5.

The wood saws easily, but with considerable blunting effect because it contains 0.1–0.5% silica; the use of stellite-tipped saw teeth is recommended. It works moderately well with both hand and machine tools. Some picking up of grain may occur during planing, and it is necessary to take extra caution in sanding and finishing. The wood polishes to a good finish when a filler is used. The nailing properties are good and the gluing properties satisfactory. The steam bending properties are poor. The wood is only moderately durable, being liable to most insect attacks. The sapwood is susceptible to attacks by *Lyctus* borers. Both heartwood and sapwood are moderately resistant to treatment with preservatives.

Description Medium-sized to large tree up to 40(–70) m tall; bole branchless for up to 25 m, straight and cylindrical, up to 100(–150) cm in diameter, often with thin buttresses; bark surface grey to reddish brown, smooth when young, later becoming rough and scaly, inner bark thin, granular, hard but brittle, pale brown or pale pink; crown with spreading branches; twigs slightly quadrangular, glabrous. Leaves opposite, simple and entire; stipules reduced to small warts; petiole 0.5–1.5 cm long, flattened, glabrous or hairy; blade obovate to elliptical, 4–20(–25) cm × 3–11 cm, cuneate to rounded or cordate at base, obtuse to acuminate at apex, leathery, glabrous or hairy on midrib and lateral veins below, pinnately veined with 5–10 pairs of lateral veins. Inflorescence a terminal, umbel-like panicle 10–25 cm long, with opposite branches bearing condensed, 3–4-flowered cymes, hairy, many-flowered; bracts sessile, kidney-shaped to heart-shaped, 7–8 mm × 8–10 mm, persistent.



Erismadelphus exsul – 1, base of bole; 2, flowering twig; 3, flower; 4, fruit.
Redrawn and adapted by J.M. de Vries

Flowers bisexual, zygomorphic, 5-merous, sessile; calyx spurred, lobes nearly equal, oblong to nearly orbicular, up to 7.5 mm × 5 mm, hairy, greenish yellow; petals free, obovate-rhomboid, 9–10 mm × 4.5–6 mm, with a long claw, finely hairy, white; fertile stamen 1, c. 3 mm long, rudimentary stamens 1–3, club-shaped; ovary inferior, 1-celled, style short. Fruit a globose nut c. 8 mm in diameter, brownish, indehiscent, 1-seeded, with sepals enlarged into unequal wings up to 8 cm × 2.5 cm.

Other botanical information *Erismadelphus* comprises 2 species. *Erismadelphus sessilis* Keay & Stafleu occurs in Cameroon, Equatorial Guinea and Gabon, and is apparently rare; it differs from *Erismadelphus exsul* in its sessile and smaller leaves.
Within *Erismadelphus exsul* 2 varieties have been distinguished: var. *exsul* distributed in Cameroon, Gabon, Congo and DR Congo, and var. *platyphyllus* Keay & Stafleu distributed in Nigeria, Cameroon, Equatorial Guinea and Gabon; the latter has more hairy leaves.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 27: intervessel pits large (≥ 10 µm); 29: vestured pits; 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 43: mean tangential diameter of vessel lumina ≥ 200 µm; 46: ≤ 5 vessels per square millimetre; (47: 5–20 vessels per square millimetre); 56: tyloses common. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 83: axial parenchyma confluent; 85: axial parenchyma bands more than three cells wide; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 96: rays exclusively uniseriate; 109: rays with procumbent, square and upright cells mixed throughout the ray; 115: 4–12 rays per mm. Secretory elements and cambial variants: 133: included phloem, concentric; 134: included phloem, diffuse. Mineral inclusions: 159: silica bodies present; 160: silica bodies in ray cells; 161: silica bodies in axial parenchyma cells.
(C. Essien, H. Beeckman & P.E. Gasson)

Growth and development In Nigeria flowering is in April–August and fruiting in June–November. The fruits with their enlarged wing-like sepals are dispersed by wind. In Gabon seedlings have been reported in the understorey of old forest.

Ecology *Erismadelphus exsul* occurs in lowland primary and secondary forest, also in littoral forest, swamp forest and riverine forest. In Gabon littoral savanna is colonized by pioneer species such as *Aucoumea klaineana* Pierre, which are progressively replaced by other species including *Erismadelphus exsul*.

Management *Erismadelphus exsul* trees usually occur scattered in the forest, sometimes in small, occasionally large groups. In Gabon as many as 40 trees per hectare were counted in littoral forest, whereas the mean wood volume in forest in Gabon has been reported to be 2 m^3 per ha. In forest dominated by *Aucoumea klaineana* Pierre and *Sacoglottis gabonensis* (Baill.) Urb., the standing volume of *Erismadelphus exsul* has been estimated at 10 m^3/ha.

Harvesting In Gabon the minimum bole diameter allowed for harvesting *Erismadelphus exsul* trees is 70 cm.

Genetic resources Although *Erismadelphus exsul* has a limited distribution, it is probably not threatened by genetic erosion since there are no indications of over-exploitation within its range.

Prospects Because of its limited durability and its instability in service the wood of *Erismadelphus exsul* does not have a wide range of uses. It may have some potential for use for interior joinery, furniture and plywood. If *Erismadelphus exsul* would become more important as a source of timber, more information would be required on its abundance, regeneration and growth rate to make sustainable exploitation possible.

Major references Anonymous, 1990; Bolza & Keating, 1972; Burkill, 2000; de Saint-Aubin, 1963; Keay & Stafleu, 1953; Robyns, 1958; Sallenave, 1971; Senterre & Obiang, 2005; Vivien & Faure, 1985; Wilks & Issembé, 2000.

Other references Boulvert, 1977; Kawasaki, 2007; Keay, 1954g; Keay, 1989; Kenfack, undated; Normand & Paquis, 1976; Noumi & Ebwelle, 2011; Raponda-Walker & Sillans, 1961; Sallenave, 1955; Sallenave, 1964; Takahashi, 1978.

Sources of illustration Keay & Stafleu, 1953; Robyns, 1958; Wilks & Issembé, 2000.

Authors E.E. Ewudzie, J.R. Cobbinah, S. Britwum Acquah & E.A. Obeng

ERYTHROPHLEUM IVORENSE A.Chev.

Protologue Vég. util. Afr. trop. Franç. 5: 178 (1909).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Ordeal tree, sasswood tree (En). Lim du Gabon, tali (Fr). Mancone (Po).

Origin and geographic distribution *Erythrophleum ivorense* occurs from Gambia to the Central African Republic and Gabon.

Uses The bark traded as 'sassy-bark', 'mancona bark', 'casca bark' or 'écorce de tali' has several medicinal uses. A bark extract is taken orally in Sierra Leone as an emetic and laxative, and is applied externally to relieve pain. In Côte d'Ivoire water, in which the bark of young branches of *Erythrophleum ivorense* is crushed, is rubbed on the skin to treat smallpox.

The bark and sometimes the seeds are widely used as hunting and ordeal poison. In Liberia and Gabon the bark of *Erythrophleum ivorense* is preferred to that of *Erythrophleum suaveolens* (Guill. & Perr.) Brenan. The bark is used as fish poison in Sierra Leone.

Erythrophleum ivorense – wild

The timber of *Erythrophleum ivorense* is marketed as 'erun', 'missanda', 'sasswood', 'alui', 'bolondo' or 'tali'. The wood is quite hard and heavy, and suitable for joinery, flooring, railway sleepers, harbour and dock work, turnery, construction and bridges. It is also used for boat building and wheel hubs. It makes excellent charcoal and good firewood. In Sierra Leone and Côte d'Ivoire the bark is used for tanning. A bark decoction added to fermenting palm wine would make it a more potent drink.

Production and international trade In trade statistics, the timber of *Erythrophleum ivorense* and *Erythrophleum suaveolens* is usually not differentiated. In 2005 the export of *Erythrophleum* ('tali') logs from Cameroon amounted to 37,500 m^3 and of sawn wood to 38,600 m^3, which made *Erythrophleum* the fourth most important timber of Cameroon. In 2005 the price of logs free-on-board was US$ 123–151/m^3, depending on the quality. The major importer is China.

Properties The alkaloid content of *Erythrophleum ivorense* is similar to that of *Erythrophleum suaveolens*; only the distribution of the main compounds is different. First investigations yielded the alkaloid erythrophleine, but this was later identified as a mixture of different alkaloids with similar activities. The alkaloids are esters of tricyclic diterpene acids, and 2 main types exist: dimethylaminoethylesters and monomethylaminoethylesters (nor-alkaloids). In addition, compounds have been found in

which the amine link is replaced by an amide link, but it is not clear whether these are natural compounds or artefacts. The bark contains as main components alkaloids of the dimethylaminoethylester type: cassaine, cassaidine and erythrophleguine, but no dominant alkaloid of the amide type. The alkaloid content of the bark ranges from 0.2% to 1.1%. In high doses, the bark extract is an extremely strong, rapid-acting cardiac poison, in warm-blooded animals causing shortness of breath, seizures and cardiac arrest in a few minutes.

The alkaloids have a stimulant effect on the heart similar to that of the cardenolides digitoxine (from *Digitalis*) and ouabain (from *Strophanthus gratus* (Wall. & Hook.) Baill.), but the effect is very short-lasting, as the alkaloids are quickly metabolized in the organism. Cassaine and cassaidine have strong anaesthetic and diuretic effects, and increase contractions of the intestine and uterus. Apart from an increase of heart contraction in systole, the alkaloids also demonstrated an increase in diastole. In addition, cassaidine caused depressive effects, while cassaine caused a violent state of excitation. Although the alkaloid content in the seeds is markedly lower than in the stem bark, the seeds are more toxic. This strong activity is due to a strong haemolytic saponin, which acts in a synergistic way with the alkaloids.

Wood from *Erythrophleum ivorense* and *Erythrophleum suaveolens* is not differentiated in trade and the following wood description is applicable to both species.

The heartwood is yellowish brown to reddish brown, darkening on exposure, sometimes striped, clearly demarcated from the 3–6 cm wide, creamy-yellow sapwood. The grain is interlocked, texture coarse. The wood is moderately lustrous.

The density is about 900 kg/m^3 at 12% moisture content. The wood dries slowly with high risks of distortion and checking. The shrinkage rates from green to oven dry are 5.1–5.8% radial and 8.4–8.6% tangential. Once dry, the wood is moderately stable in service.

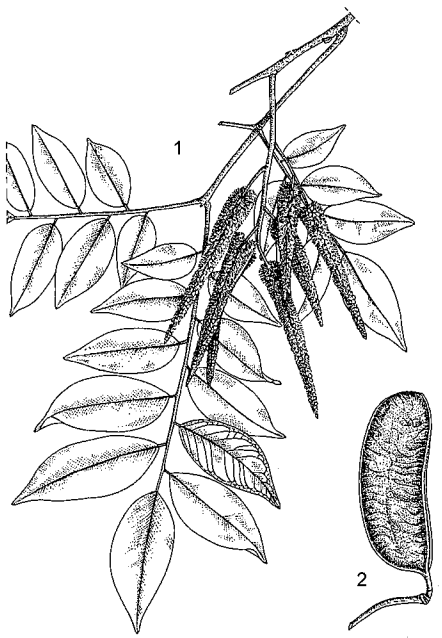
At 12% moisture content, the modulus of rupture is 99–162 N/mm^2, modulus of elasticity 10,550–19,500 N/mm^2, compression parallel to grain 56–97 N/mm^2 and Janka side hardness 13,000 N.

The wood is difficult to saw; stellite-tipped sawteeth are recommended. Finishing is generally fair, but planing may be difficult due to interlocked grain. Pre-boring is necessary for nails and screws. The gluing properties are good.

The wood is durable and resistant to fungi, dry wood borers and termites. It is suitable for use in contact with the ground. It is not permeable for preservatives. The sawdust may irritate mucous membranes and may cause allergy and asthma of labourers in sawmills.

Adulterations and substitutes *Erythrophleum* alkaloids have similar pharmacological activities as digitoxine and ouabain. The timber from *Erythrophleum ivorense* and *Erythrophleum suaveolens* is marketed indiscriminately under the trade names: 'tali', 'erun', 'bolondo' and 'alui'. The timber of *Pachyelasma tessmannii* (Harms) Harms resembles that of *Erythrophleum*, hence the trade name 'faux tali'. *Erythrophleum* wood can be used as a substitute for azobé (*Lophira alata* Banks ex P.Gaertn.).

Description Large tree up to 40 m tall; bole cylindrical, but sometimes fluted at base, with or without buttresses; bark scaly, often fissured, grey, inner bark reddish, granular; young twigs brown hairy. Leaves alternate, bipinnately compound with 2–4 pairs of pinnae; stipules minute; petiole 2–7 cm long, rachis 5–15 cm long; leaflets alternate, (6–)8–14



Erythrophleum ivorense – 1, branch with leaf and inflorescence; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

per pinna, elliptical to ovate, up to 8.5 cm × 4 cm, base asymmetrical, apex shortly acuminate. Inflorescence an axillary or terminal panicle consisting of spike-like racemes up to 8 cm long, shortly reddish brown hairy. Flowers bisexual, regular, 5-merous, red-brown; pedicel c. 1 mm long, shortly hairy; calyx c. 1.5 mm long, lobes c. 0.5 mm long; petals narrowly obovate, c. 2 mm × 0.6 mm, densely hairy; stamens 10, free, 2–3.5 mm long; ovary superior, long woolly hairy, 1-celled, stigma broadly peltate. Fruit a flat, elliptical, dehiscent pod 5–10 cm × 3–5 cm, base rounded, apex obtuse or rounded, thick leathery, pendulous, 2–6(–10)-seeded. Seeds ovoid, compressed, c. 13 mm × 9 mm × 5 mm.

Other botanical information *Erythrophleum* comprises about 10 species, 4 or 5 of which occur in continental Africa, 1 in Madagascar, 3 in eastern Asia, and 1 in Australia. The genus is one of the few *Caesalpiniaceae* reported to contain alkaloids. *Erythrophleum ivorense* and *Erythrophleum suaveolens* share many uses, vernacular names, trade names and properties and therefore confusion is common. Especially the results of earlier pharmacological work are blurred by doubtful identifications. The 2 species differ in ecology, some morphological characteristics and the alkaloid profile in the bark. Only in semi-deciduous forest does *Erythrophleum ivorense* co-occur with *Erythrophleum suaveolens*, from where the latter extends into drier habitats like woodland savanna. However, it is often difficult to distinguish the two species from each other. The leaflets of *Erythrophleum suaveolens* are often wider, its inflorescences wider (often 1.5 cm versus 1 cm in *Erythrophleum ivorense*) and its pods longer.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: (1: growth ring boundaries distinct); (2: growth ring boundaries indistinct or absent). Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 26: intervessel pits medium (7–10 μm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 43: mean tangential diameter of vessel lumina ≥ 200 μm; 46: ≤ 5 vessels per square millimetre; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled; 70: fibres very thick-walled. Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; (83: axial parenchyma confluent); (84: axial parenchyma unilateral paratracheal); 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand; (93: eight (5–8) cells per parenchyma strand). Rays: (96: rays exclusively uniseriate); (97: ray width 1–3 cells); 104: all ray cells procumbent; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Mineral inclusions: (136: prismatic crystals present); (142: prismatic crystals in chambered axial parenchyma cells).
(E. Uetimane, H. Beeckman & P.E. Gasson)

Growth and development *Erythrophleum ivorense* flowers during the rainy season. Nodulation was observed in primary rainforest and the rhizobium involved belongs to the genus *Bradyrhizobium*. In Côte d'Ivoire the mean annual bole diameter increment has been recorded as 6.5 mm, in the Central African Republic 4.5 mm.

Ecology *Erythrophleum ivorense* occurs in evergreen primary and secondary forest and moist semi-deciduous forest. *Erythrophleum ivorense* is essentially a tree of old secondary forest.

Propagation and planting *Erythrophleum ivorense* has been classified as a non-pioneer light demander. Seedlings are often found in smaller forest gaps. *Erythrophleum ivorense* can be propagated in nurseries; seed takes 3 weeks to germinate. Inoculation with *Bradyrhizobium* is beneficial and results in increases in height and diameter of about 40% after 4 months.

Management *Erythrophleum ivorense* trees usually occur scattered in the forest. In Gabon the average bole volume has been recorded as 1.4 m^3/ha. In Liberia the mean density of trees with a minimum bole diameter of 60 cm is 0.7 tree/ha. Reforestation with *Erythrophleum ivorense* is an option in degraded forests where natural regeneration of economically important species is unlikely. In Gabon the clear-cut method is superior to enrichment planting: 6 years after planting the survival rate was 97% vs 79%, the height 16 m vs 11 m and the bole diameter 13.6 cm vs 6.8 cm for the 2 methods respectively.

Harvesting Old *Erythrophleum ivorense* trees very often have heart rot. The bark of *Erythrophleum ivorense* is harvested from the wild whenever the need occurs.

Handling after harvest The logs sink in

water and can consequently not be transported by floating along a river.

Genetic resources *Erythrophleum ivorense* is often abundant in West and Central African evergreen forest. Although logging of *Erythrophleum ivorense* for its timber has shown a distinct increase in Cameroon, there are no indications that the species is under too much pressure yet.

Prospects *Erythrophleum ivorense* contains pharmacologically interesting compounds and further study of its pharmacology is justified. Internal use of unpurified medicines made from *Erythrophleum ivorense* is extremely dangerous. The differences in active ingredients between individual trees in a single population and the differences in composition related to age of the plant are large. Although *Erythrophleum ivorense* has recently gained much importance as a timber tree, especially in Cameroon, comparatively little is known about proper management practices for sustainable harvesting in natural forest.

Major references Aubréville, 1959b; Aubréville, 1968; Burkill, 1995; Chudnoff, 1980; CIRAD Forestry Department, 2003; Cronlund, 1976; de Saint-Aubin, 1963; ITTO, 2004; Neuwinger, 1996; Richter & Dallwitz, 2000.

Other references Bakarr & Janos, 1996; Diabate et al., 2005; Durrieu de Madron, Nasi & Détienne, 2000; Hegnauer & Hegnauer, 1996; Högberg & Alexander, 1995; InsideWood, undated; Koumba Zaou et al., 1998; Siepel, Poorter & Hawthorne, 2004; Sprent, 2005; Voorhoeve, 1979.

Sources of illustration Voorhoeve, 1979.

Authors C.H. Bosch

ERYTHROPHLEUM SUAVEOLENS (Guill. & Perr.) Brenan

Protologue Taxon 9: 194 (1960).

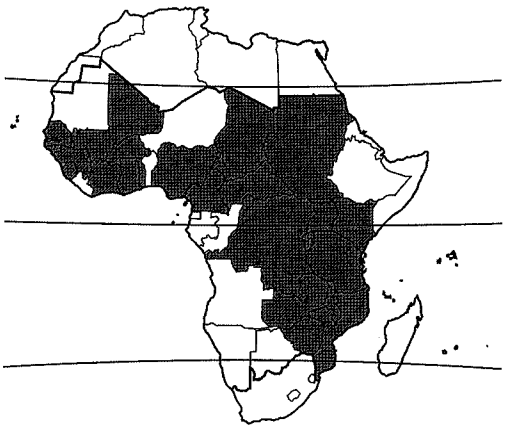
Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 24, 28$

Synonyms *Erythrophleum guineense* G.Don (1832).

Vernacular names Forest ordeal tree, red water tree, sasswood tree (En). Bois rouge, poison d'épreuve, tali, grand tali, mancône (Fr). Mancone, muave (Po). Mwavi, mwavi dume, mbaraka mkuu, mkelekele (Sw).

Origin and geographic distribution *Erythrophleum suaveolens* is distributed from Senegal to Sudan and Kenya in the east and from there south to Zimbabwe and Mozambique. It has been introduced as an ornamental in tropical Asia.



Erythrophleum suaveolens – wild

Uses The bark, traded as 'sassy-bark', 'mancona bark' or 'casca bark' is used as emetic and purgative. The crushed bark is applied to swellings caused by *Filaria*. In DR Congo the dried powdered bark is taken as a snuff to cure headache. In Kenya a diluted decoction of the roots is used as an anthelminthic, especially against tapeworm. In Malawi a decoction of the roots and bark is applied to soothe general body pain. Pieces of root or bark are a protective and love charm. The bark has been used in arrow poisons and as ordeal poison and the bark and leaves as fish poison. The use as an anaesthetic for fish in aquaculture is tricky as small differences in dosage will kill, rather than stupefy fish. In the Western world, bark extracts were used in the late 19th century to treat heart failure. Side effects and better results with digitoxine ended this practice.

The tree produces quite hard, heavy and durable wood, marketed as 'alui', 'tali', 'erun', 'missanda' or 'sasswood', which is suitable for joinery, flooring, railway sleepers, harbour and dock work, turnery, construction and bridges. It is also used for boat building and wheel hubs. The bark has been used in West Africa for tanning hides and skins; it is used in DR Congo to colour leather brown. *Erythrophleum suaveolens* is planted as an ornamental and avenue tree. In West Africa the powdered bark is mixed with the residue of palm oil processing, and after boiling it is mixed with seeds of maize, cowpea or cotton, which effectively reduces pest damage to the seeds. Dried leaves

are mixed with stored grains and pulses to repel or kill storage insects. The use in agroforestry has been promoted: nitrogen fixation and the large amount of leaf litter are advantageous to intercrops. However, in experiments a negative effect of *Erythrophleum suaveolens* leaf mulch on the yield of crops has been noted. When clearing bush to prepare fields, trees are often left standing because the wood is hard and felling is too taxing. *Erythrophleum suaveolens* wood is not highly valued as firewood but charcoal made from it is excellent.

Production and international trade Export of bark of *Erythrophleum* for medicinal purposes no longer plays a role. In local markets however, the bark is an important and expensive article. In trade statistics, the timber of *Erythrophleum ivorense* and *Erythrophleum suaveolens* (Guill. & Perr.) Brenan is usually not differentiated. In 2005 the export of *Erythrophleum* ('tali') logs from Cameroon amounted to 37,500 m^3 and of sawn wood to 38,600 m^3, which made *Erythrophleum* the fourth most important timber of Cameroon. In 2005 the price of logs free-on-board was US$ 123–151/m^3, depending on the quality. The major importer is China.

Properties The alkaloid content of bark was found to range from 0.3% to 1.5%. The alkaloid content was found to vary with the age of the tree: a water extract of the bark contained 0.5% and 0.9% respectively in 60 year- and 150 year-old trees.

The alkaloid content of *Erythrophleum suaveolens* is similar to that of *Erythrophleum ivorense*; only the distribution of the main compounds is different. First investigations yielded the alkaloid erythrophleine, but this was later identified as a mixture of different alkaloids with similar activities. The alkaloids are esters of tricyclic diterpene acids, and 2 main types exist: dimethylaminoethylesters and monomethylaminoethylesters (nor-alkaloids). In addition, compounds have been found in which the amine link is replaced by an amide link, but it is not clear whether these are natural compounds or artefacts. The bark contains as main components alkaloids of the dimethylaminoethylester type: cassaine, erythrophlamine, erythrophleguine and norcassamidine as well as the amide erythrophlamide. The bark extract has excellent local anaesthetic activity on eyes and skin, although its use on the eye was disputed because of its irritant effect on the conjunctiva. Trials using it as anaesthetic in operations or tooth extractions were less successful, as symptoms of poisoning appeared in higher doses. In high doses, the bark extract is an extremely strong, rapid-acting cardiac poison, in warm-blooded animals causing shortness of breath, seizures and cardiac arrest in a few minutes.

The alkaloids have a stimulant effect on the heart similar to that of the cardenolides digitoxine (from *Digitalis*) and ouabain (from *Strophanthus gratus* (Wall. & Hook.) Baill.), but the effect is very short-lasting, as the alkaloids are rapidly metabolized in the organism. The alkaloids also have strong diuretic effects, and increase contractions of the intestine and uterus. Apart from an increase of heart contraction in systole, the alkaloids also demonstrated an increase in diastole. In addition, cassaine caused a violent state of excitation. Although the alkaloid content in the seeds is markedly lower than in the stem bark, the seeds are more toxic. This strong activity is due to a strong haemolytic saponin, which acts in a synergistic way to the alkaloids. Norcassamidine has local anaesthetic action, and is a convulsant.

The bark further contains procyanidins (polyphenols) and hence has antioxidant properties. The relaxant effect of the bark extract of *Erythrophleum suaveolens* is due to its procyanidins.

The bark also contains the trihydroxystilbene resveratrol. Resveratrol shows antiplatelet aggregation, coronary vasodilator, antileukaemic, antifungal and protein-tyrosine kinase inhibitory activities. Trihydroxystilbenes are thought to protect against atherosclerosis and coronary heart disease. Resveratrol is, however, only registered as a food supplement, not as a medicine. The bark contains the flavone luteolin that colours orange after addition of magnesium powder and a few drops of hydrochloric acid. This reaction allows it to be distinguished from the bark of *Erythrophleum africanum* (Welw. ex Benth.) Harms, which colours violet after treatment because of the presence of 2,3-dihydroxymyricetin.

Wood from *Erythrophleum ivorense* and *Erythrophleum suaveolens* is not differentiated in trade and the following wood description is applicable to both species.

The heartwood is yellowish brown to reddish brown, darkening on exposure, sometimes striped, clearly demarcated from the 3–6 cm wide, creamy-yellow sapwood. The grain is interlocked, texture coarse. The wood is moderately lustrous.

The density is about 900 kg/m³ at 12% moisture content. The wood dries slowly with high risks of distortion and checking. The shrinkage rates from green to oven dry are 5.1–5.8% radial and 8.4–8.6% tangential. Once dry, the wood is moderately stable in service.

At 12% moisture content, the modulus of rupture is 99–162 N/mm², modulus of elasticity 10,550–19,500 N/mm², compression parallel to grain 56–97 N/mm² and Janka side hardness 13,000 N.

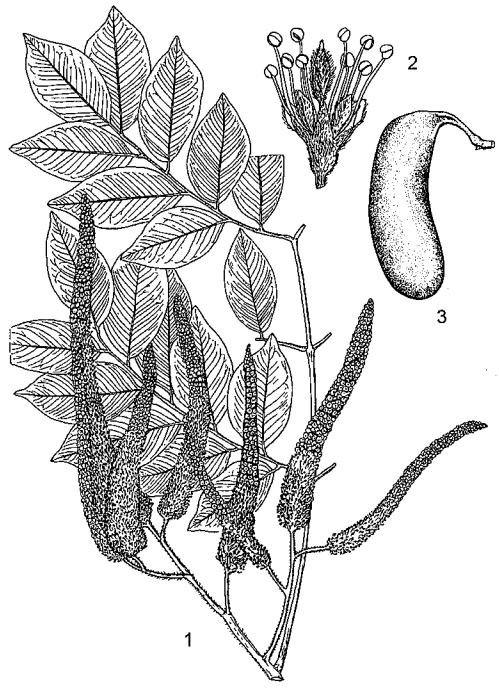
The wood is difficult to saw; satellite-tipped sawteeth are recommended. Finishing is generally fair, but planing may be difficult due to interlocked grain. Pre-boring is necessary for nails and screws. The gluing properties are good.

The wood is durable and resistant to fungi, dry wood borers and termites. It is suitable for use in contact with the ground. It is not permeable for preservatives. The sawdust may irritate mucous membranes and may cause allergy and asthma of labourers in sawmills.

Adulterations and substitutes *Erythrophleum* alkaloids have similar pharmacological activities as digitoxine and ouabain. The timber from *Erythrophleum suaveolens* and *Erythrophleum ivorense* is marketed indiscriminately under the trade names 'tali', 'erun', 'bolondo' and 'alui'.

Description Medium-sized tree up to 25(–30) m tall, often branching low; bark finely fissured, scaly, grey; twigs glabrous. Leaves alternate, bipinnately compound with 2–4 pairs of pinnae; stipules minute, soon falling; petiole and rachis up to 35 cm long, petiole thickened at base; leaflets alternate, 7–14 per pinna, ovate to ovate-elliptical, up to 9 cm × 5.5 cm, base asymmetrical, apex obtusely acuminate. Inflorescence an axillary panicle consisting of spike-like racemes up to 12 cm long, shortly yellowish hairy. Flowers bisexual, regular, 5-merous, yellowish white to greenish yellow; pedicel c. 1.5 mm long, reddish hairy; calyx lobes 1–1.5 mm long; petals 2–3 mm × 0.5 mm, short hairy at margins; stamens 10, free, c. 5 mm long; ovary superior, rusty hairy, 1-celled, stigma cup-shaped. Fruit a flat, slightly curved, dehiscent pod 5–17 cm × 3–5 cm, stipe often lateral, broadly rounded at apex, pendulous, 6–11-seeded. Seeds oblong-ellipsoid, c. 15 mm × 11 mm × 5 mm.

Other botanical information *Erythrophleum* comprises about 10 species, 4 or 5 of which occur in continental Africa, 1 in Madagascar, 3 in eastern Asia, and 1 in Australia. The genus



Erythrophleum suaveolens – 1, branch with part of leaf and inflorescence; 2, flower; 3, fruit. Source: Flore analytique du Bénin

is one of the few *Caesalpiniaceae* reported to contain alkaloids. *Erythrophleum suaveolens* superficially resembles *Burkea africana* Hook. Mistakes in identification have led to accidental poisoning and even death.

Erythrophleum lasianthum Corbishley, the 'Swazi ordeal tree', closely resembles *Erythrophleum suaveolens*. It is restricted to the area from southern Mozambique south to Swaziland. In South Africa the powdered bark is taken as a snuff to relieve headache, as a remedy for other pains and fever, and to cure lung sickness in cattle. The bark has been used as ordeal poison in the same way as *Erythrophleum suaveolens*, and is also used as a fish and rat poison. The bark contains cardioactive alkaloids, mainly norcassamidine.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 26: intervessel pits medium (7–10 μm); (27: intervessel pits large (≥ 10 μm)); 29: vestured pits; 30: vessel-ray pits with distinct bor-

ders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 µm; 43: mean tangential diameter of vessel lumina ≥ 200 µm; 46: ≤ 5 vessels per square millimetre; (47: 5–20 vessels per square millimetre); 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; 83: axial parenchyma confluent; 84: axial parenchyma unilateral paratracheal; 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 104: all ray cells procumbent; 115: 4–12 rays per mm. Storied structure: 118: all rays storied; 122: rays and/or axial elements irregularly storied. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E. Uetimane, H. Beeckman & P.E. Gasson)

Growth and development Regeneration of *Erythrophleum suaveolens* is best in fairly open forest. Flowering has been noted to occur in January–April in West Africa, December–February in Kenya and in March–July in southern Africa. Nodulation was observed and the rhizobium involved belongs to the genus *Bradyrhizobium*.

Ecology *Erythrophleum suaveolens* occurs in moist semi-deciduous forests, gallery forest and wooded grasslands, from sea-level up to 1100 m altitude. It is absent from the evergreen forest.

Propagation and planting *Erythrophleum suaveolens* can be propagated in nurseries; seed takes 3 weeks to germinate. Inoculation with *Bradyrhizobium* is beneficial, with increases in height and diameter of 20% and 28% respectively after 4 months.

Management In Sierra Leone attempts have been made to grow *Erythrophleum suaveolens* in plantations, but growth was slow.

Harvesting The main parts of *Erythrophleum suaveolens* harvested for medicinal purposes are roots and bark, while the wood is exploited for timber. Traditional herbalists use ad hoc techniques to excavate the roots and debark the stems. Virtually all trees are used, from young to old ones.

Handling after harvest *Erythrophleum suaveolens* roots and bark are washed and air-dried before use or trade. In Malawi sawing of the logs mainly takes place in the forest and the timber is transported to timber merchants before or after seasoning.

Genetic resources *Erythrophleum suaveolens* is widespread and locally common, and as such not threatened by genetic erosion. However, locally it is heavily exploited. One can hardly find a mature tree of *Erythrophleum suaveolens* that has not been debarked in Malawi and therefore it is a species of conservation concern there.

Prospects *Erythrophleum suaveolens* is an important medicinal plant and further study of its pharmacology is justified. Internal use of unpurified medicines made from *Erythrophleum suaveolens* is extremely dangerous. The difference in active ingredients between individual trees in a single population and the differences in composition related to age of the plant are not understood at all, which makes use even more hazardous. Breeding and management programmes should be started in target countries to enhance deliberate propagation and establishment in indigenous forests and plantations.

Major references Arbonnier, 2004; Ayensu, 1978; Betti, 2002; Brenan, 1967; Burkill, 1995; Kamanyi et al., 2003; Marshall, 1998; Oliver-Bever, 1986; Neuwinger, 1996.

Other references Abbiw, 1996; Aubréville, 1968; Beentje, 1994; Coates Palgrave, 1983; Cronlund, 1976; Diabate et al., 2005; Hegnauer & Hegnauer, 1996; InsideWood, undated; Ladipo & Onyeachusim, 1993; McGaw, Jäger & van Staden, 1997; Mgbenka & Ejiofor, 1998; Naderali, Doyle & Williams, 2000; Onuorah, 2001; Sprent, 2005; Wilczek et al., 1952.

Sources of illustration Akoègninou, van der Burg & van der Maesen (Editors), 2006.

Authors J.M. Okeyo

ERYTHROXYLUM MANNII Oliv.

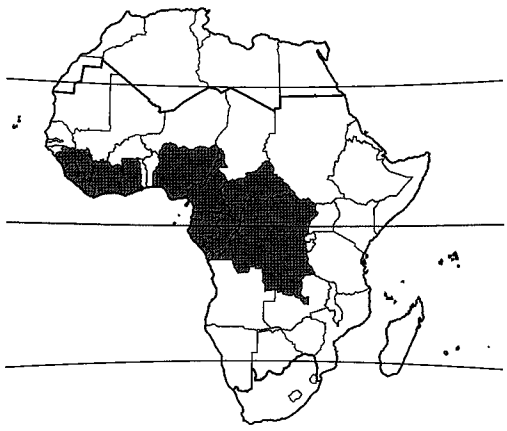
Protologue Fl. trop. Afr. 1: 274 (1868).

Family Erythroxylaceae

Chromosome number $2n = 24$

Origin and geographic distribution *Erythroxylum mannii* occurs from Guinea and Sierra Leone to Gabon and DR Congo.

Uses The wood of *Erythroxylum mannii*, traded as 'landa', is used for furniture and cabinet work, although it may be made unsightly by 'pith-flecks', small darkened streaks or flecks on the face of boards created by the larvae of tiny flies. Logs are traditionally used to make dug-out canoes. The wood is suitable for construction, flooring, joinery, interior trim,



Erythroxylum mannii – wild

mine props, ship building, toys, novelties, rifle butts, boxes, crates, vats, draining boards, turnery, carvings, veneer and plywood. It is a good firewood.
In Côte d'Ivoire a preparation from the bark is used in massaging to treat pleuritic chest pain. A decoction of leafy twigs is reputed to cure fever.

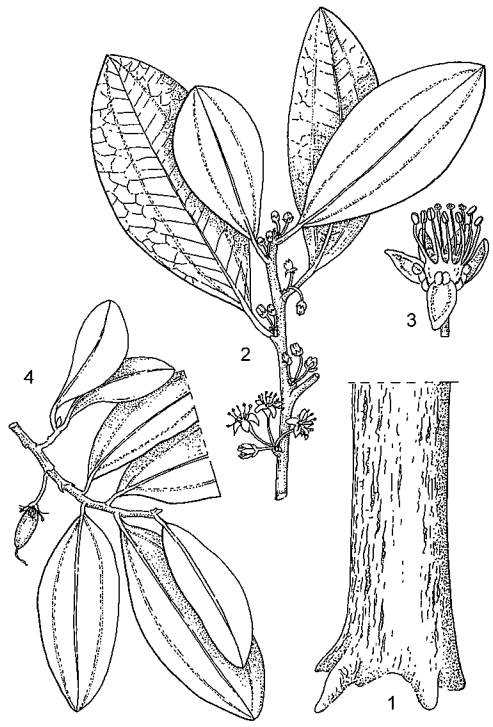
Production and international trade Very small amounts of 'landa' are traded internationally. Cameroon exported 125 m^3 as sawnwood in 2003. In Liberia the wood of *Erythroxylum mannii* has been classified as a second-class commercial timber.

Properties The heartwood is pink to pale reddish brown, darkening upon exposure, and not distinctly demarcated from the up to 6 cm wide, whitish or greyish sapwood. The grain is straight to wavy or interlocked, texture fine and generally even. A figure of broken stripes or mottles is fairly common and numerous pith flecks 2.5–5 cm long may be present. The wood is medium-weight, with a density of 630–700 kg/m^3 at 12% moisture content, and moderately hard. It air dries rapidly, with low risk of surface checking or degrade. The shrinkage rates are moderate, from green to oven dry 3.5–4% radial and 5.8–9.6% tangential. Once dry, the wood is moderately stable to unstable in service.
At 12% moisture content, the modulus of rupture is 91–134 N/mm^2, modulus of elasticity 11,270–14,010 N/mm^2, compression parallel to grain 51–57 N/mm^2, shear 7.5 N/mm^2, cleavage 15–19 N/mm, Janka side hardness 4580 N and Chalais-Meudon side hardness 2.1–3.3.
The wood saws and works well with hand and machine tools, and has a normal dulling effect on saw teeth and cutting edges. It planes well in spite of the presence of wavy or interlocked grain, but is sometimes brittle. It holds nails and screws well. Moulding properties are good, as well as gluing, polishing, painting and waxing properties. The wood is suitable for slicing and peeling. The heartwood is moderately durable, being somewhat susceptible to fungal attack but fairly resistant to termite attack. The heartwood is resistant to impregnation with preservatives, the sapwood moderately resistant.
The wood contains 37% cellulose, 31% lignin, 20% pentosan, 0.5% ash and 0.03% silica. The solubility is 6.9% in alcohol-benzene, 1.7% in hot water and 18.5% in a 1% NaOH solution.

Adulterations and substitutes The wood of *Erythroxylum mannii* has some resemblance to that of *Guarea* spp.

Description Deciduous medium-sized tree up to 25(–30) m tall; bole branchless for up to 15(–18) m, straight and cylindrical, up to 100(–140) cm in diameter, sometimes slightly fluted at base; bark surface fissured and scaly, greyish, inner bark soft, fibrous, with a pinkish layer outside and a yellowish white layer inside, quickly turning brown upon exposure; crown open and flattened, with few spreading main branches; twigs flattened, with lenticels. Leaves alternate, simple and entire, reddish when very young; stipules fused at base, triangular, c. 1 mm long, persistent; petiole 0.5–1 cm long; blade obovate to elliptical, 3–12 cm × 1.5–4.5 cm, base cuneate, apex rounded or slightly notched, papery, glabrous, pinnately veined with up to 20 pairs of lateral veins, often with a faint vein-like line at each side of the midrib. Inflorescence an axillary fascicle, 5–8-flowered. Flowers bisexual, regular, 5-merous, white; pedicel slender, 0.5–1 cm long; sepals fused at base, triangular, 1–2 mm × 1 mm; petals free, oblong, up to 5 mm long, shortly clawed at base and with nectar-producing appendage at base inside; stamens 10, fused at base, 3–5 mm long; ovary superior, obovoid, c. 1.5 mm long, 3-celled, styles 3, fused for more than half their length, stigmas head-shaped. Fruit an oblong to ovoid drupe c. 1 cm long, red when ripe, stone 3-celled but only 1-seeded. Seedling with epigeal germination; hypocotyl 3–3.5 cm long, epicotyl 6–7 mm long, glabrous; cotyledons leafy, narrowly oblong, c. 2 cm long; first leaves opposite.

Other botanical information *Erythroxylum* comprises approximately 200 species and



Erythroxylum mannii – 1, base of bole; 2, flowering twig; 3, flower; 4, twig with fruit. Redrawn and adapted by W. Wessel-Brand

occurs throughout the tropics, most of them in South America. *Erythroxylum coca* Lam. is best known, as the source of coca leaves and cocaine. In tropical Africa about 10 species are found.

Erythroxylum fischeri Engl. is an evergreen, much-branched shrub or small to medium-sized tree up to 18 m tall, with straight bole up to 60 cm in diameter. It occurs in evergreen and riverine forests and thickets up to 1350 m altitude in DR Congo and from southern Sudan and western Ethiopia southward to Tanzania. Its hard and durable wood is used for poles in house building and for utensils such as spoons. It is suitable as garden ornamental or pot plant, and in Ethiopia the leaves are used as fodder for goats. The gum exudate is used as glue and in the preparation of medicines.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; (10: vessels in radial multiples of 4 or more common); 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 25: intervessel pits small (4–7 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 42: mean tangential diameter of vessel lumina 100–200 μm; 48: 20–40 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: (76: axial parenchyma diffuse); 78: axial parenchyma scanty paratracheal; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; (106: body ray cells procumbent with one row of upright and/or square marginal cells); 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; 113: disjunctive ray parenchyma cell walls present; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.

(E.A. Obeng, P.E. Gasson & E.A. Wheeler)

Growth and development *Erythroxylum mannii* is considered to be a pioneer. In Guinea, Ghana and Gabon saplings have been recorded to be common in disturbed forest. Growth of young trees is fast; in Guinea they reached a height of about 12 m and a bole diameter of 11 cm 6 years after planting in the open and a height of about 7 m in the understorey of degraded forest. The mortality was low, less than 9% 6 years after planting. In Ghana young trees reportedly reached a height of 20 m and a bole diameter of 15 cm on logging roads of 4 years old. In natural forest in Côte d'Ivoire, the mean annual diameter growth was recorded as 3.5 mm over a period of 14 years, and in an arboretum in Cameroon it was 5 mm for trees of 50 years old, with some trees reaching 12 mm/year.

Erythroxylum mannii is often not truly deciduous; it produces new leaves well before all old ones are shed. In Sierra Leone it changes its leaves in September–November. Flowering occurs at the end of the dry season, in April–May, fruiting mainly in July–August. In Côte d'Ivoire fruits mature in June–July. They are eaten by birds, which disperse the seeds.

Ecology *Erythroxylum mannii* occurs scattered or in small groups in evergreen forest

and slightly more commonly in semi-deciduous forest.

Propagation and planting Fruits are collected during the rainy season. In Guinea it has been proposed to clear the understorey under fruiting trees to facilitate fruit collection; the seedlings developing from germinating fruits can be transplanted to the nursery. There are about 25,000 fruit stones per kg. They start to germinate 2–4 weeks after sowing. The germination rate is usually low, 2–30%. In each pot 3–5 fruit stones are placed. Shading is not necessary during germination, but is recommended after germination and is progressively reduced 1.5 months before planting seedlings into the field. Seedlings can be planted out after 9 months, when they reached about 45 cm tall.

Management In forest in eastern Sierra Leone average densities of 0.6 trees with a bole diameter of 20–40 cm have been recorded per ha, 0.2 trees with a bole diameter of 40–60 cm per ha, and 0.05 trees with a bole diameter of more than 60 cm per ha. In Cameroon average densities of up to 0.15 trees with a bole diameter of more than 60 cm have been recorded per ha, with a mean wood volume of up to 1 m^3/ha. In plantations in Guinea a first thinning has been done 4–7 years after planting at a spacing of 3 m × 3 m, depending on soil fertility. *Erythroxylum mannii* can be planted in agroforestry systems in association with banana.

Harvesting The minimum bole diameter allowed for harvesting *Erythroxylum mannii* trees is 50 cm in Cameroon and 70 cm in the Central African Republic and Gabon.

Yield Mature trees usually produce 4–7 m^3 of bole wood.

Genetic resources *Erythroxylum mannii* is widespread and although it usually occurs scattered in low densities, there are no indications that it is in danger of genetic erosion.

Prospects The wood of *Erythroxylum mannii* is likely to remain important for local applications because of its good drying and processing properties. The amounts of timber available are nowhere sufficiently common to become an important commodity in the international market. However, as a reputedly fast-growing pioneer species, investigations into its prospects as a plantation timber tree are warranted.

Major references Badré, 1972b; Bolza & Keating, 1972; Burkill, 1994; CTFT, 1950a; Hawthorne, 1995; Irvine, 1961; Normand, 1937; Savill & Fox, 1967; Takahashi, 1978; Vivien & Faure, 1985.

Other references Anonymous, 1960b; Aubréville, 1959b; Badré, 1973b; Beentje, 1994; Chudnoff, 1980; de la Mensbruge, 1966; Friis & Vollesen, 1985; Friis & Vollesen, 1998; Gilbert, 1958; Hubert, undated; Isa Ipor, 1998; Keay, 1958c; Keay, 1989; Kerharo & Bouquet, 1950; Lovett et al., 2007; Raponda-Walker & Sillans, 1961; Tailfer, 1989; Verdcourt, 1984a; Voorhoeve, 1965; White & Abernethy, 1997.

Sources of illustration Badré, 1972; Vivien & Faure, 1985; White & Abernethy, 1997.

Authors L.P.A. Oyen & D. Louppe

EUCLEA PSEUDEBENUS E.Mey. ex A.DC.

Protologue Prodr. 8: 217 (1844).

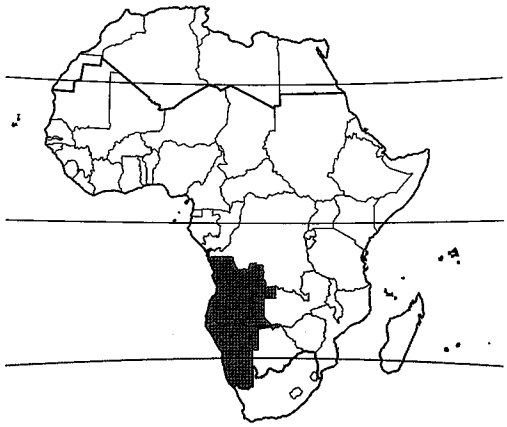
Family Ebenaceae

Chromosome number $2n = 30$

Vernacular names Cape ebony, false ebony (En).

Origin and geographic distribution *Euclea pseudebenus* occurs in dry regions of Angola, Namibia and western South Africa.

Uses The wood with its blackish heartwood and pale sapwood has much resemblance to the true ebony of *Diospyros* spp., and is locally popular for carving and inlay work, and is also used for construction of houses, fences and utensils. However, it is usually only available in small dimensions. It is important as firewood. The roots and twigs are chewed to clean the teeth. The fruits are edible although they may be quite astringent. Root infusions are applied in traditional medicine to treat headache and toothache. Leaves and fruits serve as forage for livestock. The tree gives valuable



Euclea pseudebenus – wild

shade in the hot and dry areas where it grows.

Properties The heartwood is black and distinctly demarcated from the pale sapwood. The wood has a fine texture and is hard and durable.

Several naphthoquinones have been isolated from the roots of *Euclea pseudebenus*, of which 7-methyljuglone showed potent anti-tuberculosis activity, diospyrin showed tumour inhibitory effect against different cancer cell lines, and isodiospyrin showed DNA topo-isomerase I inhibitory activity.

Botany Shrub or small tree up to 10 m tall; bole up to 30(–50) cm in diameter; bark surface deeply cracked, dark grey; branches drooping, twigs slender, hanging straight down, finely hairy. Leaves alternate, simple and entire; stipules absent; petiole up to 3 mm long; blade linear, often slightly curved, 1.5–5 cm × 2–5 mm, cuneate at base, acuminate at apex, leathery, glabrous. Inflorescence a small axillary fascicle, hairy, male one 3–7-flowered, female one 1(–3)-flowered. Flowers unisexual, regular, 5–6-merous; calyx up to 1 mm long, short-hairy; corolla urn-shaped, c. 3 mm long, shallowly lobed; male flowers with 12–20 stamens and rudimentary ovary; female flowers slightly smaller than male ones, with superior, ovoid, densely hairy ovary, usually 4-celled, styles 2, very short. Fruit a globose berry 5–8 mm in diameter, black when ripe, usually 1-seeded. Seed globose, 3–5 mm in diameter, with 2 thin lines and a groove.

Seedlings have been reported to grow rapidly in dry river beds, reaching about 60 cm tall in one year. The flowers are visited by bees and butterflies, which may serve as pollinators. The fruits are mainly eaten by birds, which disperse the seeds.

Euclea comprises about 12 species and is confined to Africa and Arabia. South Africa is richest in species.

Ecology *Euclea pseudebenus* occurs in arid areas where few other tree species can survive, often growing together with *Tamarix* spp. It is commonly found in dry river beds in the Namib desert, preferring deep sandy soils, but occurs also on stony soils.

Management Seedlings soon develop long taproots and are difficult to transplant.

Genetic resources and breeding *Euclea pseudebenus* does not seem to be threatened because it is locally common, although usually not abundant. However, collection of the beautiful wood for carving and as firewood may locally cause high pressure on the populations, for which monitoring is recommended.

Prospects Although *Euclea pseudebenus* provides a beautiful wood for ornamental purposes, its bole size is too small and its occurrence too scattered to be of great commercial importance. Further research on the pharmacological activities of *Euclea pseudebenus* is recommended because the results of preliminary studies are promising.

Major references Coates Palgrave, 1983; de Winter, 1963; Palmer & Pitman, 1972–1974; Van den Eynden, Vernemmen & Van Damme, 1992; van Wyk & Gericke, 2000.

Other references Joubert et al., 2006; Neuwinger, 2000.

Authors R.H.M.J. Lemmens

EURYPETALUM TESSMANNII Harms

Protologue Bot. Jahrb. Syst. 45: 295, fig. 1 (1910).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Eurypetalum batesii* Baker f. (1929).

Origin and geographic distribution *Eurypetalum tessmannii* occurs in southern Cameroon, Equatorial Guinea and Gabon.

Uses The wood is used locally for construction, joinery and carpentry. In Gabon it is considered durable and used for house construction.

Properties The heartwood is coppery reddish brown and distinctly demarcated from the whitish to pale orange-yellow sapwood. The texture is fine. The wood is rather heavy and hard. A red dye is present in the wood.

Eurypetalum tessmannii – wild

Botany Medium-sized to fairly large tree up to 40 m tall; bole up to 90 cm in diameter, often with many upright sprouts at base or several boles together, with buttresses, sometimes with air roots; bark surface fissured, reddish grey to dark grey or blackish, inner bark thin, fibrous; twigs usually glabrous, with lenticels. Leaves alternate, paripinnately compound with 4 leaflets; stipules ovate-lanceolate to elliptical, up to 2 cm long; petiole 1–2(–3.5) cm long, rachis 1–9 cm long; petiolules 4–8 mm long; leaflets at base of leaf alternate to opposite, at apex of leaf opposite, usually obovate-elliptical, (4.5–)6–11.5(–17) cm × (2–)2.5–6(–8.5) cm, acuminate at apex, leathery, glabrous, with marginal gland near base and with translucent dots. Inflorescence an axillary panicle up to 10 cm long, short-hairy, with long branches. Flowers unisexual or polygamous, zygomorphic, whitish; pedicel 2–7 mm long; sepals 4, ovate-oblong, 3–6 mm long, slightly unequal, glabrous; petals 5, free, 1 large and kidney-shaped, 4–8 mm × 7–17 mm, the other very small; stamens 10, in 2 whorls, 9 shortly fused at base, 1 free, up to 11.5 mm long; ovary superior, 1–1.5 mm long, hairy, with short stipe at base, style slender, curved; male flowers with reduced ovary, female flowers with reduced stamens. Fruit an obovate, flattened pod 8–11 cm × 4–5 cm, hairy, with short stipe at base, dehiscing by 2 woody valves, 1–2-seeded. Seeds elliptical to nearly round, flattened, 4–6 cm long, glabrous, brown. Seedling with epigeal germination; hypocotyl 1.5–5 cm long, epicotyl 7–13 cm long; cotyledons thick, fleshy, with fringes at base; first leaves alternate, with 2–4 pairs of leaflets.

In the forest, trees are often surrounded by sprouts from the base of the bole; these sprouts may form circles of up to 5 m in diameter. The flowers are possibly functionally unisexual. Trees with only apparently male flowers are more common than trees with apparently female flowers, in a proportion of approximately 4:1. The fruits are explosively dehiscent with spiralling valves, dispersing the seeds over some distance.

Eurypetalum comprises 2 species. It has been placed close to *Eperua* from tropical America, which has a similar flower structure but differs in wood anatomy and the presence of nectary glands.

The wood of *Eurypetalum unijugum* Harms, a medium-sized tree up to at least 20 m tall with bole up to 80 cm in diameter and endemic to Cameroon, is probably used in the same way as that of *Eurypetalum tessmannii*. *Eurypetalum unijugum* is characterized by a single pair of leaflets.

Ecology *Eurypetalum tessmannii* occurs in lowland rainforest up to 350 m altitude, in primary and old secondary forest.

Genetic resources and breeding *Eurypetalum tessmannii* is fairly widespread in Central Africa, and does not seem to be subject to threats because it is not selectively logged. However, *Eurypetalum unijugum* is classified as vulnerable because it occurs only in Cameroon, and is there rare and threatened by forest clearance.

Prospects *Eurypetalum tessmannii* is poorly known, also concerning its wood properties. However, it will probably remain of only local importance because it is often multi-stemmed with most boles of comparatively small diameter and its wood is hard and heavy without very attractive appearance. However, its vegetative way of propagation by sprouting may offer good possibilities for multiplication e.g. for reafforestation programmes.

Major references Obiang-Mbomio & Breteler, 2007; Raponda-Walker & Sillans, 1961; Sassen & Wan, 2006.

Other references Aubréville, 1968; Aubréville, 1970; Burkill, 1995; Cheek, 2004; Fougère-Danezan, Maumont & Bruneau, 2007; Léonard & Doucet, 1996; Lewis et al., 2005; Normand & Paquis, 1976.

Authors R.H.M.J. Lemmens

FAUREA SALIGNA Harv.

Protologue London Journ. Bot. 6: 373, t. 15 (1847).

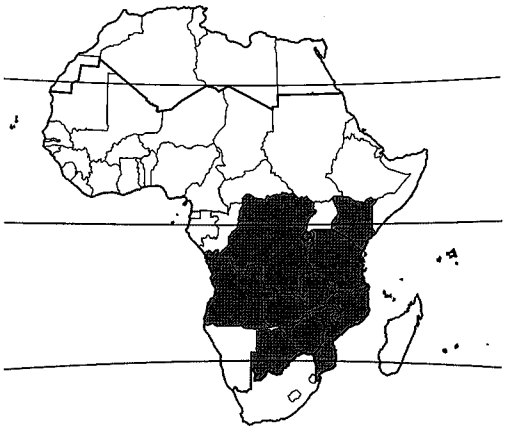
Family Proteaceae

Vernacular names Red beech, African beech, African red beech, beechwood (En).

Origin and geographic distribution *Faurea saligna* occurs from DR Congo, Rwanda and Kenya south to Angola, Botswana, Zimbabwe, Mozambique and northern and eastern South Africa.

Uses The wood is used for poles and posts in construction, joinery, panelling, furniture, utensils, ornaments and fence posts. It is suitable for flooring, railway sleepers, toys, novelties, tool handles, carvings, turnery, veneer and plywood. It is also used as firewood and for charcoal production.

Roots, bark and leaves are used in traditional medicine. Root decoctions and infusions are



Faurea saligna – wild

administered to treat diarrhoea, indigestion, colic, cough, venereal diseases, schistosomiasis and dysmenorrhoea. Bark decoctions are taken against venereal diseases, schistosomiasis, rheumatism, headache and skin complaints, and as tonic. Leaf preparations are applied to treat pneumonia, lumbago, colic, intestinal parasites, headache and skin complaints. The bark has been used for tanning leather and provides a red dye. The tree is planted as windbreak and for mulch, and occasionally as ornamental in large gardens and parks. The flowers are visited by honey bees, which collect nectar; the honey is blackish and has a strong, aromatic and malty flavour.

Properties Heartwood yellowish brown to pinkish brown or reddish brown and rather indistinctly demarcated from the slightly paler sapwood. The grain is interlocked, texture moderately coarse. The wood has a distinct net-like pattern of darker spots on tangential surfaces, and horizontal bands on radial surfaces. The wood is medium-weight, with a density of 720–770 kg/m^3 at 12% moisture content. It air dries fairly well but slowly, without splitting or warping but with slight surface checking. The rates of shrinkage are high. At 12% moisture content, the modulus of rupture is about 89 N/mm^2, modulus of elasticity 11,560 N/mm^2, compression parallel to grain 60 N/mm^2, shear 13.5 N/mm^2 and Janka side hardness 7370 N. The wood saws and works well with machine tools, and it can be planed, mortised and polished with good results. Radial surfaces may show some picking up of grain. The nailing properties are satisfactory. The wood produces good-quality veneer by slicing and peeling. It turns well. It is moderately durable to fairly durable, having some resistance to termites and wood borers. Boles of young trees are not suitable for use as poles or fence posts in contact with the ground, but those of older trees are more durable.

Botany Evergreen small to medium-sized tree up to 20(–27) m tall; bole branchless for up to 10 m, straight or twisted, slender, up to 60 cm in diameter, sometimes swollen at base; bark surface longitudinally fissured, dark greyish brown to blackish, inner bark yellowish with pink or red border; crown fairly open, with spreading branches; twigs pendent, greyish short-hairy, becoming glabrous. Leaves alternate, usually clustered near ends of twigs, simple; stipules absent; petiole up to 1.5 cm long, pinkish to red; blade lanceolate-elliptical, up to 16 cm × 3.5 cm, cuneate at base, acute at apex, margins entire or slightly wavy, leathery, glabrous, glaucous green, pinnately veined with indistinct lateral veins. Inflorescence a terminal, dense spike up to 15 cm long, greyish short-hairy. Flowers bisexual, zygomorphic, 4-merous, sessile; perianth tubular in bud, c. 12 mm long, splitting into 4 reflexing lobes, one nearly free, the others fused almost to apex, pale pinkish green; stamens fused to perianth lobes; ovary superior, with long straight hairs, 1-celled, style long and slender. Fruit a small, globose nut covered with silky white hairs, 1-seeded.

Trees grow moderately slowly. In southern Africa flowering trees can be found from August to February and fruits ripen 2–3 months later. The flowers are fragrant with a sweet smell and rich in nectar, and attract bees, which are probably the major pollinators.

Faurea comprises about 15 species and occurs in mainland Africa, but one species is endemic to Madagascar. *Faurea rochetiana* (A.Rich.) Pic.Serm. (synonym: *Faurea speciosa* Welw.) is quite similar to *Faurea saligna* and has been much confused in literature with the latter. It differs in its usually wider leaves, which are hairy below, and has an even larger area of distribution, from Nigeria east to Ethiopia and south to South Africa. Its wood is used for similar purposes, and the tree is used for other purposes which are also comparable to *Faurea saligna*. Some other *Faurea* spp. have been confused with *Faurea saligna*, particularly *Faurea arborea* Engl., *Faurea delevoyi* De Wild. and *Faurea wentzeliana* Engl., which are all medium-sized trees, occasionally up to 30 m tall. This means that information published

under *Faurea saligna* may refer to another species or to a mixture of species.

Faurea forficuliflora Baker is a small tree up to 10(–20) m tall, with a bole up to 50 cm in diameter, endemic to Madagascar, where it is widespread in the central regions up to 2500 m altitude. Its hard, yellowish brown wood has been used for fence posts.

Faurea macnaughtonii E.Phillips is restricted to South Africa and Swaziland, where it occurs in few, scattered populations. Its brown to dark brown, nicely figured wood, which is heavy (with a density of about 950 kg/m^3 at 12% moisture content) and hard, has been valued for furniture, but the tree is now protected.

Ecology *Faurea saligna* occurs in woodland, often together with *Brachystegia* spp., and grassland with scattered trees, at 700–2000 m altitude, in regions with a mean annual rainfall to as low as 500 mm. It can be found on sandy or loamy soils, and on rocky ridges. Trees are slightly fire-tolerant, but do not survive fierce fires.

Management There are about 165,000 nuts per kg. Fresh nuts should be sown in well-drained soil; they may lose viability within a month. The germination rate is reported to be variable, from poor to fair.

Genetic resources and breeding *Faurea saligna* is widespread and locally common, and there are no indications that it is in threat of genetic erosion.

Prospects *Faurea saligna* and other *Faurea* spp. do not have good prospects as timber trees of more economic importance because the logs are usually too small and trees grow too slowly. However, as multi-purpose trees valuable for local timber production, in local medicine, and as auxiliary tree, bee forage and ornamental tree, they deserve protection. Phytochemical and pharmacological studies are recommended in view of the wide use of *Faurea* spp. in traditional medicine.

Major references Chilufya & Tengnäs, 1996; Coates Palgrave, 1983; Latham, 2007; Maundu & Tengnäs (Editors), 2005; Orwa et al., 2009.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Brummitt & Marner, 1993; Burkill, 1997; Chikamai et al., undated; Chisumpa, Brummitt & Marner, 2006; Grace et al., 2002a; Mbambezeli, 2008; Neuwinger, 2000; Palmer & Pitman, 1972–1974; van Wyk & Gericke, 2000.

Authors R.H.M.J. Lemmens

FOETIDIA CLUSIOIDES Baker

Protologue Bull. Misc. Inform. Kew 1895: 104 (1895).

Family Lecythidaceae

Vernacular names Stinkwood tree (En).

Origin and geographic distribution *Foetidia clusioides* is endemic to eastern Madagascar.

Uses The wood of *Foetidia clusioides* and other *Foetidia* spp., called 'bois puant' or 'nato hofatra' in Madagascar, is used in heavy construction for posts and piles. It is suitable for heavy construction, heavy flooring, joinery, interior trim, ship building, vehicle bodies, railway sleepers, mine props, sporting goods, toys, novelties and turnery. It is also used as firewood and for charcoal production.

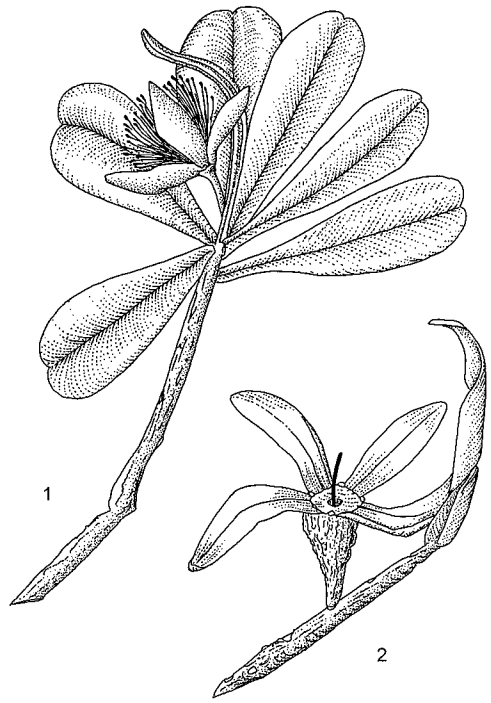
Production and international trade The wood of *Foetidia clusioides* is only locally used and traded.

Properties The heartwood is reddish grey and not distinctly demarcated from the grey sapwood. The grain is usually straight, sometimes interlocked, texture medium and even. The wood has a bad smell. It is heavy, with a density of 1000–1080 kg/m^3 at 12% moisture content, and hard, strong and fairly elastic. It air dries fairly easily, but care is needed to avoid splitting, checking or twisting. The shrinkage rates are high, from green to oven dry 7.8–9.1% radial and 13.0–13.8% tangential. Once dry, the wood is unstable in service. At 12% moisture content, the modulus of rupture is 249–322 N/mm^2, modulus of elasticity 22,740–24,220 N/mm^2, compression parallel to grain 91–104 N/mm^2, shear 8.5–13.5 N/mm^2, cleavage 20–29.5 N/mm and Chalais-Meudon

Foetidia clusioides – wild

side hardness 7.5–11.8.
The wood works fairly well with both hand and machine tools, and can be planed to a smooth surface. It is very shock resistant. It holds nails and screws well, but pre-boring is recommended. The wood takes a nice polish and glues well. It is very durable, also when in contact with the ground or water, and is rarely attacked by termites. The sapwood may be liable to *Lyctus* attack.

Description Evergreen small tree up to 15 (–20) m tall; bole up to 35 cm in diameter; twigs thick, glabrous. Leaves arranged spirally, clustered near apex of branches, simple and entire, nearly sessile, inrolled in bud; stipules absent; blade slightly obliquely oblanceolate to spatulate, 5–13 cm × 2–6 cm, base cuneate, apex rounded or notched, leathery, glabrous, pinnately veined with numerous indistinct lateral veins. Flowers solitary in leaf axils, bisexual, regular; pedicel up to 2 cm long; sepals 4, oblong-oblanceolate, c. 1.5 cm × 0.5 cm; petals absent; stamens numerous, free, arranged in 4 groups, 1–1.5 cm long; disk flat and circular; ovary inferior, 4-celled, style almost as long as stamens, thick, usually with 4 short branches. Fruit a top-shaped woody drupe 1–1.5 cm long, indehiscent, with at apex persistent disk and enlarged wing-like sepals up to 3 cm long, few-seeded.



Foetidia clusioides – 1, twig with flower; 2, twig with fruit.
Redrawn and adapted by J.M. de Vries

Other botanical information *Foetidia* comprises 16 species, of which 13 are endemic to Madagascar, 2 to the Mascarene islands, and 1 to Tanzania.
The wood of other *Foetidia* species is occasionally used in Madagascar. *Foetidia asymetrica* H.Perrier is a small to medium-sized tree up to 20 m tall, which is widespread in northern and western Madagascar. Its wood, called 'manambao', is heavy and moderately hard, and used for construction, particularly for posts in traditional houses and for bridges, carpentry and wagon construction.
Foetidia obliqua Blume is a shrub or small tree up to 10 m tall. It is the most common and widespread species of *Foetidia* in Madagascar, occurring from north to south in eastern parts of the island; it also occurs on Pemba island (Tanzania), possibly introduced and naturalized. Its wood, named 'voantsanàka' in Madagascar, is used in construction for posts and piles. The leaves are used in traditional medicine; leaf infusions are administered to treat complaints of the respiratory organs.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 24: intervessel pits minute (≤ 4 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 47: 5–20 vessels per square millimetre; 48: 20–40 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 86: axial parenchyma in narrow bands or lines up to three cells wide; 93: eight (5–8) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 113: disjunctive ray parenchyma cell walls present; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; 159:

silica bodies present; 160: silica bodies in ray cells.
(P.E. Gasson, P. Mugabi & E.A. Wheeler)

Ecology *Foetidia clusioides* occurs in humid evergreen forest, up to 1000 m altitude.

Genetic resources *Foetidia clusioides* is fairly widespread and there are no indications that it is in immediate danger of genetic erosion, although the fragmentation of the forest in eastern Madagascar may cause a serious threat in the near future. The numbers of trees of several other *Foetidia* species have fallen dramatically and these need protection urgently.

Prospects The wood is likely to remain of local importance because of its durability and good working properties.

Major references Bolza & Keating, 1972; Bosser, 1988; Lens et al., 2007; Morton et al., 1997; Perrier de la Bâthie, 1954b; Prance, 2008; Sallenave, 1964; Sallenave, 1971; Takahashi, 1978.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Guéneau, 1971a; Guéneau, Bedel & Thiel, 1970–1975; Lisan & Allorge, undated; Madagascar Catalogue, 2011.

Sources of illustration Perrier de la Bâthie, 1954b.

Authors L.P.A. Oyen

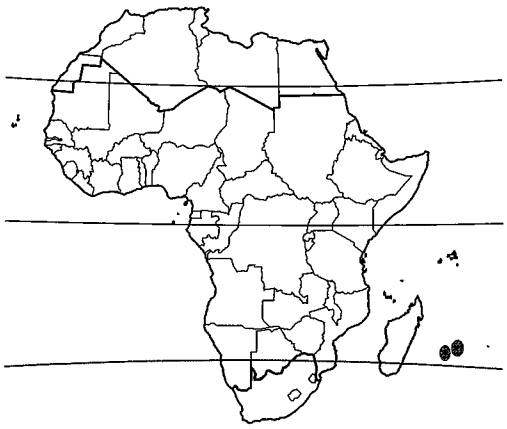
FOETIDIA MAURITIANA Lam.

Protologue Encycl. 2 (2): 457 (1788).

Family Lecythidaceae

Synonyms *Foetidia borbonica* J.F.Gmel. (1791).

Origin and geographic distribution *Foetidia mauritiana* is endemic to Mauritius and Réunion.



Foetidia mauritiana – *wild*

Uses The durable wood, called 'bois puant', was formerly well appreciated for construction and furniture, although it has a bad smell. However, nowadays larger trees are too rare to be used for such purposes.

In traditional medicine, the seeds are eaten to expel intestinal worms and as laxative or purgative. The leaves are used as emmenagogue. In Réunion, wood and bark preparations are administered in mixtures to treat complaints of the respiratory organs and fever, and externally to warts. The roots are considered diuretic and laxative, and are used to expel intestinal worms. *Foetidia mauritiana* is occasionally planted as an ornamental tree.

Production and international trade The wood is no longer traded.

Properties The wood of *Foetidia mauritiana* is probably similar to that of *Foetidia clusioides* Baker. The bark is rich in saponosides and also contains fair amounts of tannin.

Botany Evergreen small to medium-sized tree up to 20 m tall; bole usually straight, up to 60 cm in diameter; bark surface smooth, grey; twigs thick, glabrous. Leaves arranged spirally, clustered near apex of branches, simple and entire, sessile, inrolled in bud; stipules absent; blade slightly obliquely obovate, (5–)7–14(–16) cm × 3–6 cm, base cuneate, apex obtuse to slightly notched, leathery, glabrous, pinnately veined with numerous indistinct lateral veins. Flowers solitary in leaf axils, bisexual, regular; pedicel 2.5–4 cm long; sepals 4, triangular, 1.5–3 cm × 1–1.5 cm, fleshy; petals absent; stamens numerous, free, 2–3 cm long; disk flat and circular; ovary inferior, 4-celled, style c. 1.5 cm long, with 4 short branches. Fruit a top-shaped woody drupe 2–2.5 cm long, indehiscent, with at apex persistent disk and recurved sepals, few-seeded. Seeds flattened ovoid, c. 3.5 mm long, brown.

Foetidia comprises 16 species, of which 13 are endemic to Madagascar, 2 to the Mascarene islands, and 1 to Tanzania.

The wood of *Foetidia rodriguesiana* Friedmann, endemic to Rodrigues, is also called 'bois puant', is probably similar to that of *Foetidia mauritiana* and was used for similar purposes. It was also used to make canoes. In traditional medicine, bark decoctions are taken to treat gonorrhoea and dysentery. *Foetidia rodriguesiana* is a small tree up to 10 m tall, usually with a tortuous bole up to 70 cm in diameter. It is now confined to forest remnants, where only

about 50 trees remain in a single group, together with a few isolated trees; it is protected.

Ecology *Foetidia mauritiana* occurs in semi-deciduous dry forest and hill forest, up to 500 m altitude.

Management Natural regeneration is reported to be very poor. *Foetidia mauritiana* is planted in protected areas in efforts to restore the original vegetation. It fruits from October to January, but fruits can be collected from the ground throughout the year because seeds remain viable for a long time. If the fruits are still green, they should be dried in the shade. They are broken with a hammer after thorough drying. There are 400–600 seeds per kg. Seeds keep their viability for more than one year under ambient conditions and for more than 5 years in cold storage. Seeds are scarified by placing them in a 5% chlorate solution for 1 hour to kill fungi that could affect the seedlings, and then rinsed in ample water. They are sown on a sandy soil mixture poor in organic matter. Fungicides, and less often insecticides, are applied with the irrigation water. Germination may start after 2 weeks but can also take 6(–12) months. The germination rate is about 30%. Because the radicle is fragile and grows rapidly, seedlings should be transplanted very early, when the radicle is about 1 cm long, into a deep container. *Foetidia mauritiana* can also be propagated by layering.

Genetic resources and breeding Due to over-exploitation, *Foetidia mauritiana* has become rare and its conservation status is rated as vulnerable; in Réunion it is fully protected since 1987.

Prospects Focus is now on the conservation of the few remaining stands of *Foetidia mauritiana*. If the efforts to restore stands by planting are successful, some marketable wood may be produced again in the longer future.

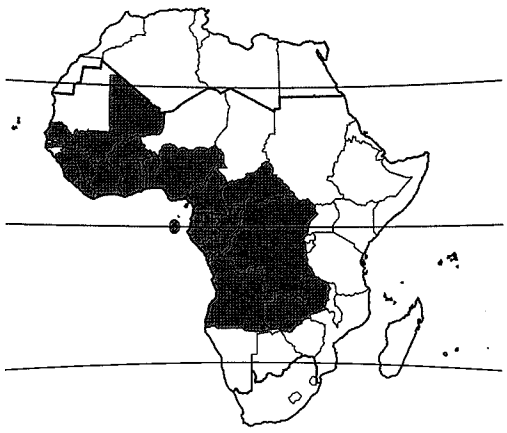
Major references Friedmann & Scott, 1993; Gurib-Fakim & Brendler, 2004; Gurib-Fakim, Guého & Bissoondoyal, 1996; Gurib-Fakim et al., 1994; Prance, 2008.

Other references CIRAD, 2008; Lavergne, 2001; Ruhomaun, 2003; Sarrailh et al., 2007.

Authors L.P.A. Oyen

GAERTNERA PANICULATA Benth.

Protologue Hook., Niger Fl.: 459 (1849).
Family Rubiaceae
Chromosome number $2n = 22$
Origin and geographic distribution *Gaertnera paniculata* is distributed from Senegal and Guinea through West and Central Africa to Zambia and Angola.



Gaertnera paniculata – wild

Uses In Nigeria the wood is made into pestles and small canoes. In DR Congo the stems are used in house construction. The wood is also used as firewood and for making charcoal. In Gabon young stems are woven into baskets used for catching fish. The roots and young shoots are sometimes eaten. In Nigeria the foliage is browsed by goats. Bees collect the nectar for honey. In traditional medicine in Congo, a root decoction is taken for the regulation of tachycardia and a bark decoction for the treatment of cough and chest pain, while the leaf pulp is rubbed in for the treatment of rheumatism and the leaves are eaten against fever. The plant has ornamental value.

Properties The wood is reddish. The roots, bark and leaves contain saponin.

Botany Evergreen shrub or small tree up to 9 m tall; bole low-branching, up to 30 cm in diameter, occasionally more; twigs glabrous or short hairy. Leaves opposite, simple and entire; stipules with 1–2 cm long tube and 4 lobes c. 1 mm long, caducous; petiole 0.5–1.5 cm long; blade elliptical to elliptical-oblong or oblanceolate, 8–18 cm × 3–9 cm, base cuneate to obtuse, apex acuminate, papery or thinly leathery, glabrous or main veins short-hairy beneath, pinnately veined with 3–8 pairs of lateral veins. Inflorescence a terminal cyme or panicle up to 30 cm long, strongly branched, many-flowered; peduncle up to 8 cm long, glabrous. Flowers bisexual, regular, 5-merous, heterostylous, usually sweetly fragrant, nearly sessile; calyx cup-shaped, up to 2 mm long, with trian-

gular lobes up to 1 mm long; corolla white or greenish, densely hairy outside, tube funnel-shaped and 2.5–4 mm long, lobes strap-shaped to linear and 1.5–2.5 mm long; stamens inserted beneath the throat of the corolla tube, with short filaments; ovary superior, 2-celled, style slender, 1.5–2 mm long or 6–7 mm long, stigma 2-lobed. Fruit a globose drupe 6–9 mm in diameter, indehiscent, violet, purple or blue when mature, 1(–2)-seeded. Seed broadly ovoid, 4 mm × 3 mm, obscurely grooved.
In Benin *Gaertnera paniculata* flowers in September–December and fruits in January–April. *Gaertnera* comprises about 70 species and occurs in tropical Africa, Asia and Australia. There are 12 species in tropical Africa.

Ecology *Gaertnera paniculata* occurs from sea-level up to 1700 m altitude in the understorey of evergreen and moist deciduous forest, also in gallery forest, in primary as well as secondary forest where it may be abundant, often in forest edges and near rivers.

Genetic resources and breeding *Gaertnera paniculata* is not threatened with genetic erosion, as it has a wide distribution and is locally common.

Prospects *Gaertnera paniculata* has a wide range of local uses, being a source of timber, fuel, food, fodder, weaving material and medicine. However, information on its properties is lacking almost entirely, and therefore it is not possible to indicate whether the species will become more important for any of these uses in the future. Its value as a timber tree is restricted by the small size of the bole.

Major references Burkill, 1997; Figueiredo, 2005; Latham, 2004; Malcomber & Taylor, 2009; Verdcourt, 1989d.

Other references Akoègninou, van der Burg & van der Maesen (Editors), 2006; Aubréville, 1959c; Hawthorne & Jongkind, 2006; Hepper & Keay, 1963; Irvine, 1961; Neuwinger, 2000; Nkeoua & Boundzanga, 1999; Raponda-Walker & Sillans, 1961.

Authors M. Brink

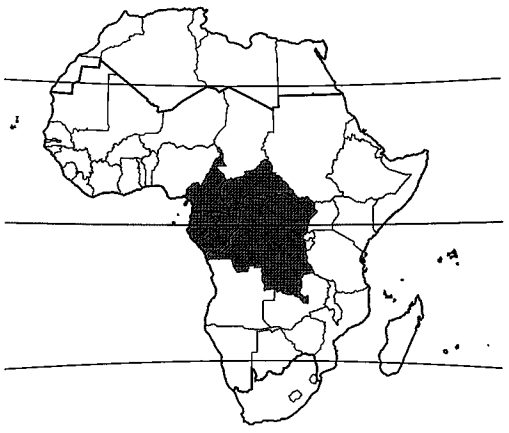
GANOPHYLLUM GIGANTEUM (A.Chev.) Hauman

Protologue Fl. Congo 9: 363 (1960).

Family Sapindaceae

Synonyms *Pseudospondias gigantea* A.Chev. (1917).

Origin and geographic distribution *Ganophyllum giganteum* occurs in Cameroon, Central African Republic, Equatorial Guinea, Gabon, Congo and DR Congo.



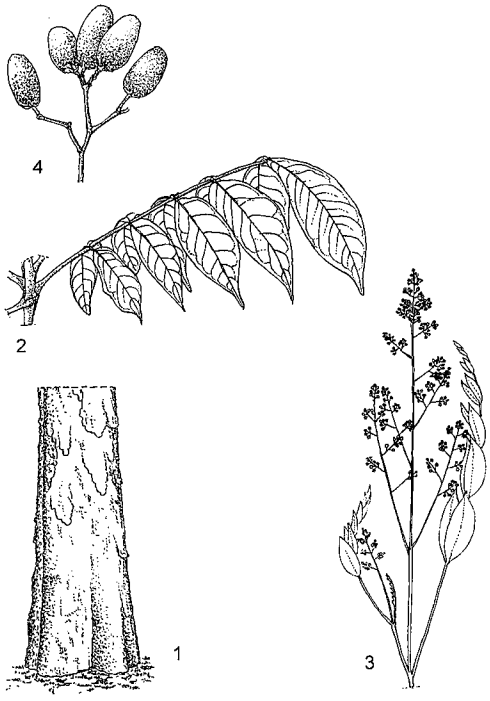
Ganophyllum giganteum – wild

Uses The wood, often traded as 'zembili', is suitable for heavy construction, joinery, vehicle bodies, furniture, handles, ladders, toys, novelties, agricultural implements, pattern making, carving and turnery. It is suitable for charcoal production.
The sweet flesh of the fruits is eaten and apparently locally popular in DR Congo. In traditional medicine, bark decoctions and macerations are taken to treat problems of the respiratory and digestive tracts, dysmenorrhoea, epilepsy, convulsions, sterility and impotence, and they are administered to treat wounds, and in a vapour bath to treat rheumatism and trypanosomiasis. The fruit is administered in a mixture with other plants to treat asthma.

Properties The heartwood is whitish yellow to pale pinkish brown, and not distinctly demarcated from the sapwood. The grain is usually straight, texture fine and even.
The wood is heavy, with a density of 825–895 kg/m^3 at 12% moisture content, fairly hard and tough. Air drying should be done with great care to avoid serious splitting and checking. The rates of shrinkage are high, from green to oven dry 7.6% radial and 12.5% tangential. At 12% moisture content, the modulus of rupture is 179 N/mm^2, modulus of elasticity 16,700 N/mm^2, compression parallel to grain 66 N/mm^2, cleavage 17.5 N/mm and Chalais-Meudon side hardness 6.3.
The wood is not difficult to work despite its hardness. It is fairly durable, but may be susceptible to termite and marine borer attacks and is only moderately durable when exposed

to the weather or in contact with the ground. The sapwood is not liable to *Lyctus* attack.
The triterpenoids zanhic acid and zanhic acid-γ-lactone have been isolated from the root bark. The crude hydromethanolic extract of *Ganophyllum giganteum* leaves showed pronounced cytotoxicity against human monocytes.

Description Dioecious, medium-sized to fairly large tree up to 40 m tall; bole branchless for up to 25 m, straight and cylindrical, sometimes crooked, up to 120 cm in diameter, with small to medium-sized buttresses or fluted at base; bark surface reddish brown, scaling off in large, irregular flakes, inner bark fibrous, orange to reddish, with menthol smell; crown irregular; twigs glabrous, resinous, with many small lenticels. Leaves alternate, clustered near the apex of twigs, paripinnately compound with 5–9(–12) pairs of leaflets, resinous; stipules absent; petiole 4–10 cm long, rachis up to 25 cm long; petiolules c. 2 mm long; leaflets usually alternate, ovate to lanceolate, 5–15(–20) cm × 2.5–5 cm, asymmetrical at base, acuminate at apex, margin entire, glabrous, distinctly glossy with very small whitish dots at upper surface, pinnately veined with 8–12 pairs of lateral veins. Inflorescence an axillary panicle up to 30 cm long. Flowers unisexual, regular, usually 5-merous, small, whitish; pedicel c. 2.5 mm long, with minute glands; sepals c. 2.5 mm long, fused at base; petals absent; stamens free, alternating with sepals, c. 5 mm long; disk lobed, glabrous; ovary superior, 2-celled, style short; male flowers with rudimentary ovary, female flowers with reduced stamens. Fruit an ellipsoid to ovoid, fleshy drupe c. 2 cm × 1.5 cm, glabrous, yellow to orange when ripe, 1-seeded. Seedling with epigeal germination; hypocotyl 4–5 cm long, epicotyl 3–4 cm long; cotyledons oblong, 2–3 cm long, fleshy; first leaves opposite, with 6–10 leaflets.



Ganophyllum giganteum – 1, base of bole; 2, leaf; 3, flowering twig; 4, fruits.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Ganophyllum* comprises 2 species. *Ganophyllum falcatum* Blume occurs in tropical Asia and Australia. It closely resembles *Ganophyllum giganteum*, differing only in its slightly smaller flowers with hairy disk. The wood of *Ganophyllum falcatum* is similar and exported in small quantities from Papua New Guinea and the Solomon Islands.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; (7: vessels in diagonal and/or radial pattern); 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 25: intervessel pits small (4–7 μm); 26: intervessel pits medium (7–10 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 μm; 42: mean tangential diameter of vessel lumina 100–200 μm; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 65: septate fibres present; (66: non-septate fibres present); 69: fibres thin- to thick-walled; 70: fibres very thick-walled. Axial parenchyma: (76: axial parenchyma diffuse); 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; (81: axial parenchyma lozenge-aliform); (82: axial parenchyma winged-aliform); 83: axial parenchyma confluent; (91: two cells per parenchyma strand); 92: four (3–4) cells per parenchyma strand; (93: eight (5–8) cells per parenchyma strand). Rays: 97: ray width 1–3 cells; 104: all ray cells procumbent; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.

(S. N'Danikou, P. Baas & H. Beeckman)

Growth and development In Gabon trees flower in November, and fruits ripen in January–February. Gorillas eat the fruits in large quantities and serve as seed dispersers.

It has been recorded that flower induction takes place when night temperatures drop below 19°C. In Gabon this is often the case during the dry season in July and August. However, in some years this does not happen and then the trees fail to flower and fruit. It has been suggested that global warming may have a disastrous effect on *Ganophyllum giganteum* and on the animals that depend on it at least part of the year, such as gorillas feeding on the fruits.

Ecology *Ganophyllum giganteum* mostly occurs in semi-deciduous forest, sometimes in evergreen forest, up to 700 m altitude.

Propagation and planting The average 1000-seed weight is 940 g.

Management *Ganophyllum giganteum* appears to be uncommon in many regions within its distribution area, and is therefore not subject to specific management measures for timber production.

Diseases and pests The foliage of *Ganophyllum giganteum* is susceptible to insect damage; in Gabon severe defoliation has been reported, particularly in the period December–February.

Genetic resources *Ganophyllum giganteum* is fairly widespread in Central Africa and at present there is no reason to consider it threatened. However, monitoring of the existing populations is recommended in view of its usually scattered occurrence, preference for undisturbed forest, probable slow growing rates and possible vulnerability in the context of climate change.

Prospects Too little is known about *Ganophyllum giganteum* to judge its possibilities as a timber tree of more economic importance. Based on trials in tropical Asia, a rotation cycle of 100 years has been estimated for sustainably harvesting sawn timber of *Ganophyllum falcatum*, with an estimated annual production of 0.9 m³/ha. When it is assumed that this is comparable to production rates in *Ganophyllum giganteum*, it is not very promising for planting for timber production on an economically valid basis.

Major references Bolza & Keating, 1972; Fouilloy & Hallé, 1973a; Lamidi et al., 2005; Raponda-Walker & Sillans, 1961; Sallenave, 1964; Takahashi, 1978; Vivien & Faure, 1985; Vivien & Faure, 1996; White & Abernethy, 1997; Wilks & Issembé, 2000.

Other references Adjanohoun et al. (Editors), 1988; Bolza & Keating, 1972; Bouquet, 1969; Dasuki, 1998; Dimbi et al., 1984; Neuwinger, 2000; Ngavoura, 1990; Voysey et al., 1999a; Voysey et al., 1999b.

Sources of illustration Raponda-Walker & Sillans, 1961; White & Abernethy, 1997; Wilks & Issembé, 2000.

Authors S. Adanu & C.H. Bosch

GILBERTIODENDRON DEWEVREI (De Wild.) J.Léonard

Protologue Bull. Jard. Bot. Etat 22: 190 (1952).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

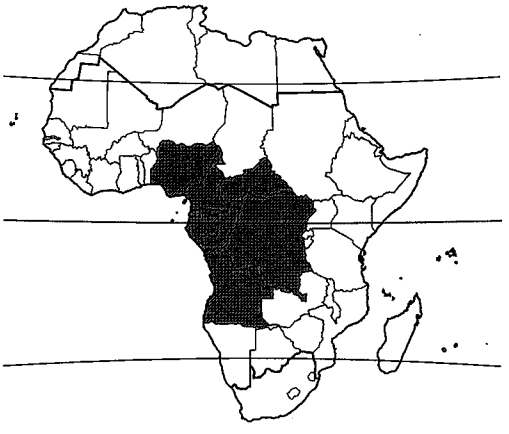
Chromosome number $n = 12$

Synonyms *Macrolobium dewevrei* De Wild. (1904).

Vernacular names Limbali (Fr).

Origin and geographic distribution *Gilbertiodendron dewevrei* is distributed from Nigeria to DR Congo and northern Angola.

Uses The wood, traded as 'limbali', is very suitable for flooring, joinery, stairs, window frames, doors and decks of bridges. It can also be used for heavy construction including hydraulic works, interior trim, mine props, ship building, vehicle bodies, garden furniture, railway sleepers, toys, novelties, agricultural implements, draining boards and turnery. As the wood does not have special aesthetic qualities, it is not very suitable for cabinet work and fine joinery. The wood is considered unsuitable



Gilbertiodendron dewevrei – wild

as firewood, but it is much sought after for the production of charcoal.

In DR Congo the inner bark is used for tying and for making bands for carrying baskets, whereas bark cylinders are sometimes used for making honey containers. The leaves are used for thatching and house walls. In north-eastern DR Congo houses were traditionally built from material of *Gilbertiodendron dewevrei* and clay only: poles for the house skeleton, small branches for the walls between rooms, string from the bark of young trees for tying, and leaves for covering the roof.

Although it has been recorded that it takes a long time to remove toxic compounds from the seeds, the roasted or boiled seeds are eaten in times of shortage in Central Africa, or they are boiled and ground into flour, which is made into porridge. The fermented seeds are ground, wrapped in leaves of *Megaphrynium macrostachyum* (Benth.) Milne-Redh., and roasted. The seeds are also eaten by the Baka pygmy people of Cameroon, after they have been boiled and the seed coat has been removed.

In traditional medicine in Congo, the powdered bark is taken for the treatment of dysentery and is sprinkled on wounds, the leaves are used against sterility and asthma, and to promote childbirth, whereas leaf ash is rubbed into scarifications on painful knees. In DR Congo sap from the stem is applied on whitlows, bark decoctions are drunk for the treatment of gastritis and blennorrhoea, sap expressed from the bark together with that of *Tephrosia vogelii* Hook.f. is used against otitis, and pounded scrapings of the dried bark are applied on burns.

Production and international trade 'Limbali' wood was regularly exported from DR Congo into Belgium before the Second World War, but only occasionally afterwards. Today, its commercial exploitation is not important anymore, and fluctuating from year to year. Exports of 'limbali' logs from Cameroon were 50 m^3 in 2000, 1770 m^3 in 2006, 2380 m^3 in 2007 and 260 m^3 in 2008. Cameroon exported 140 m^3 of sawn wood in 2004 and 80 m^3 in 2006. Congo exported 345 m^3 of finished 'limbali' products and 15 m^3 of logs in 2004, and 30 m^3 of logs and 17 m^3 of sawn wood in 2006.

Properties The heartwood is pale brown to dark reddish brown, darkening upon exposure; it is distinctly demarcated from the 5–10 cm wide, greyish or yellowish sapwood. The grain is straight or wavy, occasionally interlocked, texture medium to coarse. Gum ducts are sometimes present. Quarter-sawn surfaces are slightly mottled, with alternating pale and darker brown streaks.

The wood is medium-weight to heavy, with a density of 730–910 kg/m^3 at 12% moisture content. It air dries slowly, with a tendency to split. Kiln drying should be done carefully to prevent distortion and checking. It takes about 12 days to kiln dry boards of 2.5 cm thick to 12% moisture content. The rates of shrinkage are moderate to high, from green to oven dry 3.2–6.4% radial and 7.4–11.1% tangential. Once dry, the wood is moderately stable to unstable in service.

At 12% moisture content, the modulus of rupture is 102–189 N/mm^2, modulus of elasticity 13,300–19,300 N/mm^2, compression parallel to grain 54–76 N/mm^2, shear 8.5–12 N/mm^2, cleavage 16.5–20.5 N/mm, Janka side hardness 6670 N, Janka end hardness 6490 N and Chalais-Meudon side hardness 4.4–6.0.

Fresh wood saws relatively easily but slowly. The wood may have a significant blunting effect on saw blades, making the use of stellite-tipped saw teeth necessary. It works fairly well, but tends to blunt cutting edges. It moulds and planes easily. It holds nails and screws well, but pre-boring is recommended to prevent splitting. The wood paints, varnishes and glues well. It is not suitable for peeling.

The wood is durable, being moderately resistant to resistant to fungal attack, moderately resistant to termites and resistant to marine borers. The sapwood is susceptible to *Lyctus* borers. The heartwood is resistant to impregnation with preservatives, the sapwood more permeable.

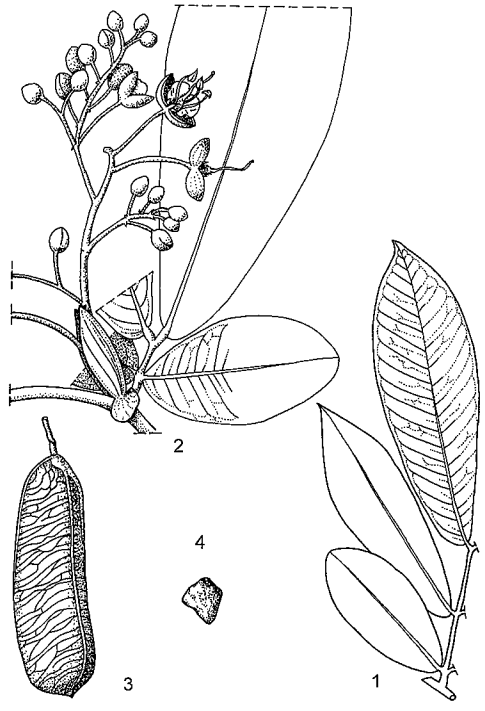
The wood contains 38–42.5% cellulose, 34.5–36.5% lignin, 14.5–15.5% pentosan, 0.8–1.6% ash and 0.03–0.04% silica. The solubility is 0.6–7.1% in alcohol-benzene, 1.3–2.3% in hot water and 13.6–17.2% in a 1% NaOH solution.

Per 100 g edible portion seeds from DR Congo contained: water 9.4 g, energy 1478 kJ (353 kcal), protein 4.8 g, fat 0.6 g, carbohydrate 82.3 g, fibre 1.5 g and ash 1.5 g.

Adulterations and substitutes Other *Gilbertiodendron* spp., such as *Gilbertiodendron brachystegioides* (Harms) J.Léonard, *Gilbertiodendron ogoouense* (Pellegr.) J.Léonard and *Gilbertiodendron preussii* (Harms) J.Léonard, are sometimes confused with *Gilbertiodendron dewevrei* and sold as 'limbali'.

Description Evergreen, large tree up to 45 m tall; bole branchless for up to 22 m, straight, cylindrical, up to 200(–300) cm in diameter,

without buttresses; bark surface grey-brown to yellowish brown, rough, exfoliating in large, irregular scales, with brown lenticels, inner bark thick, fibrous, hard, red-brown; crown dense. Leaves alternate, pendulous, paripinnately compound with (2–)3(–5) pairs of leaflets; stipules ovate-lanceolate, fused, 2–8 cm × 1.5–4 cm, with 2 kidney-shaped appendages up to 2.5 cm long, more or less persistent; petiole thick, 0.5–1 cm long, rachis 2–25 cm long, narrowly grooved above, short-hairy; petiolules thick, 1–16 mm long; leaflets opposite, oblong to oblanceolate or elliptical, slightly oblique, 9–50 cm × 3–20 cm, basal leaflets usually smaller than terminal ones, base rounded to cordate, asymmetrical, apex obtuse to acuminate, leathery, usually glabrous, often with 2–4 small glands near the margin, lower surface densely papillose, pinnately veined with 14–25 pairs of lateral veins. Inflorescence a terminal or axillary, lax panicle 8–25 cm long, reddish hairy. Flowers bisexual, zygomorphic, 5-merous, fragrant; pedicel 2–4 cm long; bracteoles 2, ovate to elliptical, 1–2 cm long; sepals ovate-lanceolate to narrowly triangular, 5–8 mm long, purplish red, fused at base; petals unequal, 1 ovate, 1.5–3 cm × 2.5–3 cm, deeply 2-lobed, wine-red, other petals linear-lanceolate, 6–8 mm × 1–1.5 mm; fertile stamens 3, 1.5–2.5 cm long, rudimentary stamens 6, 0.5–2 mm long; ovary superior, 1-celled, style 2–3 cm long. Fruit an obliquely oblong to oblong-obovoid, flattened pod 15–30 cm × 6–10 cm, with distinct longitudinal ridge and numerous transversal veins, brownish, densely covered with short brown hairs, dehiscent with 2 woody valves, 4–6-seeded. Seeds orbicular to oblong or slightly triangular, flattened, 4–5 cm in diameter, shiny brown. Seedling with epigeal germination; hypocotyl 7–20 cm long, epicotyl 14–24 cm long; first 2 leaves opposite, with 2 large and 2 minute leaflets.



Gilbertiodendron dewevrei – 1, leaf; 2, part of flowering twig; 3, fruit; 4, seed.
Redrawn and adapted by G.W.E. van den Berg

Other botanical information *Gilbertiodendron* comprises about 25 species and is restricted to tropical Africa, distributed from Guinea to DR Congo and Angola. It was formerly included in *Macrolobium*, which now consists of tropical American species only, and is closely related to *Pellegriniodendron*, which is even considered congeneric.

The wood of various other Central African *Gilbertiodendron* species is sometimes traded as 'limbali'. *Gilbertiodendron brachystegioides* (Harms) J.Léonard is a fairly large tree up to 35(–40) m tall with a straight bole branchless for up to 20 m and up to 80 cm in diameter, distributed in Cameroon, Equatorial Guinea and Gabon. The wood, occasionally traded as 'limbali' although it releases a fetid smell on felling, is medium-weight with a density of about 710 kg/m^3 at 12% moisture content.

Gilbertiodendron grandiflorum (De Wild.) J.Léonard is a small tree up to 15(–25) m tall, distributed in Nigeria, Cameroon, Gabon and DR Congo. In DR Congo the wood is valued for high-class cabinet work. It is also suitable for poles, piles, flooring, joinery, mine props, ship building, vehicle bodies, railway sleepers, agricultural implements and handles. *Gilbertiodendron grandiflorum* has been planted for shade. The wood has a density of 640–820 kg/m^3 at 12% moisture content.

Gilbertiodendron grandistipulatum (De Wild.) J.Léonard is a medium-sized tree up to 30 m tall with a bole up to 80 cm in diameter, distributed in Gabon and DR Congo. The wood is quite similar to that of *Gilbertiodendron dewevrei* and has a density of about 840 kg/m^3 at 12% moisture content.

Gilbertiodendron mayombense (Pellegr.) J.Léonard is a small to medium-sized tree up to 20 m tall with a bole up to 65 cm in diameter,

distributed from Nigeria to DR Congo and Cabinda (Angola). The wood is considered suitable for construction, flooring, joinery, mine props, ship building, vehicle bodies, furniture, railway sleepers and agricultural implements. It has a density of about 770 kg/m^3 at 12% moisture content.

Gilbertiodendron ogoouense (Pellegr.) J.Léonard is a medium-sized to fairly large tree up to 35 m tall with a cylindrical bole branchless for up to 19 m and up to 200 cm in diameter, distributed in Cameroon, Equatorial Guinea, Gabon, DR Congo and Cabinda (Angola). The wood is suitable for joinery and railway sleepers.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 1: growth ring boundaries distinct. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 24: intervessel pits minute (≤ 4 μm); 25: intervessel pits small (4–7 μm); (26: intervessel pits medium (7–10 μm)); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 43: mean tangential diameter of vessel lumina ≥ 200 μm; 46: ≤ 5 vessels per square millimetre; (47: 5–20 vessels per square millimetre); 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; 83: axial parenchyma confluent; (89: axial parenchyma in marginal or in seemingly marginal bands); 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand. Rays: (96: rays exclusively uniseriate); 97: ray width 1–3 cells; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 115: 4–12 rays per mm; (116: ≥ 12 rays per mm). Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.

(E. Uetimane, P.E. Gasson & E.A. Wheeler)

Growth and development Germination is rapid, usually within 5–7 days after seed dispersal. Regeneration is abundant under shade, and seedlings tolerate dense shade for a long time. The roots are colonized by ectomycorrhizae and vesicular-arbuscular endomycorrhizae. The proportion of the roots that is colonized by ectomycorrhizae increases with age in saplings. The rapid colonization of the roots by ectomycorrhizae gives the seedlings an advantage over species that are not or more slowly colonized. In dense, undisturbed stands, the roots are not nodulating with *Rhizobium*, but some root nodules can be found in disturbed forest.

The average annual increase in stem diameter is 5.3 mm. Observations on 10 trees originating from Gabon and Congo show annual increases in stem diameter of 2.6–11.4 mm.

Young leaves are red and formed throughout the year. In Nigeria and Cameroon flowering is in January–April, and fruiting takes place in (July–)August–September(–October). Flowering does not always occur annually, and a large number of flowers is shed without forming fruits. Still, fruiting is usually abundant, with mast seed production every 2–4 years. Seed dispersal is ballistic, with the seeds being ejected after explosive dehiscence of the fruit.

Ecology *Gilbertiodendron dewevrei* occurs below 1000 m altitude, in areas with an average annual rainfall of 1600–1900 mm and a dry season of about 2 months. It grows gregariously in humid depressions, alluvial valleys and along rivers, but also frequently in upland locations (plateaus, hill tops). On deep, well-draining sandy soils, it forms a deep tap root. On stony soils tap root formation is difficult, and the formation of lateral roots becomes prominent.

Gilbertiodendron dewevrei can form extensive, almost pure stands, sometimes covering more than 10,000 ha. In these monodominant forests, *Gilbertiodendron dewevrei* forms 75–88% of the basal area. The largest stands can be found in the northern and north-eastern part of the Congo basin, in DR Congo, where these forests are considered to be the climax vegetation. In DR Congo these stands typically consist of 3 layers: a continuous upper tree layer about 35 m high, almost uniformly consisting of *Gilbertiodendron dewevrei*, with in some places the crown of another large, heliophilous tree species (e.g. *Anthonotha fragrans* (Baker f.) Exell & Hillc., *Dialium corbisieri* Staner, *Irvingia wombolu* Vermoesen, *Prioria oxyphylla* (Harms) Breteler and *Staudtia kamerunensis* Warb.); a not very dense middle layer mainly consisting of young *Gilbertiodendron dewevrei* mixed with several rare semi-heliophytes (e.g. *Diogoa zenkeri* (Engl.) Exell & Mendonça, *Garcinia punctata* Oliv. and *Synsepalum subcordatum* De Wild.) and shrubs (e.g. *Alchornea floribunda* Müll.Arg. and *Isolona thonneri* (De Wild. & T.Durand) Engl. & Diels); and a dis-

continuous herbaceous layer of *Marantaceae* and *Commelinaceae*.

In certain regions the monodominant *Gilbertiodendron dewevrei* forest seems to gain terrain to the heterogeneous forests. Elsewhere, for instance in Cameroon, it seems to regress, being gradually invaded by species from the surrounding semi-deciduous forest, either under the influence of a decreasing groundwater table or as a result of human activities. The monodominant *Gilbertiodendron dewevrei* forests are very sensitive to forest clearing for shifting cultivation, because this permits the penetration of secondary and deciduous species into the forest. If forest clearing is too substantial and frequent, the monodominant forests may be transformed into semi-deciduous forest or degraded savanna after only 4–6 years of cultivation. Near the northern and southern limits of its distribution area, *Gilbertiodendron dewevrei* does not form stands as extensive as in the northern Congo basin, but it persists along rivers. Where *Gilbertiodendron dewevrei* is found in heterogeneous forest, it is never as isolated trees, but always in groups.

Propagation and planting *Gilbertiodendron dewevrei* regenerates abundantly under natural conditions. For planting, seeds should be sown immediately after collection. The 1000-seed weight is 18–26 kg. Seedlings can be planted out after 9–12 months in the nursery.

Management In natural forest, suppression of the herbaceous layer makes the establishment of *Gilbertiodendron dewevrei* seedlings even more abundant. Although the species is typically shade-loving, moderate light is beneficial for the growth of seedlings, but full light has adverse effect. Excessive opening of the canopy of dense *Gilbertiodendron dewevrei* stands will favour the establishment of light-loving species with rapid growth, often accompanied by abundant growth of lianas, which is not desirable for the establishment of exploitable *Gilbertiodendron dewevrei* stands.

Diseases and pests Fallen seeds of *Gilbertiodendron dewevrei* are often severely attacked by insects and are eaten by various mammals, such as antelopes, wild pigs, elephants, rodents and primates. Fungi only attack seeds already damaged by insects. Forest buffaloes and bongos eat the seedlings, and elephants sometimes dig up saplings over large areas to eat the root mat consisting of roots, fungal mycelia and decaying leaves. Primates eat the young leaves of adult trees. The young leaves of seedlings and young trees (less than 2 m tall) are most liable to damage. Adult trees do not seem to have important enemies, but they are sometimes attacked by the fungus *Fomes lignosus*.

Harvesting The minimum bole diameter for felling in Cameroon (2001) and DR Congo is 60 cm, in Gabon 70 cm and in the Central African Republic 90 cm. To make headbands for carrying baskets, the Mbuti pygmy people in DR Congo strip bark strips 2 m long and 5–10 cm wide from young trees with a bole diameter of 15–20 cm, and remove the outer bark. The harvest of bark strips from young plants can lead to heart rot of trees.

Yield In DR Congo a tree 25 m tall with a bole branchless for 10 m and a diameter of 90 cm had a wood volume of 5.5 m^3. In the Uele region in DR Congo, dense stands dominated by *Gilbertiodendron dewevrei* had on average 419 trees with a bole diameter over 10 cm per ha, with a total volume of 370 m^3/ha, of which 245 *Gilbertiodendron dewevrei* trees/ha with a volume of 283 m^3/ha.

Handling after harvest *Gilbertiodendron dewevrei* logs must be sawn soon after felling because they tend to split. Because the density of fresh wood is high, logs cannot be transported by floating.

Genetic resources *Gilbertiodendron dewevrei* is not much exploited for its wood, and it is present in protected areas, sometimes in important populations. Currently there are no important threats for *Gilbertiodendron dewevrei*, but this may rapidly change if its wood becomes more valuable, because clear-cutting of extensive monospecific stands could, in the long run, bring about a drastic decline of populations and important genetic erosion of the species.

Breeding No planting or breeding programmes of *Gilbertiodendron dewevrei* are known to exist.

Prospects The promotion of *Gilbertiodendron dewevrei* wood by a number of forest exploiters having it in their concessions, among their customers as well as on Internet, could eventually raise the question of the durability of the resource. The stands rich in *Gilbertiodendron dewevrei* are very sensitive to invasion by other species when the canopy is opened too much. Clear-cutting these stands would be deleterious for their survival, and control of the size of the gaps created by felling should be promoted to prevent invasion of light-loving species, and to stimulate regeneration and optimal growth of *Gilbertiodendron dewevrei*.

Ringing of the trees before felling can help to decrease the impact of falling trees. In certain more densely populated rural areas, forest clearing for agriculture can present an important danger because it brings about degradation of the monodominant *Gilbertiodendron dewevrei* forests, with penetration of pioneer species. Short rotations and intensive weeding of crops, as is practised in Cameroon, can lead to invasion of herbs and even to savanna formation. Therefore it would be good to monitor the evolution of *Gilbertiodendron dewevrei* stands to prevent these dangers from becoming realities. More research is still needed to establish appropriate silvicultural methods.

Major references ATIBT, 1986; Aubréville, 1970; Bolza & Keating, 1972; CTFT, 1960; Fouarge, Gérard & Sacré, 1953; Gérard, 1960; Gérard et al., 1998; Hart, 1995; Hart, Hart & Murphy, 1989; Vivien & Faure, 1985.

Other references Ankei, 1990; Blake & Fay, 1997; Burkill, 1995; Dudek, Förster & Klissenbauer, 1981; Fouarge, Quoilin & Roosen, 1970; Keay, 1989; Konda ku Mbuta et al., 2010; Likunde, 1987; Louis & Fouarge, 1949; Neuwinger, 2000; Nkeoua & Boundzanga, 1999; Nyakabwa & Lombe, 1990; Sallenave, 1955; Sallenave, 1964; Tailfer, 1989; Takahashi, 1978; Terashima & Ichikawa, 2003; Thirakul, 1989; Vivien & Faure, 1988; Wilczek et al., 1952.

Sources of illustration Aubréville, 1968; Vivien & Faure, 1985.

Authors C. Doumenge

GILBERTIODENDRON LIMBA (Scott-Elliot) J.Léonard

Protologue Bull. Jard. Bot. Etat 24: 59 (1954).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 24$

Synonyms *Macrolobium limba* Scott-Elliot (1894).

Origin and geographic distribution *Gilbertiodendron limba* is distributed from Guinea and Sierra Leone east to Ghana.

Uses The wood is used for planks, flooring, joinery and canoes. It is recommended for heavy construction, vehicle bodies, stairs and railway sleepers.

In traditional medicine in Sierra Leone, leaves have been used against fever, and leaf ash mixed with water is applied on ulcers. Leafy twigs are used for the treatment of pelvic inflammation in women.

Gilbertiodendron limba – wild

Properties The heartwood is dark brown, and distinctly demarcated from the yellowish sapwood. The sapwood usually has a lustrous surface. The texture is medium. The wood is heavy and hard, easy to work and durable.

Description Evergreen, small to medium-sized tree up to 25 m tall; bole often crooked, usually low-branching, up to 70 cm in diameter, without buttresses; bark surface fairly smooth, with some scales peeling off and leaving yellowish marks, inner bark thin, red-brown, sometimes with a purple tinge; crown with drooping branches. Leaves alternate, paripinnately compound with (1–)2(–4) pairs of leaflets; stipules lanceolate, c. 1 cm long, with rounded or kidney-shaped appendages c. 2 cm × 1 cm, persistent; petiole short, rachis 1.5–10 cm long, reddish brown, densely hairy; petiolules short, stout, reddish brown; leaflets opposite, oblong to obovate or elliptical, 6–30 cm × 3.5–10 cm, base unequal, apex obtuse, leathery, glabrous, pinnately veined with 15–25 pairs of lateral veins. Inflorescence an axillary or terminal panicle, branched, reddish brown hairy. Flowers bisexual, zygomorphic, 5-merous, sweetly fragrant; pedicel 1–2.5 cm long, hairy; bracteoles 2, c. 1.5 cm long; sepals linear-triangular, c. 8 mm long; petals unequal, 1 up to 2 cm × 2.5 cm, deeply 2-lobed, white inside, white or pinkish outside, other petals linear-triangular, c. 8 mm long; fertile stamens 3, other stamens rudimentary; ovary superior, brown hairy, 1-celled, style slender, reddish. Fruit a flattened obovoid pod, 15–20(–28) cm × 4–7.5 cm, with a prominent longitudinal ridge

and numerous transversal veins, dehiscent with 2 woody valves, several-seeded. Seeds slightly quadrangular, flattened, up to 4.5 cm × 3.5 cm, brown. Seedling with epigeal germination; hypocotyl 4–6 cm long, epicotyl 12–15 cm long, 4-ridged; cotyledons fleshy, c. 3 cm long; first leaves opposite, with 1 pair of leaflets.

Other botanical information *Gilbertiodendron* comprises about 25 species and is restricted to tropical Africa, distributed from Guinea to DR Congo and Angola. It was formerly included in *Macrolobium*, which now consists of tropical American species only, and is closely related to *Pellegriniodendron*, which is even considered congeneric.

The wood of several other West African *Gilbertiodendron* species is used for similar purposes as that of *Gilbertiodendron limba*.

Gilbertiodendron bilineatum (Hutch. & Dalziel) J.Léonard is similar to *Gilbertiodendron limba* in appearance and area of distribution. It is a medium-sized tree up to 33 m tall with bole up to 95 cm in diameter, distributed from Sierra Leone to Ghana. The wood is used for flooring in Sierra Leone. *Gilbertiodendron bilineatum* is classified as vulnerable in the IUCN Red list of threatened species, due to habitat decline caused by mining, logging and commercial forestry activities.

Gilbertiodendron ivorense (A.Chev.) J.Léonard is a small to medium-sized tree up to 20 m tall with a fairly long bole, distributed in Liberia and Côte d'Ivoire. In Liberia the wood is used for planks and construction. The wood has a density of about 750 kg/m^3 at 12% moisture content.

Gilbertiodendron preussii (Harms) J.Léonard is a medium-sized to fairly large tree up to 35 m tall with a straight bole branchless for up to 24 m and up to 120 cm in diameter, distributed from Sierra Leone to Ghana and from Cameroon to Gabon. In Liberia, where it is known as 'red oak', the wood is used for construction. It has also been used for canoes and railway sleepers and is considered suitable for flooring, joinery, furniture and tool handles. The wood has a density of 720—900 kg/m^3 at 15% moisture content.

Gilbertiodendron splendidum (A.Chev. ex Hutch. & Dalziel) J.Léonard is a medium-sized tree up to 33 m tall with a bole up to 90 cm in diameter. It is distributed in Sierra Leone, Liberia, Côte d'Ivoire and Ghana. In Ghana the wood is recommended for construction, vehicle bodies, railway sleepers and draining boards. In Liberia it is used for construction. It is suitable for poles, piles, flooring, joinery, ship building, furniture, agricultural implements and handles. The wood is moderately heavy with a density of about 720 kg/m^3 at 12% moisture content. *Gilbertiodendron splendidum* is classified as vulnerable in the IUCN Red list of threatened species, due to habitat decline caused by mining, logging and commercial forestry activities.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 1: growth ring boundaries distinct. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 24: intervessel pits minute (≤ 4 μm); 25: intervessel pits small (4–7 μm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 43: mean tangential diameter of vessel lumina ≥ 200 μm; 46: ≤ 5 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; (89: axial parenchyma in marginal or in seemingly marginal bands); 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand. Rays: 96: rays exclusively uniseriate; 104: all ray cells procumbent; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; 143: prismatic crystals in fibres.

(E. Uetimane, P.E. Gasson & E.A. Wheeler)

Growth and development *Gilbertiodendron limba* seedlings are tolerant of shade and grow slowly. Flowering of trees is in February–July and fruiting takes place in February–September. Ectomycorrhizae are present on the roots.

Ecology *Gilbertiodendron limba* occurs widespread and gregariously in evergreen forest, including swamp forest, riverine forest and secondary forest. It is usually found in areas with an average annual rainfall of 1500–2500 mm.

Propagation and planting Natural regeneration is abundant under mother trees. The 1000-seed weight is c. 10 kg. Seeds usually germinate in 8–15 days, with germination

rates over 80%.

Genetic resources and breeding Although *Gilbertiodendron limba* has a limited distribution area, it is locally common with no indications of overexploitation. It is therefore unlikely to be threatened by genetic erosion.

Prospects The wood of *Gilbertiodendron limba* will remain useful as a domestic timber. Very little is known about the wood technological properties of this species, and further research is warranted.

Major references Bâ et al., 2012; Burkill, 1995; de Koning, 1983; de la Mensbruge, 1966; Hawthorne, 1995; Keay, Hoyle & Duvigneaud, 1958; Oteng-Amoako (Editor), 2006; Poorter et al., 2004; Savill & Fox, 1967; Taylor, 1960.

Other references Abbiw, 1990; Allen & Allen, 1981; Aubréville, 1959b; Bolza & Keating, 1972; Bouquet & Debray, 1974; Hawthorne, 1990; Hawthorne, 1998; Irvine, 1961; Kryn & Fobes, 1959; Kunkel, 1965; Neuwinger, 2000; Sallenave, 1955; Takahashi, 1978.

Authors A.A. Oteng-Amoako & E.A. Obeng

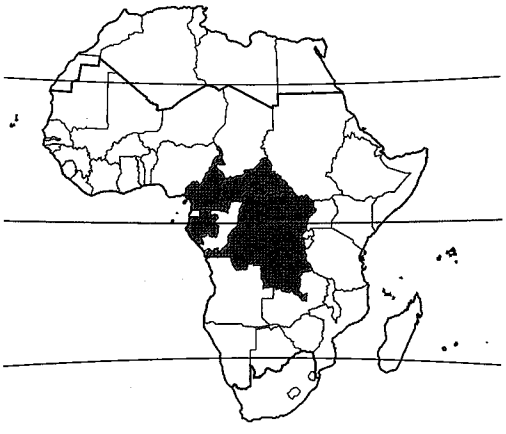
GILLETIODENDRON MILDBRAEDII (Harms) Vermoesen

Protologue Man. ess. forest. Congo: 85 (1923).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Origin and geographic distribution *Gilletiodendron mildbraedii* occurs from southern Cameroon to the Central African Republic and DR Congo.

Uses The wood is suitable for heavy construction, heavy flooring, joinery, interior trim, ship building, vehicle bodies, mine props, railway sleepers, handles, ladders, sporting goods, toys, novelties, agricultural implements, carving, turnery, veneer and plywood. The bark is used in traditional medicine in DR Congo to treat syphilis.



Gilletiodendron mildbraedii – wild

Properties The heartwood is reddish brown to chocolate brown, mottled and with a satiny shine; it is distinctly demarcated from the yellowish white, up to 8 cm wide sapwood. The grain is usually straight, occasionally slightly interlocked, texture fine. Quarter-sawn surfaces show some streaks.

The wood is heavy, with a density of 950–1060 kg/m^3 at 12% moisture content, and very hard. It air dries slowly, and shows a tendency of surface checking and sometimes also end splitting. The rates of shrinkage upon drying are high. Quarter-sawing is recommended before drying. Once dry, the wood is moderately stable in service. At 12% moisture content, the modulus of rupture is 204–270 N/mm^2, compression parallel to grain 69–82 N/mm^2, cleavage 24 N/mm and Chalais-Meudon side hardness 7.3. The wood saws rather easily but slowly due to its hardness; it has a serious blunting effect on saw teeth and working tools. It can be planed to a nice surface, and polishes well. Preboring is recommended for nailing. The bending properties are good. The wood is fairly durable, but is susceptible to the fungus *Coniophora cerebella* and to marine borer attacks. It is resistant to impregnation by preservatives.

Botany Medium-sized to large tree up to 45 m tall; bole usually straight and cylindrical, up to 110 cm in diameter, with large buttresses up to 6.5 m high; bark surface rough, dark grey, inner bark reddish or pinkish brown; twigs short-hairy. Leaves alternate, imparipinnately compound with 14–28 leaflets; stipules linear, early caducous; petiole and rachis together 5–15 cm long, grooved; leaflets usually alternate, sessile, oblong to nearly rectangular, asymmetrical, 1–4(–5) cm × 0.5–1.5(–2) cm, with some translucent dots. Inflorescence an axillary or terminal panicle 3–13 cm long, densely hairy, many-flowered. Flowers bisexual, nearly regular, whitish; pedicel 3–5 mm long; sepals 4, free, ovate to oblong, 1–3 mm long, 1 slightly larger than the other 3, reflexed; petals 5, free, linear-oblong, 3–4 mm long; stamens 10, free, unequal in length, 4–6 mm long; ovary superior, elliptical-oblong, c. 1.5 mm long, with short stipe, glabrous, 1-celled, style slender, 2.5–3.5 mm long. Fruit an obliquely obovate to elliptical, flattened pod, 3.5–6 cm × 2–3 cm, pointed

at apex, smooth to finely warty, dehiscing with 2 woody valves, few-seeded. Seeds flattened. Seedling with epigeal germination; hypocotyl 5–7 cm long, epicotyl 2–3 cm long; first 2 leaves opposite, with c. 8 leaflets.

Gilletiodendron comprises about 5 species and occurs in West and Central Africa. It is classified in the tribe *Detarieae*, in which its position is still unresolved.

Gilletiodendron glandulosum (Portères) J.Léonard is a small to medium-sized tree up to 20 m tall endemic to Mali, where it occurs in small pockets of savanna woodland. Its very hard and durable wood is used in house building, especially for support posts and cross beams, and for granaries and beds. *Gilletiodendron glandulosum* has been recommended for reaf-forestation. The seeds are reportedly edible. *Gilletiodendron glandulosum* is included in the IUCN Red List as vulnerable.

Gilletiodendron kisantuense (Vermoesen ex De Wild.) J.Léonard is a small to medium-sized tree up to 30 m tall known from Côte d'Ivoire, Gabon, Congo, DR Congo and northern Angola. The wood is probably used in house building.

Gilletiodendron pierreanum (Harms) J.Léonard is a medium-sized to large tree up to 45 m tall, with bole branchless for up to 20 m, usually fluted and with buttresses, occurring in southern Cameroon, Equatorial Guinea and Gabon. Its wood is used for joinery, furniture and implements.

Ecology *Gilletiodendron mildbraedii* occurs in lowland rainforest, often near rivers.

Management A 30 m tall tree with a bole of 18 m long and 50 cm in diameter yielded 2.2 m^3 of timber.

Genetic resources and breeding *Gilletiodendron mildbraedii* is fairly widespread and there are no signs that it is threatened by genetic erosion.

Prospects The hard wood, large buttresses and fluted bole are major drawbacks for larger-scale commercial exploitation of *Gilletiodendron* spp. As suppliers of durable wood for local house construction, they will remain of local importance.

Major references Aubréville, 1970; Bolza & Keating, 1972; Fouarge, Gérard & Sacré, 1953; Wilczek et al., 1952.

Other references Burkill, 1995; de la Mensbruge, 1966; Duvall, 2002; Lewis et al., 2005; Normand & Paquis, 1976; Raponda-Walker & Sillans, 1961; Tailfer, 1989; Vivien & Faure, 1985.

Authors R.H.M.J. Lemmens

GIVOTIA MADAGASCARIENSIS Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 811 (1889).

Family Euphorbiaceae

Origin and geographic distribution *Givotia madagascariensis* is endemic to western Madagascar, where it occurs from Antsiranana province in the north to the Onilahy river, Toliara province in the south.

Uses The soft and lightweight wood, called 'farafatsy' in Madagascar, is mainly used by Sakalava people to make dugout canoes. It is also used to make doors, caskets and the hull or splash boards of traditional fishing boats. It is suitable for thermal and acoustic insulation, inner parts of block board and model building. It is used for similar purposes as the wood of *Hildegardia erythrosiphon* (Baill.) Kosterm., which also occurs in western Madagascar. The bark, which is soft and easily cut, is used to make patterns used in wood carving.

A decoction of the aerial parts is taken in traditional medicine to treat the effects of malaria.

Production and international trade The wood is traded extensively in Madagascar. In 2000 the price of a dug-out canoe made from a *Givotia madagascariensis* bole was US$ 40–110 at the local market.

Properties The heartwood is whitish and indistinctly demarcated from the up to 6 cm wide sapwood. The grain is straight, texture coarse. The wood is lightweight, with a density of 170–260 kg/m^3 at 12% moisture content. It air dries very rapidly without distortion. The rates of shrinkage are small, from green to oven dry 1.5–2.1% radial and 3.0–4.2% tangential. Once dry, the wood is very stable in ser-

Givotia madagascariensis – wild

vice.
At 12% moisture content, the modulus of rupture is 29–44 N/mm², modulus of elasticity 2450–5100 N/mm², compression parallel to grain 8–15 N/mm² and Chalais-Meudon side hardness 0.2. The wood is easy to saw and work, but does not take a nice finish. It is not durable and dug-out canoes have to be replaced after only 3–5 years. The wood is very easy to treat with preservatives.
In an in-vitro test, the antiplasmodial activities of leaf extracts were negligible. The compounds cleistanthol, spruceanol and 1,2-dihydroheudelotinol isolated from the bark demonstrated significant antitumour activities against gastric cancer, liver carcinoma and breast cancer cell lines.

Botany Deciduous medium-sized tree up to 30 m tall; bole branchless for up to 16 m, generally straight, up to 120 cm in diameter; bark surface smooth, yellowish white, inner bark granular, yellow to orange, with a little reddish exudate; crown rather narrow; twigs short-hairy with stellate hairs. Leaves alternate, simple; stipules absent; petiole up to 17.5 cm long, sometimes with glands; blade 5.5–17 cm × 8–25 cm, shallowly to deeply 3–5-lobed, with acuminate and irregularly toothed lobes, reddish or whitish short-hairy below with stellate hairs, glandular and with translucent dots, palmately (3–)5–7-veined from the base. Inflorescence a terminal or axillary panicle. Flowers unisexual, regular, 5-merous, whitish; calyx lobes slightly unequal; petals c. 5 mm long, slightly coherent; stamens up to 15, fused at base; disk 5-lobed; ovary superior, 1–3-celled, style 2-lobed; male flowers without ovary, female flowers lacking stamens. Fruit a fleshy, globose to broadly ovoid drupe 1.5–2.5 cm in diameter, indehiscent, 1-seeded. Seed globose, with oily endosperm.
Givotia comprises 4 species, 1 of which occurs in Kenya and Somalia, 1 in India and Sri Lanka, and 2 in Madagascar. It is close to *Ricinodendron* and *Schinziophyton*.

Ecology *Givotia madagascariensis* occurs in dry bushland, deciduous forest and thickets, from sea-level up to 600(–800) m altitude.

Management Locally *Givotia madagascariensis* has been recorded to occur in high densities; in some localities in the Menabé region on average 37 stems per ha, although the stands are rapidly declining there.

Genetic resources and breeding *Givotia madagascariensis* appears to be locally common, especially in the northern parts of its distribution area, but it becomes more rare towards the south. There are indications that it is threatened by genetic erosion in several regions. It has been reported that fishermen from Toliara have to travel hundreds of kilometres to obtain suitable large logs for canoes.

Prospects The wood of *Givotia madagascariensis* is likely to remain locally important, especially for the construction of traditional canoes and boats. Monitoring the populations is highly recommended in view of the locally high demand of the wood.

Major references Boiteau & Allorge-Boiteau, 1993; Capuron, 1966b; Guéneau, Bedel & Thiel, 1970–1975; Parant, Chichignoud & Rakotovao, 1985; Rakotovao et al., en préparation.

Other references Andriamiarinosy, 2004; Bemiasa, 2009; Covi, 1986; Radcliffe-Smith, 1968; Rasoanaivo et al., 1999; Rasolofo, 1997; Schatz, 2001; Seddon et al., 2000.

Authors L.P.A. Oyen & D. Louppe

GREENWAYODENDRON SUAVEOLENS (Engl. & Diels) Verdc.

Protologue Adansonia, sér. 2, 9: 90 (1969).
Family Annonaceae
Synonyms *Polyalthia suaveolens* Engl. & Diels (1901).
Vernacular names Molinda (En). Moambe noir (Fr). Muamba preta (Po).
Origin and geographic distribution *Greenwayodendron suaveolens* is widespread from southern Nigeria east to western Uganda and northern Tanzania, and south to southern DR Congo and Cabinda (Angola).
Uses The wood is used for house construc-

Greenwayodendron suaveolens – wild

tion, joinery, mine props, furniture, stakes for yam cultivation, rafters and shafts of spears. It is suitable for flooring, interior trim, railway sleepers, toys, novelties, agricultural implements, vats, draining boards, food containers, turnery, veneer and plywood. The wood burns brightly and is used for illumination.

Various plant parts are used in traditional medicine. Bark decoctions are taken to treat stomach-ache and other pains, gonorrhoea and infertility, as diuretic, purgative and aphrodisiac, and to facilitate childbirth. Bark ash is rubbed into scarifications on the forehead to treat psychosis, and bark pulp is applied externally against rheumatism, headache, epilepsy and toothache. In Cameroon bark is applied to scarifications to treat malaria, and also in Gabon the bark is used for the treatment of malaria. Root decoctions are taken to treat liver complaints and headache, and root sap is administered as anthelmintic and aphrodisiac, and to treat oedema and swollen glands. Leaf decoctions or macerations serve to treat hepatitis and pains, and are applied externally to treat rheumatism. In DR Congo pounded bark is used in a mixture with other plants to make arrow poison. The fruit is edible.

Properties The heartwood is yellow to brown when dry and usually not distinctly demarcated from the sapwood, which is yellowish white when freshly cut, but darkening upon exposure. The grain is usually straight, texture variable. Quarter-sawn surfaces show streaky markings. The wood is lustrous.

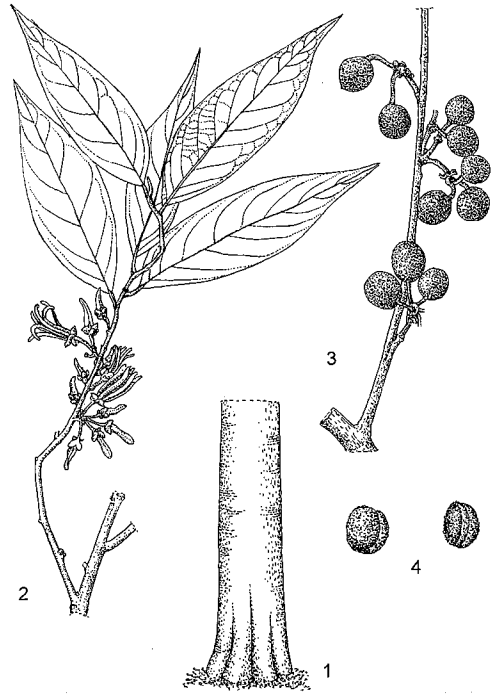
The wood is medium-weight, with a density of 750–790 kg/m^3 at 12% moisture content. It air dries well, but with a slight risk of checking and end splitting. At 12% moisture content, the modulus of rupture is 151–170 N/mm^2, modulus of elasticity 17,450–19,800 N/mm^2, compression parallel to grain 63–71 N/mm^2, cleavage 14–17.5 N/mm and Chalais-Meudon side hardness 4.4–4.7.

The wood is easy to saw and work, both with machine and hand tools. It can be planed to a smooth and lustrous surface. The nailing properties are satisfactory, with good holding power. The wood glues well, and the steam bending properties are good. The wood is only moderately durable, being liable to termite, *Lyctus* and marine borer attacks. It is easy to impregnate with preservatives.

Several alkaloids have been isolated from the bark, including some indolosesquiterpenes and aporphines. Oliverine showed filaricidal activity against *Onchocerca volvulus*, and polycarpol against *Onchocerca gutturosa*. Methanolic bark and leaf extracts showed in-vitro cytotoxic activity in human monocytes, as well as antileishmanial and antifungal activities.

The major compounds in the leaf oil are α-humulene (34%) and β-caryophyllene (33%), and in the fruit oil myrcene (34%).

Description Deciduous, medium-sized to fairly large tree up to 35(–45) m tall; bole branchless for up to 25 m, straight, cylindrical, up to 70(–90) cm in diameter, sometimes grooved at base; bark surface smooth, grey to blackish, often with hoop-marks, inner bark fibrous, yellow to orange or pale brown, becoming brownish or blackish upon exposure, with strong resinous smell; crown dense, conical, with horizontal branches; young twigs yellowish hairy, soon becoming glabrous. Leaves alternate, simple and entire; stipules absent; petiole 2–7 mm long; blade elliptical to oblong-elliptical, 4–12(–28) cm × 1.5–5.5(–10) cm, rounded to cuneate at base, acuminate at apex, papery to slightly leathery, nearly glabrous, pinnately veined with 5–13 pairs of lateral veins. Inflorescence an up to 8(–12)-flowered fascicle, often opposite the leaves, short-hairy.



Greenwayodendron suaveolens – 1, base of bole; 2, flowering branch; 3, fruiting branch; 4, seeds. Redrawn and adapted by Iskak Syamsudin

Flowers bisexual or male, regular; pedicel 3–9 mm long; sepals 3, fused at base, broadly ovate to nearly round, 2–3.5 mm long, short-hairy outside; petals in 2 whorls of 3, free, linear-oblong, 1–3 cm long, finely hairy, yellow to greenish white; stamens numerous in male flowers and up to 12 in bisexual flowers, linear, 1–4 mm long; carpels 12–20, linear-oblong, c. 2.5 mm long. Fruit consisting of up to 10(–13) indehiscent, ellipsoid to globose follicles 1–2 cm long, stipe 5–8 mm long, purplish red to bluish purple when ripe, 1–2(–3)-seeded. Seeds depressed globose, c. 1 cm in diameter, warty-wrinkled, with a groove, endosperm ruminate.

Other botanical information *Greenwayodendron* comprises 2 species and is restricted to tropical Africa. It has been separated from *Polyalthia*, which is a genus of about 120 species, most of them occurring in tropical Asia and Australia, about 15 in Madagascar and 3 in East Africa. Although wood anatomical characteristics are quite similar, molecular studies showed that *Greenwayodendron* is probably not closely related to *Polyalthia*, supporting a status as separate genus.

Subsp. *usambaricum* Verdc. has been distinguished as a distinct subspecies endemic to the Usambara Mountains in Tanzania. Subsp. *suaveolens* var. *gabonica* (Pellegr. ex Le Thomas) Verdc. is endemic to Gabon and has been distinguished because of its larger leaves, which are slightly short-hairy below, and larger flowers. Chloroplast DNA studies showed distinct genetic divergence, indicating that the two sympatric varieties are most probably reproductively isolated and might represent true biological species.

Greenwayodendron oliveri (Engl.) Verdc. (synonym: *Polyalthia oliveri* Engl.) is a small tree up to 15 m tall occurring in rainforest from Sierra Leone to Ghana. The boles are used in house building. The yellowish brown wood is rather heavy, hard and strong. Bark decoctions and infusions are taken to treat blackwater fever and stomach complaints, and the bark is also used as vermifuge.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 1: growth ring boundaries distinct. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 24: intervessel pits minute (≤ 4 μm); (25: intervessel pits small (4–7 μm)); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 46: ≤ 5 vessels per square millimetre; 47: 5–20 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled; 70: fibres very thick-walled. Axial parenchyma: 78: axial parenchyma scanty paratracheal; 86: axial parenchyma in narrow bands or lines up to three cells wide; 88: axial parenchyma scalariform; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; 99: larger rays commonly > 10-seriate; 102: ray height > 1 mm; (103: rays of two distinct sizes); 104: all ray cells procumbent; (106: body ray cells procumbent with one row of upright and/or square marginal cells); 114: ≤ 4 rays per mm; 115: 4–12 rays per mm. Secretory elements and cambial variants: (124: oil and/or mucilage cells associated with ray parenchyma).

(C. Essien, P.E. Gasson & E.A. Wheeler)

Growth and development *Greenwayodendron suaveolens* is classified as shade tolerant. In Gabon the fruits ripen in November–March. The fruit pulp is eaten by monkeys and chimpanzees, which may disperse the seeds. Elephants and hornbills have also been recorded as seed dispersers.

Ecology *Greenwayodendron suaveolens* occurs in humid evergreen and semi-deciduous forest, often as an understorey tree. In Uganda it occurs up to 1100 m altitude. It is considered a typical component of mature forest.

Management In Cameroon the average number of boles of over 15 cm in diameter has been recorded as 2.6 per ha, with an average wood volume of 1.8 m^3/ha.

Harvesting In Cameroon and Gabon the minimum bole diameter for harvesting is 60 cm, in the Central African Republic and DR Congo 70 cm.

Yield A bole of 70 cm in diameter and 10 m long yielded 3.8 m^3 of wood.

Genetic resources *Greenwayodendron suaveolens* is widespread and is locally a common understorey tree. Therefore, it does not seem to be threatened at present, but with the ongoing decline in primary rainforest, it might become under pressure in the near future.

Prospects Little information is available on this species, but in view of its often limited bole size and probable slow growth rates as understorey tree, it does not seem to have good prospects as commercially valuable timber tree.

Interesting pharmacological activities have been demonstrated and these deserve more research attention.

Major references Bolza & Keating, 1972; Burkill, 1985; Dauby et al., 2010; le Thomas, 1969; Tailfer, 1989; Takahashi, 1978; Vivien & Faure, 1985; Wilks & Issembé, 2000; Williams et al., 2010.

Other references Betti, 2001; Boutique, 1951; Cooper & Record, 1931; Cravo et al., 1991; Hawthorne & Jongkind, 2006; Keay, 1989; Lamidi et al., 2005; Mols et al., 2004; Neuwinger, 2000; Nkeoua & Boundzanga, 1999; Normand & Paquis, 1976; Nyasse et al., 2006; Raponda-Walker & Sillans, 1961; Terashima & Ichikawa, 2003; Verdcourt, 1971; White & Abernethy, 1997.

Sources of illustration le Thomas, 1969; Wilks & Issembé, 2000.

Authors R.B. Jiofack Tafokou

GUIBOURTIA ARNOLDIANA (De Wild. & T.Durand) J.Léonard

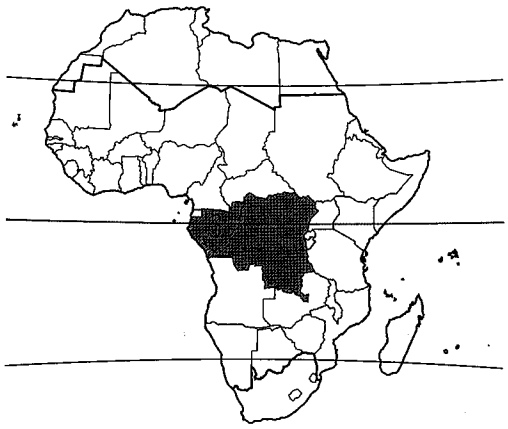
Protologue Bull. Jard. Bot. Etat 19: 403 (1949).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Olive walnut, tropical oliver (En). Olivier tropical (Fr).

Origin and geographic distribution *Guibourtia arnoldiana* occurs in Gabon, Congo, western DR Congo and Cabinda (Angola).

Uses The wood is particularly suitable for indoor uses such as flooring, carpentry, furniture, panelling and stairs, but also for turning, carving and sliced veneer. It is used for vehicle bodies, boat building, small decorations, chess boards, sporting goods, toys, household implements, pool tables, pool cues, brushes, knives and flutes.



Guibourtia arnoldiana – wild

The exudate from the bole mixed with palm oil is used as an ointment to cure scabies, and as illuminant.

Production and international trade The timber is mainly traded from Gabon under the trade name 'mutenye'. The production is limited and quantities traded are actually small. In the 1960s, 2000–6000 m^3 of logs were exported from Congo per year. In 1983 Gabon exported a maximum of 10,000 m^3.

Properties The heartwood is yellowish brown to pale olive brown or brown, often with greyish streaks, darkening on exposure. It is distinctly demarcated from the up to 8 cm wide, dull grey sapwood with a yellowish tinge when freshly cut. The grain is straight or slightly interlocked, texture moderately fine and fairly even. The wood surface is lustrous. A stripe figure is present on radial surfaces, and a flame pattern on tangential surfaces.

The wood is medium-weight to fairly heavy, with a density of 740–860 kg/m^3 at 12% moisture content. Usually it air dries well but slowly; some care is needed because warping and checking may occur. The shrinkage rates are moderately high, from green to oven dry 4.6–6.0% radial and 8.7–10.3% tangential. Once dry, the wood is moderately stable in service. At 12% moisture content, the modulus of rupture is 138–202 N/mm^2, modulus of elasticity 14,000–21,400 N/mm^2, compression parallel to grain 72–84 N/mm^2, shear 8–13 N/mm^2, cleavage 25–35 N/mm and Chalais-Meudon side hardness 4.5–8.3.

The wood works satisfactorily with hand and machine tools, but the presence of silica may cause dulling of saw teeth and cutting edges. Stellite-tipped saw teeth and tungsten carbide cutting tools are advisable. The wood takes a good finish. The nailing and screwing properties are good, but pre-boring is needed. The wood glues satisfactorily, but the presence of gum may cause some difficulties. The bending properties are moderate. The wood is easy to peel and slice after steaming of the logs. It is moderately durable. It is fairly resistant to fungal attack and wood-boring insects, and moderately resistant to termites, but the sapwood is liable to *Lyctus* attack. The wood is quite resistant to marine borers. The heartwood is resistant to treatment with preservatives, the sapwood moderately resistant. When

the wood is used as firewood, the smoke can provoke itching of the skin.

Adulterations and substitutes The wood properties of *Guibourtia arnoldiana* are close to those of iroko (*Milicia* spp.) and teak (*Tectona grandis* L.f) and the wood can be used for similar purposes. In Europe sliced veneer is sometimes used as a substitute of walnut (*Juglans regia* L.). In DR Congo the trade name 'mutenye' is often used for *Copaifera religiosa* J.Léonard.

Description Medium-sized tree up to 30 m tall; bole branchless for up to 20 m, straight and cylindrical or irregular, up to 100 cm in diameter, with buttresses up to 1 m high; bark surface orange-red, irregularly flaking leaving paler patches; crown with spreading branches. Leaves arranged spirally, paripinnately compound with 1 pair of leaflets; stipules small and early caducous; petiole 4–8 mm long; leaflets sessile, obliquely ovate, 4–8 cm × 1–4 cm, slightly acuminate at apex, glabrous, with numerous translucent dots, pinnately veined with 7–9 pairs of lateral veins, 2–3 of which from base of leaflet. Inflorescence a terminal or axillary panicle up to 10 cm long, brown short-hairy; bracts c. 1 mm long, early caducous. Flowers bisexual, regular, whitish, nearly sessile; sepals 4, ovate-elliptical, 3–3.5 mm × 1.5–2.5 mm, short-hairy inside; petals absent; stamens 10, free, 6–10 mm long; disk cup-shaped, hairy; ovary superior, rounded, c. 2 mm in diameter, hairy, 1-celled, style 3–6 mm long. Fruit an obliquely elliptical to obovate, flat pod 4–5 cm × 2.5–3 cm, with 2–6 mm long stipe, rounded at apex, with a c. 5 mm wide wing at one side, smooth, brown, reticulately veined, with papery walls, indehiscent, 1(–2)-seeded. Seed rounded to ovoid, flattened, c. 2 cm long, brownish, without aril.

Guibourtia arnoldiana – 1, flowering and fruiting branch; 2, flower; 3, fruit; 4, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Guibourtia* comprises about 14 species, all African, but a single species occurs in tropical America. The genus is related to *Hymenaea* and *Peltogyne*.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 25: intervessel pits small (4–7 µm); 26: intervessel pits medium (7–10 µm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 µm; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; 83: axial parenchyma confluent; 89: axial parenchyma in marginal or in seemingly marginal bands; 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand; (93: eight (5–8) cells per parenchyma strand). Rays: 98: larger rays commonly 4- to 10-seriate; 104: all ray cells procumbent; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E. Uetimane, P.E. Gasson & E.A. Wheeler)

Ecology *Guibourtia arnoldiana* is found in rainforest on well-drained localities up to 200 m altitude.

Handling after harvest Freshly harvested logs should not be left too long in the forest to prevent fungal and insect attacks, or they

should be treated with preservatives.

Genetic resources *Guibourtia arnoldiana* is fairly widespread and not heavily exploited. Harvesting of straight boles and leaving irregular ones may result in a negative selection pressure.

Prospects Although *Guibourtia arnoldiana* produces good-quality timber, other species seem to qualify better for promotion for research on domestication and plantation management. There is no information on growth rates and proper management methods of *Guibourtia arnoldiana.*

Major references ATIBT, 1986; Aubréville, 1968; Bolza & Keating, 1972; CIRAD Forestry Department, 2008; Fouarge, Quoilin & Roosen, 1970; Raponda-Walker & Sillans, 1961; Sallenave, 1955; Sallenave, 1971; Takahashi, 1978; Wilczek et al., 1952.

Other references Anonymous, 1963; Fougère-Danezan, Maumont & Bruneau, 2007; Fougère-Danezan et al., 2010; Fuhr et al., 1998; Léonard, 1949; Léonard, 1950a; Normand, 1950b; Normand & Paquis, 1976.

Sources of illustration Aubréville, 1968; Wilczek et al., 1952.

Authors N. Nyunaï

GUIBOURTIA COLEOSPERMA (Benth.) J.Léonard

Protologue Bull. Jard. Bot. Etat 19: 403 (1949).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

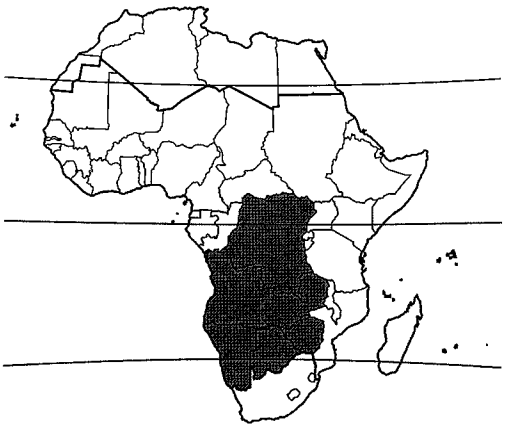
Chromosome number $2n = 48$

Vernacular names African rosewood, bastard teak, Rhodesian teak, bastard mopane, large false mopane, large mock mopane, copalwood, Rhodesian mahogany (En). Copalier, copalier de Rhodésie (Fr).

Origin and geographic distribution *Guibourtia coleosperma* occurs naturally in southern DR Congo, Zambia, Angola, Namibia, Botswana and Zimbabwe.

Uses The wood of *Guibourtia coleosperma* is used for construction, flooring, joinery, interior trim, furniture, mine props, ship building, vehicle bodies, railway sleepers, toys, novelties, tool handles, turnery and decorative veneer. It is traditionally used for canoes. It is an appreciated firewood.

The seed and its aril contain oil, which is used for cooking. The red dye from the aril has been used for staining furniture. The seeds are eaten, especially during times of food shortage, often after roasting and pounding. The arils are also eaten or used to make a nourishing drink. They are cooked with cassava leaves as a relish. The bark is used for tanning and dyeing. *Guibourtia coleosperma* is an appreciated ornamental tree, with striking flowers and fruits, which show up against the dark glossy foliage, and providing deep shade. In traditional medicine, the roots are applied to wounds to promote healing and a root decoction is used as cure for venereal diseases. Young leaves are taken to treat cough and leaf decoctions are administered after childbirth to promote recovery and to treat stomach complaints. A decoction of roots and bark is administered as a vapour bath to treat headache, whereas roots and leaves are ingredients in mixtures for the treatment of fever and mental problems.



Guibourtia coleosperma – wild

Production and international trade The wood of *Guibourtia coleosperma* is traded on the international timber market in small amounts. It is reported that about 500 m^3 per year is available from sustainably managed forest and woodland.

Properties The heartwood is pinkish brown or pale red-brown with pinkish or reddish stripes, darkening to a rich mahogany-like red-brown colour with the stripes becoming more faint. It is clearly demarcated from the yellowish white to pale pink, up to 9 cm wide sapwood. The grain is straight or interlocked, texture moderately fine and even. The wood has an attractive figure. It has a fragrant smell when freshly cut.

The wood is heavy, with a density of (670–) 800–960 kg/m^3 at 12% moisture content. It air

dries slowly; drying should be done with care to avoid excessive warping and splitting. The sawn timber can be kiln dried at a moderate speed and temperature. The rates of shrinkage are moderate, from green to oven dry 2.0–3.7% radial and 3.2–5.7% tangential.

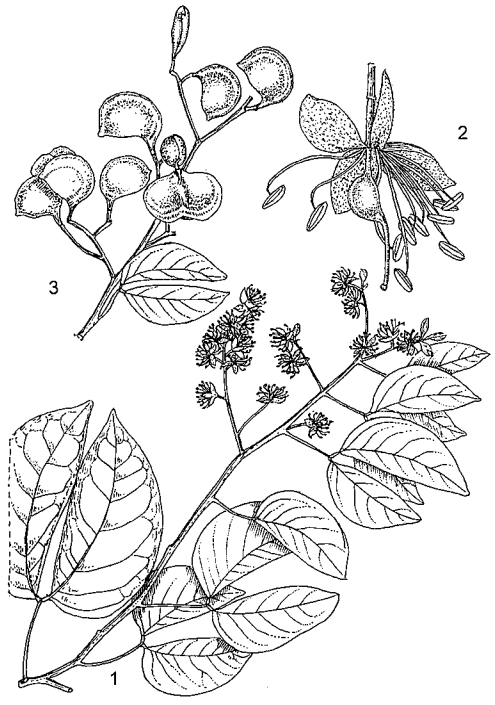
At 12% moisture content, the modulus of rupture is 85–142 N/mm², modulus of elasticity 9210 N/mm², compression parallel to grain 51–58 N/mm², compression perpendicular to grain 14 N/mm², shear 14–16 N/mm², cleavage 20 N/mm, Janka side hardness 8820–9065 N and Janka end hardness 9800–11,150 N.

The wood saws and works well despite its high density and hardness. It finishes well although the presence of interlocked grain may sometimes cause picking up of grain in planing. It polishes well. Pre-boring is needed for nailing and screwing. The gluing and varnishing properties are satisfactory, but staining may be difficult. Veneer of good quality can be produced by slicing and rotary peeling. The wood is moderately durable to durable, being moderately resistant to fungal attack and resistant to termite attack. The sapwood is susceptible to *Lyctus* borers. The heartwood is resistant to preservative treatment.

The seeds have an oil content of about 6.5% and a protein content of 14.5%. The heartwood contains proguibourtinidins (with and without stilbenoid constituent units), profisetinidins and derived compounds. Flavonoid glycosides have been isolated from the bark.

Adulterations and substitutes Much of *Guibourtia coleosperma* timber is mixed with that of *Baikiaea plurijuga* Harms, traded as 'mukusi' or 'Zambezi teak'. The two species grow in the same vegetation type and the wood is similar in appearance and characteristics.

Description Semi-evergreen medium-sized tree up to 30 m tall; bole branchless for up to 15 m, up to 65(–125) cm in diameter, slightly buttressed or fluted at base; bark surface smooth or sometimes flaking, grey to pinkish cream, inner bark reddish; crown rounded, large; young branches reddish brown, glabrous. Leaves arranged spirally, paripinnately compound with 1 pair of leaflets; stipules 1–2 cm long, early caducous; petiole 1.5–4 cm long; leaflets nearly sessile, obliquely ovate or elliptical, 3.5–12 cm × 2–6 cm, base cuneate, apex usually acuminate, glabrous, with numerous translucent dots, pinnately veined with 7–11 pairs of lateral veins, 1–3 of which from base of leaflet. Inflorescence an axillary or terminal panicle up to 12 cm long, nearly glabrous; bracts up to 2 mm long, very early caducous. Flowers bisexual, zygomorphic, whitish to creamy, fragrant; pedicel 2–5 mm long; sepals 4(–5), unequal, 5–6 mm × 1.5–4 mm, hairy inside; petals absent; stamens 10, free, up to 7 mm long; ovary superior, rounded, c. 1 mm in diameter, glabrous, 1-celled, with short stipe, style 4–5 mm long. Fruit an obliquely elliptical, flattened pod 2–3.5 cm × 1.5–2 cm, glabrous, wrinkled and brown, tardily dehiscent, 1-seeded. Seed ellipsoid, somewhat flattened, 1–2 cm long, dark brown, shiny, completely enclosed by red aril, hanging out of dehisced fruit on a thread-like funicle. Seedling with epigeal germination; cotyledons nearly rounded, leafy.



Guibourtia coleosperma – 1, flowering twig; 2, flower; 3, fruiting twig.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Guibourtia* comprises about 14 species, all African, but a single species occurs in tropical America. The genus is related to *Hymenaea* and *Peltogyne*.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 1: growth ring boundaries distinct. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal;

26: intervessel pits medium (7–10 μm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 78: axial parenchyma scanty paratracheal; 79: axial parenchyma vasicentric; (80: axial parenchyma aliform); (81: axial parenchyma lozenge-aliform); (83: axial parenchyma confluent); 86: axial parenchyma in narrow bands or lines up to three cells wide; 89: axial parenchyma in marginal or in seemingly marginal bands; 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; 104: all ray cells procumbent; 115: 4–12 rays per mm.
(F.D. Kamala, P.E. Gasson & E.A. Wheeler)

Growth and development *Guibourtia coleosperma* is slow growing, with a mean annual increase in bole diameter of about 3 mm. In an experimental plantation in Zimbabwe of 16 years old, mean annual height increment was only 14–21 cm and survival only 5%. Coppice shoots reach about 1 m long in one year. The tree is usually leafless for short periods only and often nearly evergreen. Flowering is from December to March. The seeds can be harvested from (May–)June to October. The bright red arils attract birds such as glossy starlings and parrots as well as monkeys, which feed on them and thereby disperse the seeds. Lateral roots were found at a depth of 10–60 cm in Zimbabwe, but the taproot can reach a depth of 10 m or more. Endomycorrhizae are associated with the roots.

Ecology *Guibourtia coleosperma* occurs in woodland and dry forest, often along rivers, at 750–1400 m altitude. It is found in areas with a mean annual temperature of 20–28°C and an annual rainfall of (450–)650–1100 mm. It is often one of the dominant species in the upper storey together with *Baikiaea plurijuga* Harms and *Pterocarpus angolensis* DC., which are also important timber species. It is almost exclusively found on Kalahari sand soils, which are deep and infertile with a low water-holding capacity. *Guibourtia coleosperma* is sensitive to fire and somewhat insensitive to frost, although frost may cause severe damage to seedlings and saplings.

Propagation and planting *Guibourtia coleosperma* can be propagated by seeds, cuttings or root suckers. Seed production is reported to vary considerably from year to year, and is mainly influenced by the amount and distribution of rainfall. The 1000-seed weight is about 275 g. Germination usually starts within 10 days after sowing. In Botswana germination tests using fresh, untreated seeds gave a 95% germination rate. Shelter and adequate moisture are essential for a high survival rate of seedlings. In experimental plantations, spacings of 2 m × 2 m to 5 m × 5 m have been practised.

Management In southern DR Congo *Guibourtia coleosperma* is locally common, with 5–6 trees per ha. Controlled early burning in May of the undergrowth and litter layer has been tested and was found useful to avoid the more detrimental burning in September. Trees may produce root suckers and coppice shoots when cut. *Guibourtia coleosperma* is occasionally planted. In plantations regular weeding is required for at least the first 3 years.

Diseases and pests In the nursery, the seedlings are susceptible to spider mites, especially under glass. The foliage is browsed by elephants and antelopes, but serious damage has not been reported.

Harvesting Boles with a minimum diameter of 35 cm have been harvested from natural woodland in a cutting cycle of 40 years. In Zimbabwe, the recommended minimum bole diameter for *Guibourtia coleosperma* as well as *Baikiaea plurijuga* is 50 cm. Selective logging did not aggravate erosion problems because the Kalahari soils allow high infiltration and have a gradient of only 1% or less. However, it may lead to increased fire hazards. Regeneration after logging was satisfactory. However, elsewhere it was observed that regeneration of *Guibourtia coleosperma* after harvesting was not adequate, whereas that of *Baikiaea plurijuga* was more than adequate; this would result in a shift towards more dominance of the latter species in the vegetation.

Handling after harvest Logs should not be left in the forest for longer periods or should be treated with insecticides because the sapwood is liable to insect attacks. The oil is extracted by pounding and boiling the seeds. People in Botswana and Zambia remove arils with warm water.

Genetic resources *Guibourtia coleosperma* is widely distributed with no apparent threats,

but in Namibia and Botswana it is legally protected.

Prospects Although *Guibourtia coleosperma* is a useful multipurpose tree that provides timber and non-timber products such as edible seeds and traditional medicine, no attempts have been made to domesticate it or exploit its genetic variation. Efforts to explore its potential for plantations are urgently needed, although the low growth rates seem to limit its prospects as a plantation timber tree of economic importance, as well as a timber tree that can be harvested from natural forest on a sustainable basis. Little information is available on management practices and therefore research in this area is needed.

Major references Brummitt et al., 2007a; Burke, 2006; CAB International, 2005; Calvert, 1986b; Coates Palgrave, 2002; Fanshawe, 1962; Högberg, 1986; Storrs, 1979; van Wyk & Gericke, 2000; Wilczek et al., 1952.

Other references Anonymous, 1964b; Anonymous, 1979; Bekker, Bekker & Brandt, 2006; Calvert, 1986a; Fanshawe, 1972; Fox & Norwood Young, 1988; Holdo & Timberlake, 2008; Leger, 1997; Léonard, 1949; Léonard, 1950a; Neuwinger, 2000; Palmer & Pitman, 1972–1974; Ross, 1982; SEPASAL, 1999; Storrs, 1982; Tietema, Merkesdal & Schroten, 1992; van Vuuren, Banks & Stohr, 1978; van Wyk & van Wyk, 1997; Watt & Breyer-Brandwijk, 1962; White, 1962.

Sources of illustration Ross, 1982.

Authors W. Mojeremane & I. Kopong

GUIBOURTIA CONJUGATA (Bolle) J.Léonard

Protologue Bull. Jard. Bot. Etat 19: 402 (1949).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Small false mopane, small bastard mopane, small mock mopane, small copalwood, tsotso tree (En). Chacate, chacate-preto (Po).

Origin and geographic distribution *Guibourtia conjugata* occurs in Zambia, Zimbabwe, Mozambique and northern South Africa.

Uses The wood is mainly used for fence posts, but is also suitable for flooring, furniture, carving and turnery. In Mozambique it is classified as a precious timber. The semi-fossil resin is traded under the name 'inhambane copal' or 'Mozambique copal' and is used as a base to produce varnishes.

Guibourtia conjugata – wild

Properties The heartwood is dark brown with paler streaks and distinctly demarcated from the pale yellowish sapwood. The grain is interlocked, texture fine. The wood has fairly lustrous surfaces. It is heavy with a density of 950–1100 kg/m^3 at 12% moisture content, and hard. In spite of its density, it air dries rather easily and is not difficult to work. It sands to a smooth finish, and glues and varnishes well. Pre-boring is needed for nailing and screwing. The wood is durable and very resistant to fungal and insect attacks.

Botany Deciduous shrub or small to medium-sized tree up to 18 m tall; bole branchless for up to 12 m, up to 75 cm in diameter; bark surface fairly smooth to flaky, pale greyish to yellowish brown; twigs slender, sparsely hairy. Leaves arranged spirally, paripinnately compound with 1 pair of leaflets; stipules 3–4 mm long, early caducous; petiole 1–2 cm long; leaflets nearly sessile, obliquely ovate, 3–7(–9) cm × 2–4.5(–6.5) cm, base rounded, apex usually rounded, sometimes acute, glabrous, with numerous translucent dots, with 3–4 veins from base of leaflet. Inflorescence a short axillary or terminal panicle, short-hairy; bracts early caducous. Flowers bisexual, nearly regular, whitish, fragrant; pedicel 1.5–2 mm long; sepals 4, slightly unequal, c. 6 mm × 2–4 mm, hairy inside; petals absent; stamens 10, free, c. 6 mm long; ovary superior, rounded, c. 1 mm in diameter, glabrous, 1-celled, with short stipe, style c. 3 mm long. Fruit a slightly oblique elliptical-oblong, flattened pod 3–4 cm × c. 2.5 cm, glabrous, indehiscent or tardily dehiscent, 1-seeded. Seed broadly elliptical, flattened, c. 2 cm long, shiny brown, without aril. Seedling

with epigeal germination; hypocotyl hairy; cotyledons rounded, leafy.
Guibourtia conjugata grows slowly. Trees flower from November to January and fruits ripen from June to July.
Guibourtia comprises about 14 species, all African, but a single species occurs in tropical America. The genus is related to *Hymenaea* and *Peltogyne*.

Ecology *Guibourtia conjugata* occurs in dry forest and woodland, often on rocky localities and river banks, from sea-level up to 1500 altitude. It prefers deep sandy soils.

Genetic resources and breeding It is unlikely that *Guibourtia conjugata* suffers from genetic erosion because it is fairly widespread and has limited usage. It is protected by law in Mozambique.

Prospects *Guibourtia conjugata* is poorly known, but it does not seem to have good prospects as a timber tree of more commercial importance because of the limited amount of trees available in most of its range of distribution, the relatively small bole size, and the apparently low growth rate.

Major references Brummitt et al., 2007a; Coates Palgrave, 1983; Managed Timber Resources, 1998; Storrs, 1979; van Wyk & Gericke, 2000.

Other references Hyde & Wursten, 2010b; Léonard, 1950b; Palmer & Pitman, 1972–1974; Richter & Dallwitz, 2000; Ross, 1977; Schmidt, Lötter & McCleland, 2002; Storrs, 1982; van Wyk & van Wyk, 1997; Watt & Breyer-Brandwijk, 1962.

Authors E.A. Obeng

GUIBOURTIA EHIE (A.Chev.) J.Léonard

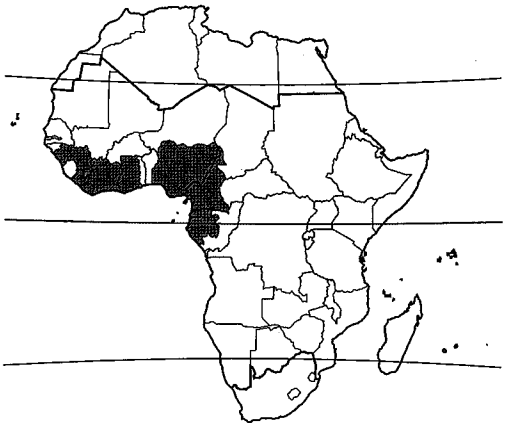
Protologue Bull. Jard. Bot. Etat 19: 404 (1949).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 24$

Origin and geographic distribution *Guibourtia ehie* occurs from Guinea and Liberia eastwards to Cameroon, and south to Gabon.

Uses The wood is commonly used for flooring, joinery, interior trim, panelling, furniture, vehicle bodies, agricultural implements, musical instrument, toys, novelties, carvings, turnery, veneer and plywood.
The solidified fresh or semi-fossil resin from the bark ('copal') is made into fragrant necklaces and traded locally. It is reported to have



Guibourtia ehie – wild

uses in the pharmaceutical and cosmetic industries and as a suitable base for varnishes and lacquers, and is also used for illumination. Traditionally, it is believed to drive away evil spirits when burnt. The seeds are edible. The decoction of a mixture of stem barks of *Guibourtia ehie* and *Tetrapleura tetraptera* (Schum. & Thonn.) Taub. is drunk to cure stomach ulcers in Ghana.

Production and international trade The wood is traded as 'ovengkol' or 'ovangkol' in Gabon, as 'amazakoué' in Côte d'Ivoire and as 'hyedua' in Ghana. The export in the period 1970–1974 was 36,000 m³ of logs from Côte d'Ivoire. The mean annual export of 'ovengkol' timber from Gabon in the period 1991–1999 was 12,000 m³. In 1999 it ranked 19th on the list of most important export timbers of Gabon. In 2001–2003 Gabon exported on average 16,000 m³/year. In 2004 the export of 'hyedua' plywood from Ghana was 1000 m³ at an average price of US$ 399/m³, and in 2010 the wood was still traded as first-quality parquet flooring from Ghana.

Properties The heartwood is yellowish brown to dark brown with greyish to blackish streaks, and distinctly demarcated from the yellowish white, up to 10 cm wide sapwood. The grain is straight to slightly interlocked, texture fine to medium. The wood has a distinct odour when freshly cut, and an attractive stripe figure.
The wood is medium-weight to heavy, with a density of 730–900 kg/m³ at 12% moisture content, hard and tough. It air dries slowly with a tendency of splitting and slight distortion; care should therefore be taken in drying. The rates

of shrinkage are moderately high, from green to oven dry 3.4–5.5% radial and 6.8–10.7% tangential. Once dry, the wood is moderately stable in service.

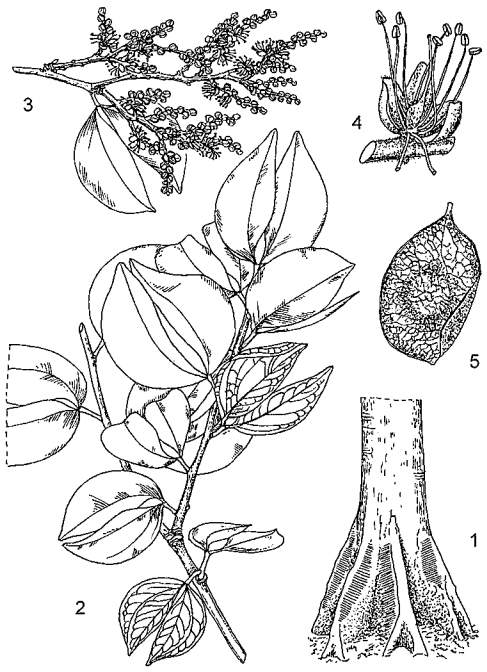
At 12% moisture content, the modulus of rupture is 127–210 N/mm², modulus of elasticity 13,900–21,500 N/mm², compression parallel to grain 57–81 N/mm², shear 8–15 N/mm², cleavage 17–34 N/mm and Chalais-Meudon side hardness 5.4–11.3.

The wood generally saws and works fairly easily with ordinary hand and machine tools, but the blunting effect on saw teeth and cutting edges may be considerable due to the presence of silica. Stellite-tipped saw teeth and tungsten-carbide cutting edges are recommended. The wood planes to a good finish. It holds nails and screws well, but pre-boring is needed. The wood glues, varnishes and polishes well and has good resistance to abrasion. It produces excellent sliced veneer, but it is advisable to heat logs before slicing. The wood is durable, being quite resistant to termite, *Lyctus* and marine borer attacks. The heartwood is resistant to impregnation with preservatives, the sapwood moderately resistant.

The traditional use of stem bark to cure stomach ulcers was verified in laboratory tests with mice. Aqueous bark extracts of *Guibourtia ehie* showed significant inhibition of ulceration of the stomach, but those of *Tetrapleura tetraptera* and of a combination of the two barks (1:4) were even more effective. The toxicity of the extracts using brine shrimp larvae was also investigated. The *Guibourtia ehie* extract was the only one that did not kill larvae, even at high concentrations.

Adulterations and substitutes The wood of *Guibourtia ehie* is a common substitute for rosewood (*Dalbergia* spp.), which is used for similar purposes. It is very similar to the wood of *Guibourtia arnoldiana* (De Wild. & T.Durand) J.Léonard.

Description Evergreen or deciduous, medium-sized to large tree up to 45(–50) m tall; bole branchless for up to 25 m, usually straight and cylindrical, up to 100(–300) cm in diameter, often with narrow buttresses up to 2.5 m high; bark surface nearly smooth, finely fissured, often with thin horizontal ridges, pale to dark grey or yellowish, inner bark granular or fibrous, thick, pinkish brown to brown or yellowish orange, with a yellowish, sweet scented exudate; crown flattened or rounded, finely branched; twigs hairy. Leaves arranged spirally, paripinnately compound with 1 pair of leaflets; stipules leaf-like, up to 2 cm long, often persistent; petiole 0.5–1 cm long; leaflets sessile, obliquely ovate or elliptical, 3–8 cm × 1.5–3.5 cm, base cuneate on one edge and rounded on the other, apex usually acuminate, glabrous, with numerous translucent dots or without these, pinnately veined with 5–7 pairs of lateral veins. Inflorescence an axillary or terminal panicle up to 20 cm long, hairy; bracts small, very early caducous. Flowers bisexual, nearly regular, whitish, fragrant, sessile; sepals (3–)4, slightly unequal, up to 4.5 mm long, hairy inside; petals absent; stamens 10, free, up to 7 mm long; ovary superior, broadly elliptical, c. 1 mm long, sparsely hairy, 1-celled, sessile, style 4–5 mm long. Fruit an elliptical, flattened, papery pod 4–6 cm × 3–4 cm, glabrous, reticulately veined, black, indehiscent, with a small wing at one side, 1-seeded. Seed rounded, flattened, c. 1.5 cm in diameter, brown, without aril. Seedling with epigeal germination; hypocotyl 6–12 cm long, epicotyl up to 3 mm long; cotyledons fleshy, nearly round, up to 1.5 cm in diameter, caducous; first leaf sessile, with 2 nearly round leaflets c. 3 cm long.



Guibourtia ehie – 1, base of bole; 2, leafy branch; 3, flowering twig; 4, flower with one sepal removed; 5, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Guibourtia* comprises about 14 species, all African, but a single species occurs in tropical America. The genus is related to *Hymenaea* and *Peltogyne*.
Guibourtia leonensis J.Léonard is a medium-sized tree up to 25 m tall with a straight bole, occurring in Senegal, Guinea-Bissau, Guinea, Sierra Leone and Liberia. The wood has an attractive appearance and it is suitable for general carpentry work. In Sierra Leone the bark is used as fish poison.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 25: intervessel pits small (4–7 μm); 26: intervessel pits medium (7–10 μm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 46: ≤ 5 vessels per square millimetre; 47: 5–20 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; (82: axial parenchyma winged-aliform); 83: axial parenchyma confluent; 89: axial parenchyma in marginal or in seemingly marginal bands; (91: two cells per parenchyma strand); 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; 104: all ray cells procumbent; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(F.D. Kamala, P.E. Gasson & E.A. Wheeler)

Growth and development *Guibourtia ehie* grows slowly. In Guinea the mean height of young trees was 3.5 m after 6 years. In Côte d'Ivoire a mean annual bole diameter growth of 0.5 cm has been recorded. *Guibourtia ehie* is fairly shade tolerant, but saplings require light at initial stages of growth. They usually have red flushes of leaves. In Liberia and Côte d'Ivoire, trees flower around November, lose their leaves soon thereafter, and new leaf flushes are developed when the fruits ripen in January–February. Fruits are dispersed by wind.

Ecology In West Africa *Guibourtia ehie* is most common in semi-deciduous forest, especially in drier types. In Central Africa it can also be found in well-drained localities in evergreen forest, up to 500 m altitude. Trees are very sensitive to fire.

Propagation and planting Natural regeneration is often abundant around the mother plant. In Liberia it has been reported that seedlings rarely reach sizes of more than 30 cm, but in Ghana saplings have been reported to be locally abundant.
There are about 2500 seeds per kg. Germination starts 10–25 days after sowing and the germination rate is usually fairly high, 65–80% after 5 weeks. In the nursery, seedlings should be grown in the shade. They reach about 25 cm tall after 4.5 months. In Guinea the mortality was very high (over 80%) in full sun. In Gabon seedlings had a survival rate of over 90% when planted in the open as well as in the forest; they reached a mean height of 2.3 m in full sun and 3.3 m in the shade 3 years after planting.

Management In general *Guibourtia ehie* occurs scattered in the forest, or in small groups of a few trees. In Gabon the average wood volume is 1.6 m^3/ha. In semi-deciduous forest in Côte d'Ivoire, an average of 3.1 trees with a bole diameter of more than 10 cm has been recorded.

Harvesting The prescribed minimum felling diameter is 90 cm in Ghana, in Gabon 70 cm and in Liberia and Côte d'Ivoire 60 cm.

Yield A tree with a bole diameter of 60 cm yielded 3.5 m^3 of wood and one with a bole diameter of 90 cm 8.1 m^3. In 1970 in Côte d'Ivoire, logs yielded 41% of sawn wood, of which 18% was considered of export quality.

Handling after harvest After harvesting, logs should not be left in the forest too long because they are liable to splitting.

Genetic resources Although *Guibourtia ehie* is fairly widespread, it suffers from overexploitation and could suffer from genetic erosion. It is included as vulnerable in the IUCN Red List of threatened species, but it is indicated that its status should be reviewed.

Prospects The wood of *Guibourtia ehie* is in high demand on the timber market, but research is needed to be able to determine its possibilities for commercial exploitation on a sustainable basis. There is little information available on growth rates, propagation and planting, and suitable management measures. The apparently slow growth can be a serious drawback because long cutting cycles could be necessary for sustainable exploitation. The

potential of its copal resin in the cosmetic and pharmaceutical industries could be harnessed, and experiments showed interesting possibilities for drug development of the bark. The phytochemistry of the seeds should be investigated to guarantee safe use as food. *Guibourtia ehie* might be worth to be promoted for wider planting as a true multipurpose tree.

Major references Aubréville, 1970; Bolza & Keating, 1972; Burkill, 1995; CIRAD Forestry Department, 2008; de Saint-Aubin, 1963; Hawthorne, 1995; Keay, 1989; Oteng-Amoako (Editor), 2006; Vivien & Faure, 1985; Voorhoeve, 1979.

Other references African Regional Workshop, 1998; Aubréville, 1959b; Aubréville, 1968; Brancheriau et al., 2006; Christy et al., 2003; de la Mensbruge, 1966; Hawthorne & Jongkind, 2006; Irvine, 1961; Kunkel, 1965; Léonard, 1949; Léonard, 1950b; Lisowski, 2009; Mangenot & Mangenot, 1957; Noamesi et al., 1994; Normand & Paquis, 1976; Tailfer, 1989; Takahashi, 1978; Taylor, 1960; UNEP-WCMC, 2006; Wilks & Issembé, 2000.

Sources of illustration Voorhoeve, 1979; Wilks & Issembé, 2000.

Authors A.A. Oteng-Amoako & C. Essien

GUIBOURTIA TESSMANNII (Harms) J.Léonard

Protologue Bull. Jard. Bot. Etat 19: 404 (1949).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Bois de rose d'Afrique (Fr).

Origin and geographic distribution *Guibourtia tessmannii* occurs in Cameroon, Equatorial Guinea and Gabon.

Guibourtia tessmannii – wild

Uses The wood of *Guibourtia tessmannii*, known as 'bubinga' or 'kevazingo', is used for flooring, joinery, decorative panelling, furniture, cabinet work, mine props, vehicle bodies, boxes, crates, musical instruments, tool handles, brush backs and carvings. It is suitable for ship building, toys, novelties, turnery, veneer and plywood.

In traditional medicine, bark decoctions are administered for the treatment of gonorrhoea and hypertension, and for preventing abortion. They are also taken as an anthelmintic and applied as a cleanser for washing wounds. In the markets of Yaoundé (Cameroon), stem bark is for sale to cure many complaints: convulsions, diarrhoea, lumbago, hernia, malaria, anaemia and female infertility. A survey among villagers yielded claims that use of bark, leaves or fruits also controls typhoid fever, haemorrhoids, cancer, sexually transmittable diseases and hepatitis. Bark extracts are used in southern Cameroon as a pesticide, often in mixtures with other plant species, to control the 'black pod disease' in cacao cause by fungi. The bark is much sought after and has often been removed at the base of the bole of standing trees.

Production and international trade The wood is traded from Gabon as 'kevazingo' in mixture with that of *Guibourtia pellegriniana* J.Léonard. In 1997 about 55,000 m^3 of logs were exported at an average price of FCFA 350,000/m^3.

Properties The heartwood is reddish brown, often with violet-brown or purplish streaks, and distinctly demarcated from the whitish, up to 7.5 cm wide sapwood. The grain is straight or interlocked, texture fine and even. The wood is lustrous and scented when freshly cut.

The wood is heavy, with a density of 860–930 kg/m^3 at 12% moisture content, and hard. It air dries slowly with high risk of distortion. The rates of shrinkage are quite high, from green to oven dry 5.2–8.1% radial and 6.3–10.5% tangential. At 12% moisture content, the modulus of rupture is 166–195 N/mm^2, modulus of elasticity 15,100 N/mm^2, compression parallel to grain 66–73 N/mm^2, shear 9.5 N/mm^2, cleavage 20–27 N/mm and Chalais-Meudon side hardness 7.9–9.0.

The wood is fairly easy to saw and work with both machine and hand tools, and it planes to a good finish. It polishes well and varnishes satisfactorily. It holds nails well and has good

gluing properties. Good-quality veneer can be produced by slicing. The wood is durable and resistant to termites, *Lyctus* and other wood-boring beetles. The heartwood is resistant to impregnation with preservatives, the sapwood moderately resistant.

The wood of *Guibourtia tessmannii* contains flavanols of leucofisetinidin and guibourtacacidin, tannins and sugars. Some stilbene glycosides have been isolated from the bark, as well as asebotin, a dihydrochalcone glucoside. Pharmacological screening showed antifungal activity.

Botany Medium-sized to large tree up to 40 m tall; bole branchless for up to 20 m, straight, cylindrical, up to 200 cm in diameter and often with large, slender buttresses up to 3 m high; bark surface greenish grey to reddish brown, scaly with small, rounded scales leaving orange to red depressions, inner bark brittle, reddish to brown, often with a gelatinous reddish exudate; crown dense, rounded. Leaves arranged spirally, paripinnately compound with 1 pair of leaflets; stipules small and early caducous; petiole 1.5–3 cm long; leaflets nearly sessile, obliquely ovate or elliptical, 6–15 cm × 3–6 cm, base cuneate, apex acuminate, glabrous, without translucent dots, pinnately veined with up to 10 pairs of lateral veins. Inflorescence an axillary or terminal panicle c. 10 cm long, with thick branches, reddish hairy; bracts small, very early caducous. Flowers bisexual, nearly regular, whitish, fragrant, sessile; sepals 4, slightly unequal, up to 6 mm long, hairy inside; petals absent; stamens 10, free, up to 8 mm long; ovary superior, broadly ellipsoid, c. 2 mm long, hairy, 1-celled, sessile, style c. 5 mm long. Fruit an obliquely ellipsoid pod 3–4 cm × 2–2.5 cm, slightly flattened, glabrous, densely striped, dark copper-brown, dehiscent with 2 leathery valves, 1(–2)-seeded. Seed kidney-shaped, c. 1.5 cm long, slightly flattened, completely covered by an orange-red aril.

The seed is eaten by monkeys, chimpanzees and hornbills, which may serve as dispersers.

Guibourtia comprises about 14 species, all African, but a single species occurs in tropical America. The genus is related to *Hymenaea* and *Peltogyne*.

Guibourtia pellegriniana J.Léonard occurs from south-eastern Nigeria south to Cabinda (Angola). It is a tall tree, with a straight bole. In Gabon it is locally harvested for the commercial timber trade from secondary forest where okoumé (*Aucoumea klaineana* Pierre) is the dominant species. The wood, with a density of about 940 kg/m^3 at 12% moisture content, is quite similar to that of *Guibourtia tessmannii*.

Ecology *Guibourtia tessmannii* occurs in evergreen forest, usually in primary forest on well-drained localities.

Management *Guibourtia tessmannii* generally occurs scattered in the forest. In Gabon the average wood volume of *Guibourtia tessmannii* and *Guibourtia pellegriniana* together is 1.4 m^3/ha, and in 1995 the standing stock was estimated at 13 million m^3.

The minimum bole diameter for exploitation is 90 cm in Gabon. In Cameroon a tree with a bole diameter of 80 cm yielded 5.6 m^3 of wood, one of 100 cm 8.6 m^3 and one of 150 cm 19.1 m^3. Freshly harvested logs do not float in water.

Genetic resources and breeding Although *Guibourtia tessmannii* has a limited geographical distribution and usually occurs scattered in primary forest, there are no indications that it is under threat of genetic erosion at present. However, it is advisable to monitor populations because the species may easily become liable to genetic erosion.

Prospects The wood of *Guibourtia tessmannii* is in demand on the timber market, but research is needed to be able to determine its possibilities for commercial exploitation on a sustainable basis. There is no information available on growth rates, propagation and planting, and suitable management measures. Slow growth has been reported for some other *Guibourtia* species, and could also be a serious drawback for *Guibourtia tessmannii* because long cutting cycles would be necessary for sustainable exploitation. The common application of the bark in traditional medicine warrants more research on phytochemistry and pharmacological properties.

Major references Bolza & Keating, 1972; Burkill, 1995; CIRAD Forestry Department, 2008; CTFT, 1977a; Vivien & Faure, 1985.

Other references ATIBT, 1986; Aubréville, 1968; Betti, 2002; Coulibaly et al., 2002; de Saint-Aubin, 1963; Jiofack et al., 2009; Nkengfack et al., 2001; Nyemba, 1995; Takahashi, 1978; Wilks & Issembé, 2000.

Authors E.A. Obeng

GYROCARPUS AMERICANUS Jacq.

Protologue Select. stirp. amer. hist.: 282 (1763).

Family Hernandiaceae

Chromosome number $2n = 30$

Synonyms *Gyrocarpus jacquinii* Gaertn. (1791), *Gyrocarpus asiaticus* Willd. (1806).

Vernacular names Propeller tree (En). Mbamba-mweupe, mbawa, mbomba (Sw).

Origin and geographic distribution *Gyrocarpus americanus* is extremely widespread, occurring in Central America and northern South America, in the drier parts of tropical Africa, throughout tropical Asia, in northern Australia, and on islands in the Pacific Ocean towards Tahiti. In tropical Africa it is found from eastern Senegal, Guinea and Mali east to Eritrea and Kenya, and south to Namibia and South Africa; it is also found in western and southern Madagascar.

Uses The boles of *Gyrocarpus americanus* are traditionally used for dug-out canoes. The wood is used for roof laths, wall covering, insulation, toys, model making and carvings. In tropical Asia it is additionally used for wooden clogs, light furniture, boxes, crates, trays and floats. It is suitable for sporting goods, turnery, veneer, plywood, hardboard, particle board and pulpwood. It is also used as firewood.

Bark infusions are taken to treat cancer and kidney pain, whereas pounded roots or root decoctions are applied to wounds. Root decoctions are also administered to treat diarrhoea. In Mali crushed leaves are applied to treat scabies. In Bangladesh twigs are used as toothbrush. The yellowish bark exudate has been used as a substitute of rubber.

Production and international trade The wood is seldom traded and on a local scale only.

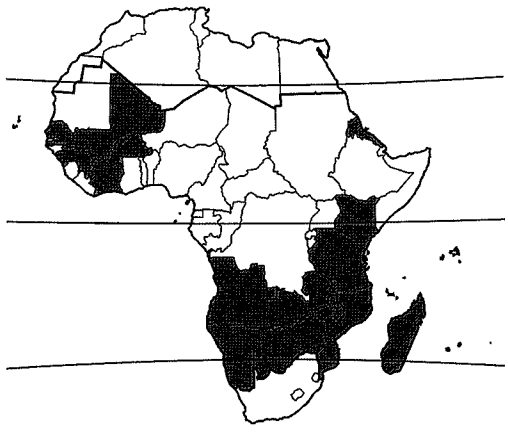
Properties The heartwood is greyish white to pale yellow, sometimes with a pink tinge, darkening to greyish brown upon drying, and indistinctly demarcated from the sapwood. The grain is straight, sometimes slightly interlocked, texture coarse but even. The wood is lustrous, particularly when quarter-sawn.

The wood is lightweight, with a density of 250–440 kg/m^3, and soft. It air dries easily. The rates of shrinkage are low, from green to oven dry 1.6–3.5% radial and 4.2–6.4% tangential. Once dry, the wood is fairly stable in service. At 12% moisture content, the modulus of rupture is 39–96 N/mm^2, modulus of elasticity 4510–10,750(–13,900) N/mm^2, compression parallel to grain 19–33 N/mm^2 and Chalais-Meudon side hardness 0.3–1.8.

The wood saws and works easily, both with hand and machine tools, but sharp tools are recommended because it has a tendency to crumble. In finishing, it often produces woolly surfaces. The wood nails and screws easily, and the holding power of nails and screws is satisfactory. It glues and stains satisfactorily. It is not durable, being liable to termite, pinhole borer, *Lyctus* and marine borer attacks. The wood is easy to impregnate with preservatives.

The presence of alkaloids has been demonstrated for several plant parts. One of these is magnocuranine, which has ganglion-blocking activity. Gyrocarpine showed moderate antileishmanial activity in mice. Twig extracts showed antibacterial activity against *Bacillus pumilus*.

In Australia some tests have been done on the essential oil from the leaves of *Gyrocarpus americanus*. The yield was 0.2–0.7%, and the composition of the oil was quite variable, with up to 40% α-pinene and β-pinene, but sometimes sesquiterpenes were dominating with germacrene D as the major component (31%).



Gyrocarpus americanus – wild

Botany Deciduous small to medium-sized tree up to 20(–30) m tall; bole cylindrical, up to 80(–100) cm in diameter, without buttresses; bark surface smooth to scaly, greyish white to whitish brown or greenish brown, inner bark straw-coloured with greenish margin, with a yellowish exudate; crown open, rounded, with often short branches; twigs brittle, short-hairy, with lenticels. Leaves arranged spirally, clustered near twig ends, simple; stipules absent; petiole 4–18 cm long, channelled; blade ovate-lanceolate or 3–5(–7)-lobed to near the middle, 4–25 cm × 4–22 cm, obtuse to heart-shaped at base, acuminate at apex, papery, glabrous to short-hairy, 3–5(–7)-veined from the base and with 3–6 pairs of lateral veins. Inflorescence an axillary, much-branched cyme up to 15 cm long, hairy, with long peduncle. Flowers bisex-

ual or male, regular or slightly zygomorphic, scented, yellowish to greenish brown; perianth lobes 4–8, c. 2 mm long, equal or unequal with 2 larger ones, hairy; stamens (1–)4(–7), up to 4 mm long, hairy or glabrous, anthers opening with 2 flap-like valves, alternating with rudimentary stamens up to 1 mm long; ovary inferior, 1-celled, style recurved or S-shaped. Fruit a dry, ovoid nut 1–2 cm long, with c. 8 longitudinal ridges, with 2 large brown to blackish wings (enlarged perianth lobes) up to 11 cm × 1.5 cm, 1-seeded. Seed with spongy seed coat. Seedling with epigeal germination; cotyledons leafy, 2-lobed; first few leaves entire, subsequent ones 3-lobed.

Growth is fairly rapid, with a mean annual growth rate in height of 45 cm in Madagascar. In the nursery seedlings reach 50–100 cm in height after one year. In West Africa trees usually flower at the end of the dry season, shortly before new leaves develop. In Madagascar new leaves develop at the beginning of the rainy season, usually in early November. The leaves fall at the end of May, about one month after the end of the rainy season. Trees regularly flower in September–October and fruit 1–2 months after flowering. Pollination is probably by wind. The winged fruits are an obvious adaptation for wind dispersal. They rotate when falling. Dispersal may also be by water as the fruits can float for several months. The viability of fruits having floated in water for 2 months was not affected.

Gyrocarpus comprises 4 species, 3 of which are found in tropical Africa. *Gyrocarpus angustifolius* (Verdc.) Thulin is a shrub or small tree up to 15 m tall, occurring in scrub and open bushland in Ethiopia, Somalia and Kenya. *Gyrocarpus hababensis* Chiov. has a similar habit and occurs in the same region and additionally in Eritrea and Djibouti. The wood of both species works easily and is occasionally used for utensils and carvings.

Gyrocarpus americanus has been subdivided into 8 subspecies. Within mainland Africa 3 subspecies are found: subsp. *africanus* Kubitzki occurring from Eritrea, through Kenya and Tanzania, southward to South Africa; subsp. *americanus* in Kenya and Tanzania; and subsp. *pinnatilobus* Kubitzki in West Africa. In Madagascar 3 more subspecies occur: subsp. *capuronianus* Kubitzki, subsp. *glaber* Kubitzki and subsp. *tomentosus* Kubitzki.

Ecology *Gyrocarpus americanus* occurs in hot and dry areas, in Madagascar up to 600 m altitude, in southern Africa up to 1200 m and in Eritrea up to 1400 m, often in deciduous woodland on rocky ridges or stony slopes, also in riverine thickets. In Madagascar it occurs in regions with a mean annual rainfall of 500–1000(–1200) mm, with 5–7 dry months, and a mean annual temperature of 24°C. It prefers sandy soils with good drainage, but can locally also be found on humid clayey soils. *Gyrocarpus americanus* is not resistant to fire and does not tolerate periodic waterlogging.

Management In Madagascar natural regeneration is said to be quite rare. Fruits are usually collected from the ground. The weight of 1000 fruits is 250–350 g. It is recommended to sow fruits as soon as possible, after removal of the wings by hand. Nevertheless, they can be stored after drying in the sun in air-tight containers for up to 1 year without losing much of their germination power. Pre-treatment is not needed, although in Madagascar it is recommended to soak fruits in water for 24 hours before sowing. The seeds start germinating after about 10 days, and the germination rate is 60–85%. However, in a trial in Malaysia seeds germinated much later: about 70% germination was achieved from 11 months to almost 3 years. In India the germination rate decreased when seeds were sown under shade. Seeds can be sown directly into the field, but in Madagascar the survival rate of seedlings was only 9% after 15 months. Planting of 6–12-month-old, bare-rooted seedlings raised in the nursery showed better results, with a survival rate of 70% after 2 years.

Genetic resources and breeding *Gyrocarpus americanus* is extremely widespread and locally common, and not easily liable to genetic erosion. In West Africa (subsp. *pinnatilobus*) it occurs very localized, and there it may be more vulnerable.

Prospects Commercial interest in *Gyrocarpus americanus* is unlikely to increase because it is often a smaller tree with moderate wood properties. However, its utilization for carving in cottage industry may attract interest in the future.

Major references Arbonnier, 2004; Blaser et al., 1993; Boer & Sosef, 1998; Chikamai et al., undated; Randrianasolo, 1989.

Other references Bein et al., 1996; Bolza & Keating, 1972; Brophy, Goldsack & Forster, 2000; Burkill, 1994; Capuron, 1966h; CFPF, 2008; Coates Palgrave, 2002; Gelfand et al., 1985; Inngjerdingen et al., 2004; Neuwinger, 2000.

Authors R.H.M.J. Lemmens & D. Louppe

HAPLOCOELUM FOLIOLOSUM (Hiern) Bullock

Protologue Bull. Misc. Inform. Kew 1931: 356 (1931).

Family Sapindaceae

Synonyms *Haplocoelum gallaense* (Engl.) Radlk. (1916), *Haplocoelum mombasense* Bullock (1931).

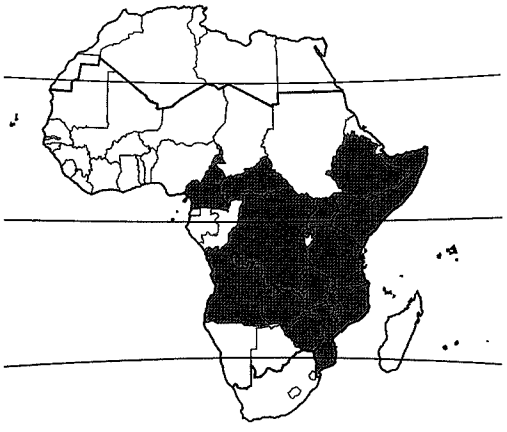
Vernacular names Galla plum, northern galla plum (En).

Origin and geographic distribution *Haplocoelum foliolosum* is distributed from Cameroun east to southern Ethiopia and Somalia, and south to Zambia, Angola, Zimbabwe, Mozambique and South Africa.

Uses The wood of *Haplocoelum foliolosum* is used in East Africa for construction, furniture and tool handles. The fruit is eaten. The flowers are an important source of nectar for honey bees. In Kenya leaf decoctions are used as eye lotion. The twigs are used as toothbrushes.

Properties The wood is reddish and very hard.

Botany Deciduous, dioecious shrub or small tree up to 15(–25) m tall; bark smooth, grey; branchlets grey-brown to black, short-hairy. Leaves alternate, paripinnately compound with 2–16 pairs of leaflets; stipules absent; petiole 0.5–1.5 cm long, rachis 2–10 cm long, narrowly winged; petiolules up to 0.5 mm long; leaflets opposite, oblong to elliptical, 1.5–6 cm × 0.5–1 cm, cuneate to obtuse and asymmetrical at base, usually notched at apex, glabrous or sparsely hairy on midrib, pinnately veined with numerous closely spaced lateral veins. Inflorescence an axillary fascicle or cyme. Flowers unisexual, regular, white to yellowish; pedicel 1–3 mm long in male flowers, 5–10 mm in female flowers; sepals 5, oblong, c. 2 mm long, short hairy; petals absent; stamens 4–5, free, filaments 2–5 mm long; ovary superior, ovoid to rounded, 3-celled, style up to 1 mm long, 3-fid; male flowers without ovary, female flowers with rudimentary stamens. Fruit an ovoid to nearly globose capsule 1.5–2 cm × 1–1.5 cm, yellow to red-purple when ripe, indehiscent or irregularly rupturing, 1–2-seeded. Seeds ellipsoid, flattened, 1–1.5 cm × c. 0.5 cm, brown, covered by a thin, fleshy aril.



Haplocoelum foliolosum – *wild*

Trees usually flower before new leaves develop. *Haplocoelum foliolosum* shows a lot of variation. Three subspecies have been distinguished, mainly based on the number of leaflets per leaf, but a large part of the variation seems to be caused by growing conditions. At 1850 m altitude on Mount Mulanje in Malawi, it can be a tree up to 25 m tall, but at lower altitudes it is often a straggling shrub or small tree of only 3–4 m in height.

Haplocoelum comprises 4 species on the mainland of tropical Africa. A fifth species endemic to Madagascar was included in the genus as *Haplocoelum perrieri* Capuron, but it differs from the other species to such an extent that it was transferred to a distinct genus; its name is now *Gereaua perrieri* (Capuron) Buerki & Callmander. It is a small tree up to 15(–20) m tall suitable for timber; its branches are used for fencing and the seed aril is edible.

Haplocoelum inoploeum Radlk. (synonym: *Haplocoelum trigonocarpum* Radlk.), called 'mchumbi' and 'mfunga tanzu' in Swahili, is a shrub or small tree up to 15 m tall occurring in coastal East Africa from Somalia to Tanzania. Its hard wood is used to manufacture walking sticks and clubs, and the seed aril is edible.

Ecology *Haplocoelum foliolosum* is found in grassland, thickets and woodland, including *Brachystegia-Isoberlinia* woodland, from sea-level up to 1500 m altitude, in Malawi up to 1850 m.

Genetic resources and breeding As *Haplocoelum foliolosum* is widely distributed and not heavily exploited, no threats are envisaged.

Prospects *Haplocoelum foliolosum* does not seem to have prospects as a timber tree of commercial importance because it rarely reaches large dimensions. In view of the large variation, it is an interesting subject for combined taxonomic and ecological research.

Major references Burkill, 2000; Coates Palgrave, 1983; Davies & Verdcourt, 1998; Kokwaro, 1993.

Other references Beentje, 1994; Buerki et

al., 2010; Fouilloy & Hallé, 1973a; Friis & Vollesen, 1999; Friis, Verdcourt & Vollesen, 1996; Hauman, 1960; Ichikawa, 1987; McGinley (Editor), 2008.

Authors C.H. Bosch

HAZOMALANIA VOYRONII (Jum.) Capuron

Protologue Adansonia, sér. 2, 6: 377 (1966).

Family Hernandiaceae

Synonyms *Hernandia voyronii* Jum. (1921).

Vernacular names False camphor (En). Faux camphrier (Fr).

Origin and geographic distribution *Hazomalania voyronii* is endemic to western and central Madagascar, where it occurs from near Mahajanga southward to close to Toliara.

Uses The wood, known as 'hazomalany' or 'hazomalana', is considered among the most valuable woods of western Madagascar. Traditionally, the wood has been used for dug-out canoes, floaters of canoes, peddles, ceremonial coffins, chests to preserve clothes and food, and weather-boards. It is used for planks, joinery, furniture, moulding, boxes, crates, frame-work and shingles. It is suitable for light construction, interior trim, toys, novelties, matches, turnery, veneer, plywood, hardboard, particle board and pulpwood.

The bark is used in traditional medicine to treat fever including malaria, hepatitis and digestive problems. Bark decoctions or macerations are traditionally used as coadjuvant to chloroquine in the treatment of malaria. Powdered wood is applied to wounds. The smoke of the wood is used to dispel mosquitoes. The fruits are used to prepare a reddish dye applied as nail polish; the pulp is crushed and mixed with some water.

Hazomalania voyronii – wild

Production and international trade The wood of *Hazomalania voyronii* has been traded extensively in western Madagascar for local applications, but over-exploitation reduced the volumes in trade considerably. Since a long time, the wood has been exported to India and China to make coffins.

Properties The heartwood is straw-coloured to yellowish brown and distinctly demarcated from the 4–5 cm wide sapwood. The grain is usually straight, texture coarse. The wood has a persistent camphor-like smell.

The wood is lightweight, with a density of 370–470 kg/m^3 at 12% moisture content. It air dries rapidly with little or no degrade. The rates of shrinkage are low, from green to oven dry 2.3–3.4% radial and 4.2–6.6% tangential. It takes 1–2 months to air dry 2.5 cm thick boards, and 4–5 months for 4 cm thick boards. Once dry, the wood is stable in service.

At 12% moisture content, the modulus of rupture is 59–77 N/mm^2, modulus of elasticity (3330–)5300–8000 N/mm^2, compression parallel to grain 28–34 N/mm^2, shear 5 N/mm^2, cleavage 7.5–8.5 N/mm and Chalais-Meudon side hardness 0.6–1.4.

The wood saws and works easily, with both hand and machine tools, but it is fissile. The nail-holding power is moderate. The wood glues satisfactorily, and it varnishes, paints and polishes well when a filler has been used. It has excellent peeling and slicing characteristics, and is suitable for moulding and turning.

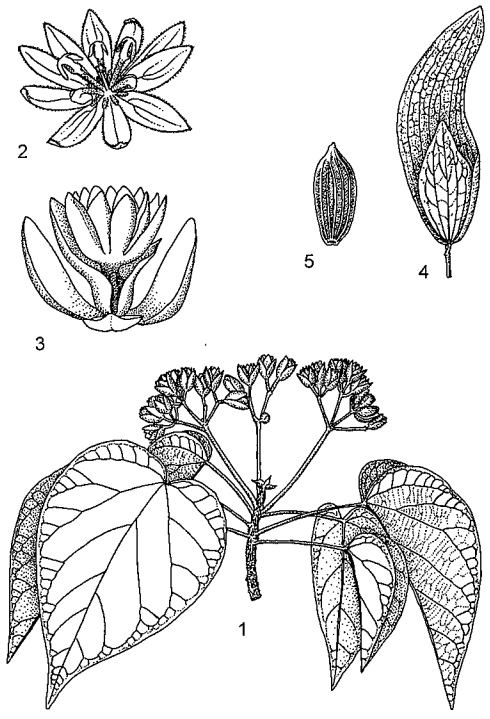
The heartwood is durable, being quite resistant to fungal, termite and wood-borer attacks, but moderately susceptible to marine borers. The heartwood is resistant to impregnation with preservatives, the sapwood moderately resistant.

Several benzyltetrahydroisoquinoline alkaloids have been isolated from the bark: hervelines A–D, reticuline and laudanosine. These compounds have moderate in-vitro antiplasmodial activity, but a pronounced chloroquine-potentiating action against chloroquine resistant *Plasmodium falciparum* strains. Bark extracts showed low cytotoxicity against HeLa cells and L929 fibroblasts.

An essential oil has been obtained by hydrodistillation from the bark. Perillaldehyde is the major constituent (about 83%), responsible for the distinct camphor-like smell. The oil showed noteworthy antibacterial and antifungal activities.

Adulterations and substitutes The wood of *Hazomalania voyronii* has been suggested as a good substitute of softwood. The names 'hazomalany' and 'hazomalana' are used for other trees with a pronounced smell, but their wood is often quite different from that of *Hazomalania voyronii*.

Description Deciduous, dioecious, medium-sized tree up to 25 m tall, all parts with a camphor-like smell; bole branchless for up to 12 m, usually straight and cylindrical, up to 80(–100) cm in diameter; bark surface longitudinally fissured and scaly, whitish, inner bark thick, yellowish; crown dense; twigs thick, densely whitish grey short-hairy. Leaves arranged spirally, clustered near apex of twigs, simple and entire; stipules absent; petiole 2.5–10 cm long; blade ovate to heart-shaped, 5.5–14 cm × 4–11 cm, rounded to cordate at base, obtuse to acuminate at apex, papery, more or less densely hairy below, with minute translucent dots, 3–5-veined from the base. Inflorescence an axillary umbel-like compound cyme, with main axis up to 5(–6) cm long and usually 4–5 branches up to 2 cm long, yellowish white short-hairy; bracts up to 1(–3) cm long. Flowers unisexual, regular, whitish; male flowers (4–)5(–6)-merous, with c. 1 mm long pedicel, tepals obovate-oblong, 6–7 mm × 2–3 mm, short-hairy, in 2 whorls, alternating with c. 2.5 mm long glands, stamens 4–5 mm long, ovary rudimentary; female flowers (5–)6-merous, with 2 unequal, up to 1 cm long bracteoles at base, sessile, tepals obovate-oblong, 6–7 mm × 2–3 mm, short-hairy, in 2 whorls, alternating with c. 2 mm long glands, rudimentary stamens c. 2 mm long, ovary inferior, 1-celled, style 3.5–4 mm long, hairy, stigmas 2, rounded and slightly lobed. Fruit a dry, slightly fleshy, almond-shaped drupe c. 4.5 cm × 1.5 cm, slightly laterally compressed, with c. 10 longitudinal ridges, enclosed by 2 large, unequal wings (enlarged bracteoles) up to 12 cm × 4 cm; stone obovoid, c. 2.5 cm × 1 cm, laterally compressed, 1-seeded. Seed with leafy cotyledons cordate at base.



Hazomalania voyronii – 1, flowering twig; 2, male flower; 3, female flower with bracts and bracteoles; 4, fruit enclosed by wings; 5, fruit. Redrawn and adapted by J.M. de Vries

Other botanical information *Hazomalania* comprises a single species and is closely related to *Hernandia* or is even considered to belong to the latter genus. *Hernandia* differs in being evergreen and monoecious.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 12: solitary vessel outline angular; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; (26: intervessel pits medium (7–10 μm)); 27: intervessel pits large (≥ 10 μm); 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 32: vessel-ray pits with much reduced borders to apparently simple: pits horizontal (scalariform, gash-like) to vertical (palisade); (33: vessel-ray pits of two distinct sizes or types in the same ray cell); 42: mean tangential diameter of vessel lumina 100–200 μm; 47: 5–20 vessels per square millimetre; 56: tyloses common. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 68: fibres very thin-walled; (69: fibres thin- to thick-walled). Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; (83: axial parenchyma confluent); 90: fusiform parenchyma cells; 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 104: all ray cells procumbent; 114: ≤ 4 rays per mm;

115: 4–12 rays per mm.
(L. Awoyemi, P.E. Gasson & E.A. Wheeler)

Growth and development Young trees require shade and grow slowly, with a mean annual growth under good conditions of 20–40 cm in height. Diameter growth of the stem is slow until the diameter reaches 10 cm, but then it increases to 3–4 mm/year. The age of a tree with a bole diameter of 50 cm has been estimated at 200 years. In young trees, the leaves are peltate, but this condition disappears in older trees. Leaves fall at the beginning of the dry season and trees are leafless for about 4.5 months until the rainy season. Trees usually flower in February–April at the end of the rainy season, before the leaves fall. They fruit irregularly; fruits ripen about 4 months after flowering, mostly near the middle of the dry season. The fruits, with their long unequal wings, are dispersed by wind, but they are rarely found more than 40 m from the mother tree, indicating that strong winds are needed for wider dispersal.

Ecology *Hazomalania voyronii* occurs in dry deciduous forest, up to 800 m altitude. The mean annual rainfall in the area of distribution is 500–1600 mm, with 5–8 dry months, and the mean annual temperature 20–27°C. *Hazomalania voyronii* is found on well-drained localities on deep red ferruginous soils with clay, alluvial soils and other relatively rich soils, sometimes on sandy soils.

Propagation and planting Natural regeneration seems to be poor or erratic. The fruits are usually collected from the trees by shaking the branches, sometimes from the ground, between the end of June and mid-September. The fruit stones are extracted manually, sorted by floating and dried in the sun. There are 600–800 stones per kg. They can be sown without pre-treatment. Fruits without wings can be stored in air-tight containers for up to 6 months, after which the viability decreases rapidly. Fresh stones start germinating after 2–3.5 weeks and the germination rate is about 30%. Immersion of fresh stones in water for 6 hours increases the germination rate to 60–80%. The stones are sown under shade in nursery beds at a spacing of 10 cm × 10 cm. The seedlings stay in the nursery for 12–18 months, when they have reached 30–50(–70) cm in height and 1.5 cm in stem diameter at the collar. Planting out is most successful in the dry season (survival rate of 67% versus 42% in the rainy season). Coppice shoots of more than 10 cm in diameter have also been used for propagation.
Propagation tests showed poor results for cuttings, which did not root well. In-vitro propagation on a modified Murashige and Skoog medium gave nearly 90% success.

Management *Hazomalania voyronii* has been used for enrichment planting. Seedlings of 30–70 cm tall with clipped roots are planted in close lines. They should be planted in light shade.

Diseases and pests The fruits often fall off prematurely and are often parasitized by insects. Seedlings and saplings are attacked by the Malagasy giant rat (*Hypogeomys antimena*).

Genetic resources *Hazomalania voyronii* is fairly widespread in western Madagascar, but it has become under high pressure because of over-exploitation for the valuable wood and for the bark valued in medicinal preparations. Already in the early 1970s, it was nearly impossible to find larger trees. Protection seems to be needed at present, but inventories of the remaining stands should confirm this.

Prospects *Hazomalania voyronii* is a tree with great cultural value which has been used traditionally by the local population, both for its highly esteemed timber and in traditional medicine. The wood is lightweight and easy to work, and additionally fairly durable, which makes it usable for many purposes. The bark has a reputation of an important medicine to combat malaria.
Hazomalania voyronii deserves to be protected. More studies on propagation, planting and suitable silvicultural management are needed to safeguard its role as a timber producer of some commercial importance. Pharmacological studies support the traditional use of *Hazomalania voyronii* bark extracts against malaria, particularly as an adjuvant to chloroquine. This might offer possibilities for new drug development, but additional studies are needed.

Major references Blaser et al., 1993; Bolza & Keating, 1972; Caniato & Puricelli, 2003; Capuron, 1966g; CFPF, 2008; Ramahaimananjato, 2008; Randrianarivelojosoa, 1992; Rasoanaivo et al., 1998; Ratsimamanga Urverg et al., 1994a; Takahashi, 1978.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Capuron, 1966f; Chalcat et al., 1997; Decary, 1946; Guéneau, 1971a; Guéneau & Guéneau, 1969; Guéneau, Bedel & Thiel, 1970–1975; Kubitzki, 1993b; Parant, Chichignoud & Rakotovao, 1985; Rakotovao et al., en préparation; Ramaroson & Ravoavy,

1988; Ratsimamanga Urverg et al., 1994b; Sallenave, 1955; Sallenave, 1964; Schatz, 2001.

Sources of illustration Capuron, 1966g; Kubitzki, 1993b.

Authors R.H.M.J. Lemmens & D. Louppe

HEISTERIA PARVIFOLIA Sm.

Protologue Rees, Cycl. 17: Heisteria 3 (1811).

Family Olacaceae

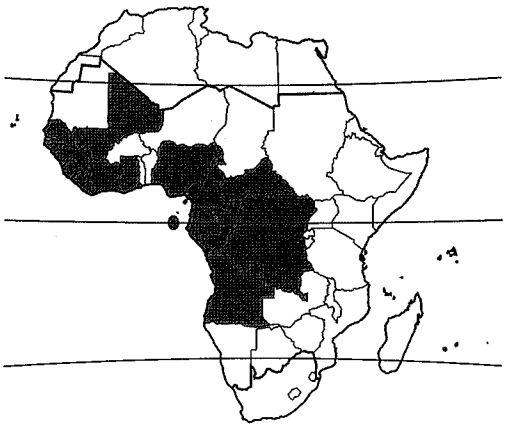
Chromosome number $2n = 38$

Origin and geographic distribution *Heisteria parvifolia* occurs from Senegal and southwestern Mali eastward to the Central African Republic and southward to DR Congo and northern Angola; possibly also in Uganda and southern Sudan.

Uses The wood of *Heisteria parvifolia* is used for construction, poles, piles, carpentry, palisades and tool handles. The flexibility of stems and wood make them suitable for making bows, arrows, snares, springs, fishing spears and other fishing goods. The wood is also used as firewood.

The glossy, dark green leaves and enlarged scarlet calyx persisting on the developing fruit make the shrub or tree an attractive ornamental. In several areas the fruits are eaten fresh; the small oil-rich seeds are eaten fresh, roasted or cooked. The twigs are used as chew-sticks. The leaves are used to line baskets for carrying fruits. In Congo leaves have been used to dye shields.

In traditional medicine in Ghana, ground roots are applied as enema against stomach-ache. In Congo sap from the root bark is dropped into the nose against migraine and into the eye to treat painful, infected eyes. Stem bark is taken in Ghana, Côte d'Ivoire and DR Congo as a cough medicine. In Gabon bark is applied to circumcision wounds. In Ghana and Côte d'Ivoire leaf decoctions are taken or applied as a bath to invigorate rachitic children and to treat convulsions. They are also used as analgesic and rubbed onto painful breasts of young mothers, and in Sierra Leone to treat toothache. In Congo leaf decoctions are administered against asthma, costal pain, stomach pain and menstrual problems. Ground seeds are used to stupefy fish. In DR Congo powdered bark is an ingredient in the preparation of arrow poison.



Heisteria parvifolia – wild

Production and international trade The various products of *Heisteria parvifolia* are only traded locally.

Properties The wood is pinkish grey to pale brown, heavy and hard. The texture is fine.

The seed kernel contains about 50% fat and has a nice flavour like hazel-nut. The fatty acid composition is reported as: mainly long-chain (C16–C28) saturated fatty acids 18.5%, oleic acid 31%, other mono and di-enoic fatty acids 5%; in addition several rare fatty acids are present, including trans-unsaturated acids. Leaves contain some tannin.

Botany Evergreen shrub or small tree up to 15(–20) m tall; bole up to 40(–60) cm in diameter, slightly fluted at base or with thin buttresses; bark surface finely fissured, grey to dark brown, inner bark pinkish with a reddish resin; crown with long, arching branches, drooping and much-branched at the ends; twigs slightly winged or ridged, glabrous and often with conspicuous lenticels. Leaves alternate, simple and entire; stipules absent; petiole 0. 5–1.5 cm long, grooved above; blade elliptical to oblong or lanceolate, 6–25 cm × 2.5–12 cm, base rounded or cuneate, apex acuminate, leathery, margin slightly inrolled, glabrous, pinnately veined with (5–)6–11 pairs of lateral veins. Inflorescence an axillary fascicle. Flowers bisexual, regular, 5-merous, creamy to greenish white, very small; pedicel 1.5–4 mm long, elongating in fruit; calyx lobes deltoid, c. 1 mm long; petals free, oblong-lanceolate, 2–2.5 mm long; stamens free, in 2 whorls, those of outer whorl slightly longer than those of inner one; ovary superior, 3-celled. Fruit an ellipsoid drupe 10–12 mm × 6–8 mm, whitish to greenish, enclosed by the enlarged, reddish brown to dark red calyx lobes up to 3 cm long; stone ellipsoid, 7–9 mm × 4–6 mm, 1-seeded. Seeds oily. Seedling with epigeal germination; hypocotyl

5–8 cm long, epicotyl c. 1 cm long; cotyledons leafy, elliptical, 2–3.5 cm long; first leaves alternate.
In several regions *Heisteria parviflora* can be found flowering and fruiting nearly throughout the year. Numerous animals eat the fruits and serve as seed dispersers.
Heisteria comprises about 65 species in tropical America and 3 in tropical Africa. The wood of the other African *Heisteria* species is used for similar purposes as that of *Heisteria parvifolia*. *Heisteria trillesiana* Pierre is a shrub or small to medium-sized tree up to 20 m tall with bole branchless for up to 7 m and up to 40 cm in diameter, occurring in Cameroon and Gabon. Its wood is white to yellow with a pinkish hue, strong and hard but easy to split, and is probably used for similar purposes as that of *Heisteria parvifolia*. The oily seed kernels are eaten raw or boiled, but are said to cause colic. *Heisteria zimmereri* Engl. is a shrub or small tree up to 7(–15) m tall with straight bole up to 50 cm in diameter, occurring in Cameroon, Equatorial Guinea, Gabon, Congo, DR Congo and Cabinda (Angola). Its pinkish grey wood is used for house posts, joinery and utensils. The oily seed kernels are eaten raw or boiled. Several parts of the plant have applications in traditional medicine similar to *Heisteria parvifolia*.

Ecology *Heisteria parvifolia* occurs in a variety of habitats, in the understorey of evergreen moist rainforest, coastal and riverine forest and primary upland forest, but also in seasonally flooded forest, swamp forest, *Raphia* forest and occasionally in thickets in savanna and secondary forest, from sea-level up to 1450 m altitude. In Ghana it has been reported to be strongly associated with acid, base-poor soils, and in Côte d'Ivoire it is locally abundant on sandy soils.

Management *Heisteria parvifolia* is easily propagated by seed. There are about 1000 seeds per kg. Germination takes 2–4 weeks with a success rate of 50–60%.

Genetic resources and breeding *Heisteria parvifolia* is very widespread and there are no indications that it is in danger of genetic erosion.

Prospects *Heisteria parvifolia* is likely to remain a producer of timber and firewood of minor importance; also the fruit and seed kernels are likely to remain of local food use only. The seed oil may gain importance as a source of rare fatty acids. The many medicinal uses warrant further pharmacological research.

Major references Keay, 1958h; Lucas, 1968b; Malaisse, N'Gasse & Lognay, 2004; Nickrent, 1997; Villiers, 1973a.

Other references Aubréville, 1959b; de Koning, 1983; de la Mensbruge, 1966; Hall & Swaine, 1981; Hawthorne, 1995; Irvine, 1961; Louis & Léonard, 1948; Villiers, 1973b; Vivien & Faure, 1985; Vivien & Faure, 1996.

Authors L.P.A. Oyen

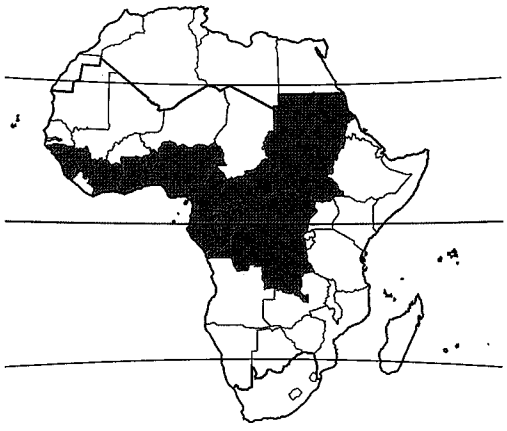
HEXALOBUS CRISPIFLORUS A.Rich.

Protologue Hist. phys. Cuba, Pl. vasc. 1: 43 (1845).

Family Annonaceae

Origin and geographic distribution *Hexalobus crispiflorus* occurs from Guinea Bissau east to southern Sudan, and south to Gabon and DR Congo.

Uses The wood, known as 'owui' in Cameroon and Gabon and as 'duabaha' in Ghana, is used for house construction, joinery, knife-handles, gun-butts, paddles and shingles. It is suitable for flooring, interior trim, ship building, vehicle bodies, furniture, cabinet work, mine props, sporting goods, toys, novelties, agricultural implements, boxes, crates, vats, turnery, hardboard, particleboard and pulpwood.
The fruit is edible; it is eaten fresh. The outer part of the pulp is firm and has a slightly tart taste, the inner part surrounding the seeds is jelly-like and sweet. The inner bark is used as a masticatory together with kola nut. Bark decoctions are used in a bath to treat fever and skin troubles. A bark macerate is taken to treat venereal diseases, and pulped bark is applied



Hexalobus crispiflorus – wild

to wounds, furuncles and swollen glands. A decoction of the twig bark is drunk as emetic and purgative. In Cameroon the bark is used to treat gonorrhoea and syphilis. In Sierra Leone the bark is stripped off from young trees and used as fibre.

Production and international trade The wood is not traded on the international market and only used domestically. The stem bark is sometimes traded on local markets. In 2002 in markets in Yaoundé (Cameroon) 1 kg of bark was sold at a price of 3000 FCFA.

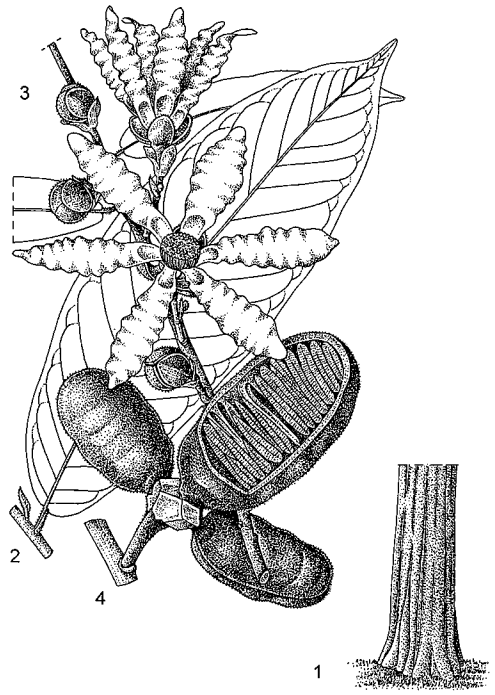
Properties The heartwood is pale yellow to pinkish or pale brown and not distinctly demarcated from the sapwood. The grain is straight, texture fine. The wood is slightly streaked on quarter-sawn and backsawn surfaces, and is lustrous.

The wood is medium-weight, with a density of 530–600 kg/m^3 at 12% moisture content. The rates of shrinkage during drying are moderate. At 12% moisture content, the modulus of rupture is 94–111 N/mm^2, compression parallel to grain 49–53 N/mm^2, cleavage 18–22.5 N/mm and Chalais-Meudon side hardness 1.8–2.4.

The wood works readily with both hand and machine tools, but is difficult to saw and peel because of the sinuous and strongly fluted logs. It planes well and takes a nice polish. The wood seems to have fair nailing properties. It is moderately durable. It shows some resistance to attacks by termites and marine borers, but is susceptible to *Lyctus* attack. The heartwood is resistant to impregnation with preservatives, the sapwood moderately resistant.

Bark, wood and leaves contain alkaloids, with the bark having the highest concentration (0.64% on a dry weight basis). An essential oil was isolated from the bark; this oil has a high sesquiterpene content (99.5%). The oil showed distinct activity against the W2 strain of *Plasmodium falciparum*. Nerolidol, which is present in the oil at a concentration of about 3%, may be partly responsible for the antiplasmodial activity. Diprenylated indoles, called hexalobines, with significant antifungal activity, have been isolated from the bark.

Description Small to medium-sized tree up to 30 m tall; bole branchless for up to 15(–27) m, often sinuous, up to 100(–140) cm in diameter, strongly fluted; bark surface longitudinally fissured and becoming scaly with small elongate scales, greyish brown, inner bark soft, fibrous and yellowish turning orange upon exposure, slightly scented; crown rounded, with ascending branches; twigs short-hairy to nearly glabrous. Leaves alternate and distichous, simple and entire; stipules absent; petiole 3–6 mm long; blade elliptical to ovate-lanceolate, 7.5–23 cm × 3–8 cm, obtuse to rounded and slightly asymmetrical at base, acuminate at apex, papery to thin-leathery, usually short-hairy below, pinnately veined with 12–18 pairs of lateral veins. Inflorescence an axillary fascicle of 1–3 flowers. Flowers bisexual, regular, 3-merous; pedicel 0.5–1.5 cm long; sepals free, ovate to elliptical-ovate, 1–2 cm long, reflexed, hairy; petals in 2 whorls, narrowly oblong, 2.5–8.5 cm long, fused at base, crispy at margins, short-hairy, pale yellow; stamens numerous, with short filaments and oblong-linear anthers 3–4 mm long; carpels 7–10, 4–5 mm long, ovaries oblong, hairy, stigmas 2-lobed. Fruit consisting of up to 4 indehiscent, oblong follicles 8–9 cm × 4–5 cm, finely wrinkled and rusty brown hairy, many-seeded. Seeds flattened-ellipsoid, 3–4 cm long. Seedling with epigeal germination; hypocotyl 10–12 cm long, epicotyl 2–3 cm long; cotyledons leafy, broadly elliptical, c. 4 cm × 2 cm; first leaves alternate.



Hexalobus crispiflorus – 1, base of bole; 2, leaf; 3, flowering branch; 4, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Hexalobus* comprises 4 species and is confined to mainland tropical Africa. It is most closely related to *Uvariastrum* and *Asteranthe*.
Hexalobus salicifolius Engl. closely resembles *Hexalobus crispiflorus*, differing in usually smaller leaves and smaller fruits. It is a medium-sized tree up to 35 m tall with bole up to 100 cm in diameter, and has been recorded from Cameroon, Equatorial Guinea and Gabon, and doubtfully from Côte d'Ivoire. It is undoubtedly used for similar purposes as *Hexalobus crispiflorus*.

Growth and development Growth of *Hexalobus crispiflorus* seems to be rather slow. A tree planted in DR Congo did not yet flower 8 years after planting. In Côte d'Ivoire trees flower in April–May and in September.

Ecology *Hexalobus crispiflorus* occurs usually scattered in dense, humid, mainly semi-deciduous forest. It is most common in undisturbed forest. It is often found along rivers, and can penetrate savanna regions through gallery forest. It prefers deep, well-drained soils with good water-retaining capacity.

Propagation and planting Artificial propagation is only done by seed. One kg contains about 600 seeds. Germination starts 1–3 months after sowing, and the germination rate is about 80%. Seedlings seem to require partial shade for good growth and survival. Planting distance should be up to 6 m × 6 m.

Management *Hexalobus crispiflorus* usually occurs in low densities in the forest. In Cameroon, an average density of 0.14 bole of more than 15 cm in diameter per ha has been recorded, with an average wood volume of 0.5 m^3/ha. In Gabon the average wood volume is 0.8 m^3/ha. In Ghana a minimum bole diameter of 70 cm has been recommended for felling.

Yield A bole harvested in DR Congo of 27 m long and 140 cm in diameter yielded 26.5 m^3 of wood.

Genetic resources *Hexalobus crispiflorus* is widespread and does not seem to be in immediate danger of genetic erosion. However, it usually occurs in low densities in the forest and prefers undisturbed forest, which may make it vulnerable with ongoing decline in primary forest area.

Prospects *Hexalobus crispiflorus* is a multipurpose tree with local importance for people living in or close to the forest. It yields not only wood, but also edible fruits and products used in traditional medicine. Its importance as a commercial timber tree is limited because of the scattered occurrence in the forest and its poor bole shape. It could be promoted for planting as a fruit tree, but research is needed on propagation methods and proper management of planted trees. The bark seems to have prospects for drug development against malaria.

Major references Bolza & Keating, 1972; Boyom et al., 2003; Burkill, 1985; Danforth & Noren, 1997; Fouarge & Gérard, 1964; le Thomas, 1969; Oteng-Amoako (Editor), 2006; Takahashi, 1978; Vivien & Faure, 1985; Vivien & Faure, 1996.

Other references Abbiw, 1990; Achenbach, Renner & Waibel, 1995; Aké Assi et al., 1985; Aubréville, 1959b; Bouquet & Debray, 1974; Boutique, 1951; de la Mensbruge, 1966; de Saint-Aubin, 1963; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Irvine, 1961; Keay, 1989; Neuwinger, 2000; Normand & Paquis, 1976; Okpoti-Paulo, 1990; Raponda-Walker & Sillans, 1961; Sallenave, 1955; Tailfer, 1989; Wilks & Issembé, 2000.

Sources of illustration Irvine, 1961; Wilks & Issembé, 2000.

Authors G.D. Djagbletey

HEYWOODIA LUCENS Sim

Protologue For. fl. Cape: 326 (1907).

Family Euphorbiaceae (APG: Phyllanthaceae)

Vernacular names Stink ebony, Cape ebony (En).

Origin and geographic distribution *Heywoodia lucens* has a disjunct distribution, occurring from Kenya and Uganda to northern Tanzania, and then again more than 2600 km to the south from the southern part of Mozam-

Heywoodia lucens – wild

bique to northern and eastern South Africa and Swaziland.

Uses The wood, known as 'Cape ebony' or 'stink ebony' in South Africa, is used for poles, agricultural implements, sledges, tool handles and wooden spoons. It is suitable for heavy construction, flooring, joinery, interior trim, furniture, railway sleepers, toys, novelties and veneer, and also for precision and musical instruments. It is used as firewood and for charcoal production.

Production and international trade The wood of *Heywoodia lucens* is only traded locally.

Properties The heartwood is dark purplish to nearly black, and distinctly demarcated from the narrow sapwood. The grain is usually straight, texture coarse and even. The wood has a foetid smell. It is heavy, with a density of South-African wood in green condition (at 51% moisture content) of 1010–1140 kg/m^3 and at 10% moisture content of 780–960 kg/m^3. It is hard and strong. The rates of shrinkage are moderate, from green to oven dry 4.7% radial and 7.0% tangential. At 12% moisture content, the modulus of rupture is 121 N/mm^2, modulus of elasticity 13,820 N/mm^2, compression parallel to grain 64 N/mm^2, shear 16 N/mm^2, Janka side hardness 9515 N and Janka end hardness 12,045 N.

Notwithstanding its high density and hardness, the wood works fairly well. Upon finishing, it takes a nice polish and is especially lustrous when quarter-sawn. It produces sliced veneer of good quality. The wood is moderately durable, being moderately resistant to termites and other insects, but the sapwood is susceptible to *Lyctus* attack. The heartwood is moderately resistant to impregnation with preservatives.

Botany Evergreen, dioecious, medium-sized tree up to 30 m tall; bole cylindrical, up to 100(–150) cm in diameter; bark silvery green to grey-brown or dark brown, irregularly peeling in thin, patchy pieces c. 5 cm long; crown much-branched; twigs 4-angled at first, soon becoming rounded, glabrous, pale greyish brown. Leaves alternate, simple and entire; stipules triangular, 1–1.5 mm long, early caducous; petiole 1–2(–4) cm long; blade broadly ovate to elliptical-ovate, 4–15(–25) cm × 2–12(–15) cm, cuneate to rounded or truncate at base, short-acuminate at apex, leathery, glabrous, pinnately veined with 5–8(–13) pairs of lateral veins. Inflorescence an axillary fascicle, many-flowered in male inflorescence, 1–3-flowered in female one, glabrous; bracts up to 4, transversely ovate, c. 1 mm × 1.5 mm, margin irregularly toothed. Flowers unisexual, regular, greenish; sepals (2–)3, free, resembling the bracts but slightly larger; petals 5(–6), free, elliptical-oblong, 2–2.5 mm long; disk slightly lobed; male flowers sessile, stamens (8–)10–11(–12), free, in 2 whorls, c. 3 mm long, rudimentary ovary minute; female flowers with 3–5 mm long pedicel, rudimentary stamens c. 1 mm long, ovary superior, ovoid to globose, c. 1.5 mm long, 4–5-celled, with 4–5 sessile, 2-lobed stigmas. Fruit a slightly depressed globose, shallowly 8–10-lobed capsule c. 1 cm × 1.5 cm, greenish, splitting in 4–5 parts, each splitting again into 2, up to 5-seeded. Seeds obliquely ovoid, 7–8 mm × 5–6 mm, smooth, pale brown to dark brown.

The leaves of juvenile trees are slightly peltate, with the stalk not attached to the margin of the leaf blade but to the lower surface. The flowering period of trees seems to be quite long, and fruit in various stages of development can be found on a tree at one time. *Heywoodia* comprises a single species.

Ecology In East Africa *Heywoodia lucens* occurs in evergreen forest, riverine forest or the slightly drier parts of swamp forest, at 1150–1800 m altitude. It is often found on termite mounds, and is commonly dominant or may even form pure stands. In southern Africa it inhabits coastal evergreen forest, often growing on river banks, up to 600 m altitude. *Heywoodia lucens* often grows gregariously in rather small groups of trees. In South Africa it is usually found on fairly dry, sandy soils.

Management Studies in eastern South Africa indicate that regeneration of *Heywoodia lucens* is poor, although it has also been reported that young trees are common in the deep shade of adult trees. *Heywoodia lucens* probably does not coppice.

Genetic resources and breeding *Heywoodia lucens* has a wide although disjunct distribution, and there are no indications that it is subject to genetic erosion. However, in Swaziland it is considered endangered. In coastal forest in South Africa, it is locally heavily exploited in communal forests, but common in state forests.

Prospects The heavy, hard and strong, but foetid smelling wood is likely to remain of local importance. Too little is known on growth rates, ecological requirements and regeneration of *Heywoodia lucens* to assess its prospects as a commercial timber tree in sustainably

managed forest.

Major references Bolza & Keating, 1972; Coates Palgrave, 2002; Milne-Redhead, 1957; Palmer & Pitman, 1972–1974; Radcliffe-Smith, 1987a.

Other references Lovett, Ruffo & Gereau, 2003; Obiri & Lawes, 2004; Obiri, Lawes & Mukolwe, 2002; Radcliffe-Smith, 1995; Radcliffe-Smith, 1996; Takahashi, 1978; van Vuuren, Banks & Stohr, 1978.

Authors L.P.A. Oyen

HOLOPTELEA GRANDIS (Hutch.) Mildbr.

Protologue Notizbl. Bot. Gart. Berlin-Dahlem 8: 53 (1921).

Family Ulmaceae

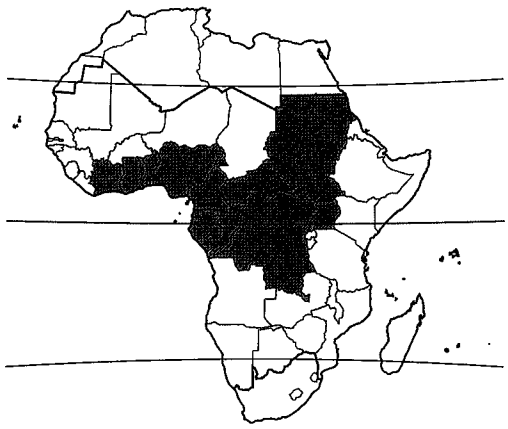
Chromosome number $2n = 28$

Vernacular names Orange-barked terminalia (En).

Origin and geographic distribution *Holoptelea grandis* occurs from Côte d'Ivoire east to Sudan and Uganda and south to DR Congo and Cabinda (Angola).

Uses The wood of *Holoptelea grandis*, sometimes traded as 'cedar', 'kekele', 'mumuli', 'ayo' and 'beli', is mainly used for construction, flooring, joinery, interior trim, furniture, ladders, toys, novelties, boxes, crates, food containers, tool handles, canoes, turnery, matches, hardboard and particleboard. It is suitable for ship building, mine props, railway sleepers, veneer, plywood and pulpwood. It is also used as firewood and for charcoal production.

Several plant parts are used in traditional medicine. In Nigeria macerations of roots and bark are applied as poultice for treating rheumatism. A bark infusion is drunk as an anthelmintic and the seeds are eaten as a laxative. In Côte d'Ivoire crushed leaves are applied as plaster to treat oedema and piles. The leaf sap is instilled into the eye to relief ophthalmia. In the Central African Republic washing the body with water mixed with pulped bark is considered to have a strengthening effect. *Holoptelea grandis* is sometimes planted as an ornamental and roadside tree.



Holoptelea grandis – wild

Production and international trade The timber is rarely traded internationally and is mainly used locally, but in several countries it figures on lists of timbers to be promoted.

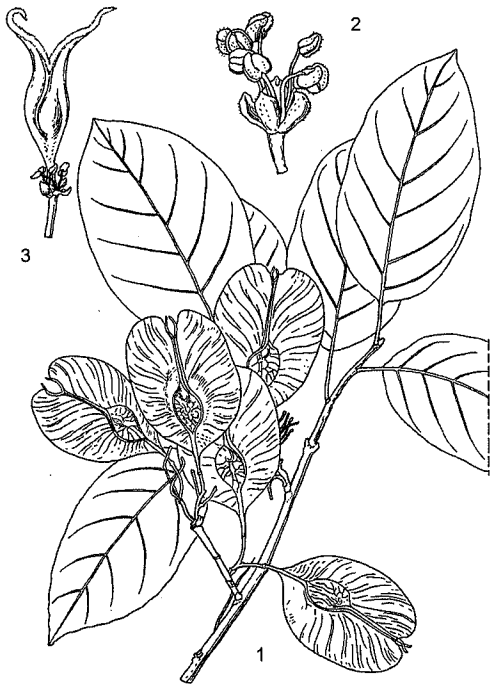
Properties The heartwood is creamy white to pale yellowish brown and indistinctly demarcated from the sapwood. The grain is straight to interlocked, texture moderately fine and even. The wood is slightly lustrous.

The wood is medium-weight, with a density of 625–700(–765) kg/m^3 at 12% moisture content, and soft to fairly hard. It dries fairly rapidly and well, but careful drying is recommended, especially the usage of thinner piling sticks in air drying to avoid case-hardening and mild drying schedules in kiln drying. The shrinkage rates are quite high, from green to oven dry 4.0–4.8% radial and 7.5–9.8% tangential. Once dry, the wood is moderately stable in service. At 12% moisture content, the modulus of rupture is 105–147 N/mm^2, modulus of elasticity 10,000–14,900 N/mm^2, compression parallel to grain 49–64 N/mm^2, cleavage 14–20 N/mm and Chalais-Meudon side hardness 2.7–3.6.

The wood saws and works well with both hand and machine tools, with moderate blunting effect on cutting edges. Occasional picking up may occur in quarter-sawn material due to the presence of interlocked grain. The wood sands and finishes very well, and has good jointing and moulding properties. Nailing properties are variable, boring and mortising properties satisfactory. The wood glues and paints well. It is suitable for peeling and slicing.

The wood has a low to moderate durability. It is susceptible to fungal attacks and moderately susceptible to termite and marine borer attacks. The heartwood is moderately resistant to treatment with preservatives, sapwood is permeable. The wood has a reputation of burning slowly and evenly and therefore has been used for torches. The bark has an iodine-like smell, which is said to repel elephants.

Description Deciduous medium-sized to large tree up to 50 m tall; bole branchless for up to 30 m, straight or slightly wavy, up to 120



Holoptelea grandis – 1, fruiting twig; 2, male flower; 3, bisexual flower.
Source: Flore analytique du Bénin

cm diameter, slightly fluted at the base or with steep buttresses up to 3(–6) m high; bark surface smooth or rough, usually cracking longitudinally, greyish to yellowish or pale orange, inner bark hard, granular, yellowish brown with green outer layer; crown irregular, with branches drooping at tips; twigs corky, with many lenticels, glabrous. Leaves alternate, simple and entire; stipules linear, 3–5 mm long, short-hairy, caducous; petiole 0.5–1 cm long, blackish; blade ovate to elliptical, 5–18 cm × 3–9.5 cm, rounded to cordate at base, short-acuminate at apex, papery or slightly leathery, with many small whitish dots, rough to the tough, glabrous or hairy on veins beneath, pinnately veined with 5–8 pairs of lateral veins. Inflorescence a cyme up to 4 cm long, usually in the axils of fallen leaves, with few–many male flowers at base and few bisexual flowers higher up. Flowers unisexual or bisexual; pedicel slender, 4–8 mm long; tepals 4–6, 1–2 mm long; stamens 7–12, free; ovary superior, flattened, styles 2, spreading, 4–6 mm long, persistent; male flowers with rudimentary ovary. Fruit a rounded to obovoid winged nut (samara), 3.5–4.5 cm × 2.5–3.5 cm, with short stipe, with papery, radially veined wings with notch at apex, nut in lower half of the wings, 9–13 mm × 6–8 mm, 1-seeded. Seed flattened, c. 6 mm × 4 mm. Seedling with epigeal germination; hypocotyl 2.5–3.5 cm long, slightly hairy, epicotyl 1–2.5 cm long; cotyledons slightly fleshy, 2-lobed, shortly stalked; first two leaves opposite, distinctly toothed.

Other botanical information *Holoptelea* comprises 2 species, one of them in tropical Africa and one in tropical Asia.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 1: growth ring boundaries distinct; 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 26: intervessel pits medium (7–10 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 42: mean tangential diameter of vessel lumina 100–200 μm; 47: 5–20 vessels per square millimetre; (56: tyloses common). Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled; (70: fibres very thick-walled). Axial parenchyma: 78: axial parenchyma scanty paratracheal; 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 82: axial parenchyma winged-aliform; 83: axial parenchyma confluent; (89: axial parenchyma in marginal or in seemingly marginal bands); (91: two cells per parenchyma strand); 92: four (3–4) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; (98: larger rays commonly 4- to 10-seriate); (104: all ray cells procumbent); 106: body ray cells procumbent with one row of upright and/or square marginal cells; 115: 4–12 rays per mm. Storied structure: 118: all rays storied; 119: low rays storied, high rays non-storied; 120: axial parenchyma and/or vessel elements storied; 122: rays and/or axial elements irregularly storied. Mineral inclusions: (157: crystals in tyloses).
(E. Ebanyenle, P.E. Gasson & E.A. Wheeler)

Growth and development *Holoptelea grandis* is a light-demanding species which grows rapidly. In Côte d'Ivoire trees usually flower in January and fruits mature in February–March when twigs are leafless. Fruiting mostly occurs on trees with a bole of at least 60 cm in diameter, but sometimes fruits can be observed in

young trees with a bole of hardly over 18 cm in diameter. The fruits are dispersed by wind.

Ecology In West and Central Africa *Holoptelea grandis* is most common in semi-deciduous forest, but it can also be found scattered in moist evergreen forest, riverine forest and sometimes even in savanna forest. It is most abundant in logged or otherwise disturbed forest, including burnt forest. In Côte d'Ivoire it has often been found together with *Triplochiton scleroxylon* K.Schum. In Uganda it occurs up to 1200 m altitude.

Propagation and planting *Holoptelea grandis* is a pioneer species and seedlings and saplings are commonly found in canopy gaps and in abandoned agricultural fields. It produces a lot of fruits and natural regeneration readily occurs. For planting, it is propagated by fruits which are easily collected near fruiting trees. There are 13,200–15,400 fruits/kg. Fruits can be stored in a cool and dry place. It is recommended to sow fruits in seed beds and to transplant into pots later. Sowing can be done with the fruit wings still present; pretreatment before sowing is not necessary. Seeds germinate abundantly after 5–10 days.

Management *Holoptelea grandis* requires tending during the initial growing stages until plants are established. In Uganda planting either in pure stands or with an intercrop of coffee or banana is recommended.

Yield In DR Congo a bole of 17 m long with a diameter of 86 cm yielded 6.3 m^3 of wood.

Handling after harvest It is recommended to treat the logs with preservatives soon after felling.

Genetic resources *Holoptelea grandis* is fairly widespread and common in many regions, and therefore unlikely to suffer from genetic erosion.

Prospects Even though its commercial importance as timber tree is actually limited, *Holoptelea grandis* is a fast-growing tree with a potential to yield timber and fuel in a short time, and is probably of some commercial importance in the near future. It can be considered suitable for commercial plantations and agroforestry systems, also because it has prospects for use as a shade tree. Further research is however warranted on growth and management practices.

Major references ATIBT, 1986; Bolza & Keating, 1972; Burkill, 2000; CIRAD Forestry Department, 2008; Fouarge & Gérard, 1964; Katende, Birnie & Tengnäs, 1995; Oteng-Amoako (Editor), 2006; Polhill, 1966; Takahashi, 1978; Vivien & Faure, 1985.

Other references Aké Assi et al., 1985; Akoègninou, van der Burg & van der Maesen (Editors), 2006; Baker & Wright, 1909–1913; de la Mensbruge, 1966; Eggeling & Dale, 1951; Hauman, 1948; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Irvine, 1961; Keay, 1958l; Keay, 1989; Laws, 1970; Letouzey, 1968; Neuwinger, 2000; Normand & Paquis, 1976; Ogunkunle & Oladele, 2004; Plumptre, 1996; Safou-Tchiamaa et al., 2007; Salzmann & Hoelzmann, 2005; Sokpon, 1995.

Sources of illustration Akoègninou, van der Burg & van der Maesen (Editors), 2006.

Authors E.A. Obeng

HOMALIUM LETESTUI Pellegr.

Protologue Bull. Mus. natl. Hist. nat. 27(2): 193 (1921).

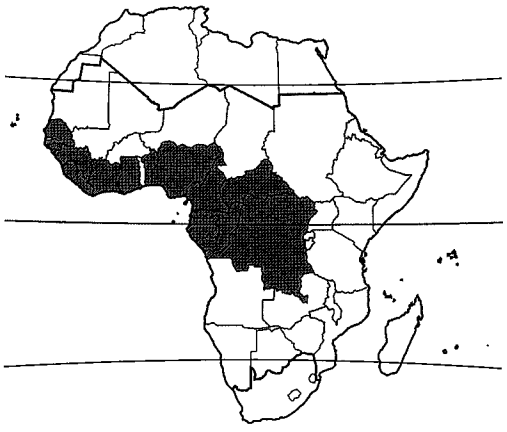
Family Flacourtiaceae (APG: Salicaceae)

Synonyms *Homalium dolichophyllum* Gilg (1921).

Vernacular names African homalium (En).

Origin and geographic distribution *Homalium letestui* occurs from Senegal east to the Central African Republic and south to western DR Congo and Cabinda (Angola).

Uses The wood, most commonly known as 'African homalium' or 'melefoufou', is commonly used for posts in house building, and for joinery and boards. It is suitable for heavy construction, heavy flooring, interior trim, mine props, ship building, vehicle bodies, railway sleepers, furniture, sporting goods, toys, novelties, agricultural implements and carvings.
Bark sap is applied as enema and bark pulp



Homalium letestui – wild

rubbed in to treat oedema. Bark decoctions are taken in mixtures to treat orchitis and as tonic for women after childbirth. Root extracts are administered to treat malaria. The tree is decorative with its showy flowers, fruits and reddish young leaves, and is sometimes planted as ornamental.

Production and international trade The wood is used locally and has no importance on the international timber market.

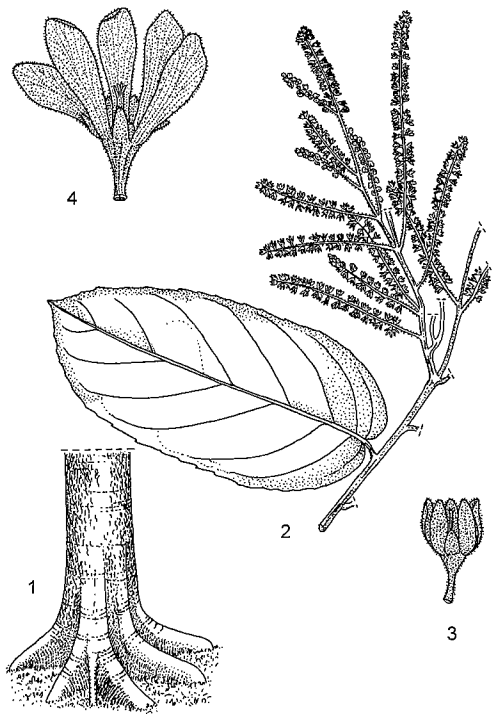
Properties The heartwood is whitish yellow to pale brown, sometimes with darker streaks, and indistinctly demarcated from the yellowish sapwood. The grain is straight or interlocked, texture fine.

The wood is heavy, with a density of about 870 kg/m^3 at 12% moisture content, and hard. It should be air dried slowly and carefully because the rates of shrinkage are high, from green to oven dry 7.0–7.5% radial and 9.6–10.5% tangential. At 12% moisture content, the modulus of rupture is 160 N/mm^2, modulus of elasticity 18,230 N/mm^2, compression parallel to grain 70 N/mm^2, shear 9 N/mm^2, cleavage 21.5 N/mm and Chalais-Meudon side hardness 5.6.

The wood is easy to saw and work, but stellite-tipped saw teeth and tungsten-carbide tipped cutting tools are recommended because the wood is hard and contains silica. It can be planed and finished smoothly. The steam bending properties are satisfactory. The wood is rather durable, being fairly resistant to wood-boring insects and marine borers. It is resistant to impregnation with preservatives.

Ethanolic root extracts showed significant in-vivo antiplasmodial activity in tests with mice, comparable to that of chloroquine. Experiments with streptozotocin-induced diabetic rats showed antidiabetic activity comparable to that of the reference drug glibenclamide.

Description Evergreen or deciduous, medium-sized tree up to 30(–35) m tall; bole branchless for up to 20 m, straight and cylindrical, up to 90 cm in diameter, thickened at base or with small buttresses; bark surface smooth, becoming scaly with small scales, yellowish grey to greyish brown or red-brown, inner bark granular, whitish with yellow-orange blotches; crown small, with short and horizontal branches; twigs glabrous. Leaves alternate, simple; stipules lanceolate, small, early caducous; petiole 3–6(–8) mm long; blade usually oblong, (10–)15–30 cm × 6–12(–18) cm, cordate at base, short-acuminate at apex, margins wavy to obtusely toothed, leathery, glabrous, pinnately veined with up to 12 pairs of lateral veins. Inflorescence a terminal panicle, consisting of several spikes up to 20 cm long, greyish hairy, many-flowered. Flowers bisexual, regular, 5(–6)-merous, greenish white or cream-coloured; pedicel up to 1 mm long; calyx top-shaped with tube c. 2.5 mm long and lobes c. 2.5 mm long; petals free, spoon-shaped, c. 3 mm long but enlarging to 10–15 mm in fruit, short-hairy; stamens opposite the petals, alternating with hairy glands; ovary semi-inferior, densely hairy, 1-celled, style 4–5-branched, hairy. Fruit a conical capsule c. 3 mm long, enclosed by the persistent and enlarging pinkish to reddish petals, hairy, dehiscing with 4–5 valves, few-seeded. Seeds small. Seedling with epigeal germination; hypocotyl c. 2 cm long, epicotyl 2–3 mm long, hairy; cotyledons leafy, rounded, c. 1 cm long; first leaves alternate, toothed.



Homalium letestui – 1, base of bole; 2, flowering twig; 3, flower; 4, fruit.
Redrawn and adapted by J.M. de Vries

Other botanical information *Homalium* comprises about 200 species and occurs in all tropical regions. It is related to the African genera *Bivinia*, *Calantica*, *Gerrardina* and *Trimeria*. In tropical Africa approximately 60 species are found, Madagascar being richest

with nearly 40 species. In tropical Asia *Homalium* has some importance as export timber, mainly from Papua New Guinea. The wood of several other *Homalium* spp. is used in mainland tropical Africa for similar purposes as that of *Homalium letestui.*

Homalium africanum (Hook.f.) Benth. is a shrub or small to medium-sized tree up to 25(–35) m tall with bole up to 40 cm in diameter. It is widespread, occurring from Guinea east to DR Congo and Tanzania, and south to Angola, Zambia and Mozambique. The yellowish white to pale brown and hard wood is locally used for construction, joinery and yam stakes.

Homalium dentatum (Harv.) Warb. is a medium-sized to fairly large tree up to 35 m tall. It occurs from Malawi and Zambia south to South Africa and Swaziland. The hard wood is yellowish white with brownish streaks and known as 'brown ironwood'; it is used for similar purposes as that of *Homalium letestui.* Bark powder is taken to treat colic.

Homalium longistylum Mast. (synonyms: *Homalium aylmeri* Hutch. & Dalziel, *Homalium macropterum* Gilg) is a medium-sized tree up to 30(–45) m tall with bole up to 50 cm in diameter. It is widespread, occurring from Guinea east to Kenya and Tanzania, and south to Angola, Zambia and Mozambique. The yellowish white and hard wood is locally used for posts in house building. The bark sap is applied to treat chest problems and migraine.

Homalium smythei Hutch. & Dalziel (synonym: *Homalium aubrevillei* Keay) is a shrub or small to medium-sized tree up to 25 m tall with bole up to 50 cm in diameter. It occurs in humid forest from Guinea to Côte d'Ivoire. The yellowish and hard wood is used for poles in house building, and for pestles and charcoal production. Bark ash mixed with palm oil is applied as anodyne.

In Madagascar the wood of several *Homalium* spp., known as 'hazombato', is particularly valued for heavy construction and railway sleepers because of its durability. It is heavy and hard, but unstable in service and somewhat brittle.

Homalium albiflorum (Boivin ex Tul.) O.Hoffm. is a shrub or small to medium-sized tree up to 20 m tall with bole up to 60 cm in diameter. It is widespread in Madagascar. Its wood is used for construction, and as firewood and for charcoal production. Bark decoctions are used to treat diabetes, venereal diseases and stomach complaints, and as diuretic.

Homalium planiflorum (Boivin ex Tul.) Baill. is a small tree up to 15(–30) m tall with bole up to 30 cm in diameter. It is widespread in northern and eastern Madagascar. Its wood is used for construction, joinery and charcoal production. The roots are used to treat gonorrhoea, wounds and impotence, and as tonic.

In Réunion and Mauritius the wood of *Homalium paniculatum* (Lam.) Benth. is considered excellent for construction and joinery. *Homalium paniculatum* is a shrub or small to medium-sized tree up to 30 m tall with bole up to 60 cm in diameter.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 24: intervessel pits minute (≤ 4 μm); 25: intervessel pits small (4–7 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 47: 5–20 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 65: septate fibres present; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 75: axial parenchyma absent or extremely rare; 78: axial parenchyma scanty paratracheal; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand; 94: over eight cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 98: larger rays commonly 4- to 10-seriate; 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells.

(L. Awoyemi, P.E. Gasson & E.A. Wheeler)

Growth and development *Homalium letestui* has been classified as a non-pioneer light demander. Seedlings have been found in full sunlight. They develop a whitish and long taproot with fine lateral roots. Initial growth is slow. The tree is often evergreen, but it can be deciduous for a short period in the dry season, developing striking flushes of red young leaves. In Sierra Leone trees flower in January–May, in Côte d'Ivoire in September–January and in Gabon in January–February. However, they are more conspicuous when they are fruiting. The fruits with their large wing-like petals are dispersed by wind. In regions with many ele-

phants, the base of the bole is often damaged because they feed on the bark.

Ecology *Homalium letestui* occurs in evergreen and semi-deciduous forest, also in gallery forest and secondary forest, up to 900 m altitude. It often occurs on rocky localities.

Propagation and planting It is difficult to collect seeds because they are very small and there are only few in each small fruit, which is surrounded by the calyx and petals and easily spread by wind. Seeds start germinating rapidly, 1–2 weeks after sowing, and the germination rate is high, 75–80%.

Management *Homalium letestui* is locally common, although it usually occurs scattered in the forest. In forests in western Cameroon, an average density of 1.6 tree with a bole diameter of more than 15 cm per ha has been recorded, with a mean wood volume of 2.2 m^3/ha. In Gabon the average wood volume has been recorded to be only 0.13 m^3/ha.

Genetic resources There are no indications that *Homalium letestui* is liable to genetic erosion. It occurs widespread and is locally common, although it usually is found scattered in the forest at rather low densities. It is not included in the IUCN Red List like *Homalium smythei*, which is classified as vulnerable.

Prospects The wood of *Homalium letestui* and other *Homalium* spp. is valued for local applications because of its strength and durability, and will remain of some importance. Virtually nothing is known about growth rates and silviculture, and much research is still needed to judge the possibilities for increased use. *Homalium letestui* is an interesting ornamental tree that deserves more attention, whereas the pharmacological properties seem interesting enough for more research towards drug development, particularly for the treatment of malaria and diabetes.

Major references Bolza & Keating, 1972; Burkill, 1994; de Saint-Aubin, 1963; Okokon, Antia & Ita, 2007; Okokon, Ita & Udokpoh, 2006; Oteng-Amoako (Editor), 2006; Savill & Fox, 1967; Sleumer, 1973; Takahashi, 1978; Vivien & Faure, 1985.

Other references Aubréville, 1959c; Boiteau & Allorge-Boiteau, 1993; Chudnoff, 1980; Coates Palgrave, 1983; de Koning, 1983; de la Mensbruge, 1966; Grace et al., 2002a; Gurib-Fakim & Brendler, 2004; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Hudson, Lee & Rasoanaivo, 2000; Hul, 1995; Neuwinger, 2000; Ngavoura, 1990; Raponda-Walker & Sillans, 1961; Sallenave, 1955; Sleumer & Bamps, 1976; Sleumer & Bosser, 1980; White & Abernethy, 1997; Wilks & Issembé, 2000.

Sources of illustration Hul, 1995; Wilks & Issembé, 2000.

Authors R.B. Jiofack Tafokou

HOPLESTIGMA KLAINEANUM Pierre

Protologue Bull. Mens. Soc. Linn. Paris, ser. 2, 1: 116 (1899).

Family Hoplestigmataceae

Origin and geographic distribution *Hoplestigma klaineanum* is found in Côte d'Ivoire, southern Cameroon, Equatorial Guinea and Gabon.

Uses The wood of *Hoplestigma klaineanum* is used locally for carpentry and joinery.

Properties The heartwood of *Hoplestigma klaineanum* is pale yellowish brown and indistinctly demarcated from the sapwood. It shows a silver-grain figure on quarter-sawn surfaces. The wood is medium-weight with a density of 600–650 kg/m^3 at 12% moisture content. It works easily and finishes nicely.

Botany Small to medium-sized tree up to 25 m tall; bole straight, up to 40 cm in diameter, with buttresses; bark surface dark grey, cracked, inner bark fibrous, white to orange darkening quickly to dark brown; young twigs hairy, later glabrous. Leaves alternate, clustered at the end of branches, simple and entire; stipules absent; petiole 1–1.5 cm long; blade broadly obovate-elliptical, 15–30 cm × 5–15 cm, base cuneate, apex rounded, glabrous above, stiffly short-hairy below, pinnately veined with 8–12 pairs of lateral veins. Inflorescence a terminal cyme, many-flowered. Flowers bisexual, regu-

Hoplestigma klaineanum – wild

lar, sessile, white; calyx 2-lobed; corolla tube c. 1 cm long, lobes 9, ovate, c. 1 cm long, glabrous; stamens numerous, inserted above base of corolla tube, exserted, anthers 4-celled; ovary superior, 2-celled, style with 2 long branches. Fruit a broadly ellipsoid 2-seeded drupe up to 3 cm long, yellow when ripe, with persistent calyx at base.
In Côte d'Ivoire seeds ripen in January–February.
Hoplestigma comprises only 2 species. *Hoplestigma pierreanum* Gilg occurs in the evergreen forest of coastal Cameroon and is threatened by forest clearance for timber and agriculture. It is critically endangered or possibly even extinct.

Ecology *Hoplestigma klaineanum* occurs at low altitudes in evergreen forest and on river banks.

Management There are about 250 seeds per kg. The germination rate is 20–30% after 30–45 days.

Genetic resources and breeding The conservation status of *Hoplestigma klaineanum* is unclear, but it seems to be uncommon, and as the only other *Hoplestigma* species is critically endangered, protection measures are justified.

Prospects Because of the small diameter of the bole and its restricted range *Hoplestigma klaineanum* is not likely to gain importance.

Major references Burkill, 1994; Hawthorne & Jongkind, 2006; Raponda-Walker & Sillans, 1961.

Other references Aubréville, 1959c; Cable & Cheek, 1998; Cheek & Cable, 2000a; de la Mensbruge, 1966; Hepper, 1963; Normand, 1960; Normand & Paquis, 1976; Wang & Harley, 2004.

Authors C.H. Bosch

HUMBERTIA MADAGASCARIENSIS Lam.

Protologue Encycl. 2: 356, t. 103 (1786).
Family Convolvulaceae
Vernacular names Bois de fer (Fr).

Origin and geographic distribution *Humbertia madagascariensis* is endemic to Madagascar, where it is restricted to the south-eastern part of the island, from Manakara south to Taolañaro.

Uses The wood from this tree, most commonly known as 'endranendrana' but also as 'fantsinakoho', is used for purposes where extreme durability and strength are required, mainly for heavy construction, outdoor and

Humbertia madagascariensis – wild

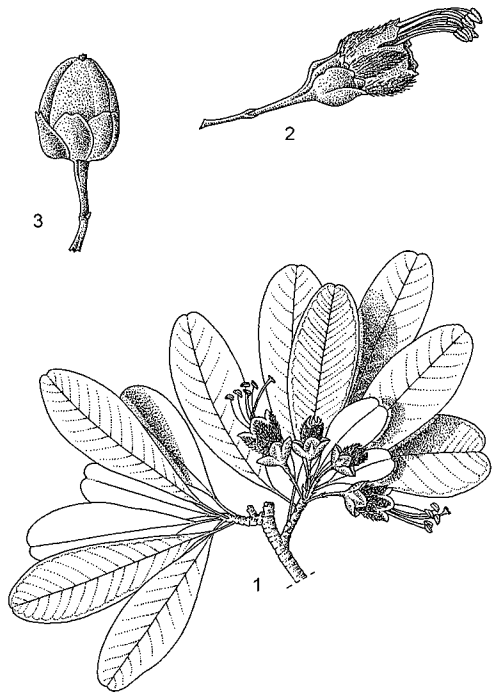
indoor joinery, poles, naval construction, wharves and bridges. Its nice polish makes it suitable for sculptures and turning. It is also suitable for heavy-duty and luxury parquet flooring, mine props, vehicle bodies, railway sleepers, sporting goods, toys, novelties and agricultural implements. However, it is little used because it is extremely difficult to saw and work.

Properties The heartwood is pinkish creamy-white to pinkish pale brown, and distinctly demarcated from the greyish yellow sapwood. The grain is usually wavy, texture very fine. Fresh wood has a strong turpentine smell, but the odour has also been described as close to that of sandalwood.
The wood is extremely heavy, with a density of 1260–1300 kg/m^3 at 12% moisture content, and extremely hard. The shrinkage rates during drying are moderate for such a heavy wood, from green to oven dry 4.4–6.6% radial and 6.8–7.9% tangential. Once dry, the wood is unstable in service. At 12% moisture content, the modulus of rupture is 168–276 N/mm^2, modulus of elasticity 14,100–23,540 N/mm^2, compression parallel to grain 91–108 N/mm^2, shear 6–9.5 N/mm^2, cleavage 18.5–19.5 N/mm and Chalais-Meudon side hardness 29–30.5.
The wood is very difficult to saw, work and plane; high power is needed and the wood causes severe blunting of saw teeth and cutting edges. It takes an excellent polish. Nailing is impossible because of its hardness. The wood glues and paints well. It is extremely durable, being resistant to fungal, insect and marine borer attacks. The heartwood is not treatable with preservatives.

Some sesquiterpenes have been isolated from the heartwood, including humbertiol.

Adulterations and substitutes The wood of *Phylloxylon* spp. and *Dialium unifoliolatum* Capuron is used for similar purposes, although that of the latter species is less hard.

Description Medium-sized tree up to 30 m tall; bole usually straight and cylindrical, up to 200 cm in diameter, often with small buttresses; bark surface grey to brown, finely cracked, inner bark with white bands; twigs with distinct leaf scars, reddish hairy when young. Leaves alternate, clustered at ends of twigs, simple and entire; stipules absent; petiole 0.5–1.5 cm long; blade obovate, 3–10.5 cm × 1.5–4 cm, cuneate at base, obtuse to slightly notched at apex, leathery, glabrous, pinnately veined with 6–9 pairs of lateral veins. Flowers axillary in leaf axils at ends of twigs, solitary or few together, bisexual, slightly zygomorphic, 5-merous; pedicel 1–1.5 cm long; sepals nearly free, obovate to rounded, c. 1 cm long, with membranous margins; corolla campanulate, c. 1.5 cm long, hairy outside, creamy white with membranous margins; stamens inserted on the corolla tube, c. 4.5 cm long; ovary superior, c. 4 mm long, hairy near apex, 2-celled, style slender, c. 4 cm long. Fruit an ellipsoid-ovoid berry c. 1.5 cm long, fruit wall slightly fleshy, smooth, brownish, indehiscent, 1–2(–4)-seeded. Seeds ovoid, c. 7 mm long, grooved on one side, beige, glabrous.



Humbertia madagascariensis – *1, flowering branch; 2, flower; 3, fruit.*
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Humbertia* comprises a single species. It is considered a primitive genus of *Convolvulaceae* and has been placed in the tribe *Erycibeae* together with genera from America and Asia, but also in a separate family *Humbertiaceae* and in a subfamily *Humbertioideae* within *Convolvulaceae*. The latter view is most supported at present.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 9: vessels exclusively solitary (90% or more); 13: simple perforation plates; 22: intervessel pits alternate; 26: intervessel pits medium (7–10 μm); 27: intervessel pits large (≥ 10 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 42: mean tangential diameter of vessel lumina 100–200 μm; 43: mean tangential diameter of vessel lumina ≥ 200 μm; 47: 5–20 vessels per square millimetre; 57: tyloses sclerotic. Tracheids and fibres: 62: fibres with distinctly bordered pits; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 78: axial parenchyma scanty paratracheal; 92: four (3–4) cells per parenchyma strand. Rays: 96: rays exclusively uniseriate; (97: ray width 1–3 cells); 104: all ray cells procumbent; (106: body ray cells procumbent with one row of upright and/or square marginal cells); 113: disjunctive ray parenchyma cell walls present; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm.
(E. Ebanyenle, P.E. Gasson & E.A. Wheeler)

Ecology *Humbertia madagascariensis* occurs in humid evergreen forest up to 600(–1000) m altitude.

Harvesting Cutting *Humbertia madagascariensis* trees with their extremely hard wood is nearly impossible with hand tools and difficult with machine tools; special equipment is needed. Therefore they often were killed by fire and left standing after deforestation. Dead trees can stay upright for many years and fallen boles and branches remain undamaged for long

periods.

Genetic resources Already by the end of the 19th century *Humbertia madagascariensis* has been reported to have become rare, and at the end of the 1940s it was considered nearly extinct, mainly because of land clearance and burning. Although populations still exist in south-eastern Madagascar, *Humbertia madagascariensis* is certainly threatened and protection is needed.

Prospects The wood with its extreme durability is in demand for special purposes, especially for construction in contact with water. However, current focus should be at protection, and research on many aspects of this poorly studied species is recommended, particularly on propagation and growth rates.

Major references Bolza & Keating, 1972; Capuron, 1957; Deroin, 2001; Guéneau, 1971a; Guéneau & Guéneau, 1969; Guéneau, Bedel & Thiel, 1970–1975; Parant, Chichignoud & Rakotovao, 1985; Sallenave, 1964; Schatz, 2001; Takahashi, 1978.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Deroin, 1993; Rakotovao et al., en préparation; Sallenave, 1971.

Sources of illustration Deroin, 2001; Schatz, 2001.

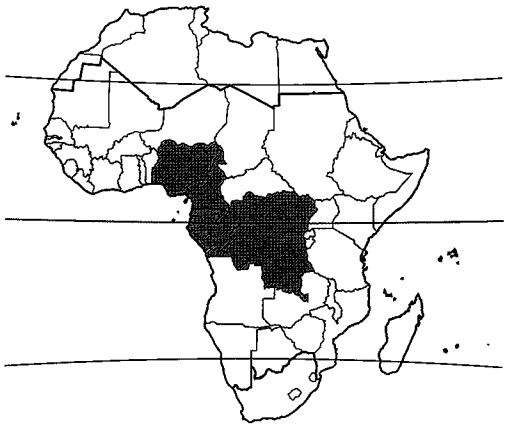
Authors S. Rakotonandrasana

HYLODENDRON GABUNENSE Taub.

Protologue Engl. & Prantl, Nat. Pflanzenfam. III, 3: 386 (1894).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Origin and geographic distribution *Hylodendron gabunense* occurs from southern Nigeria to south-western DR Congo.



Hylodendron gabunense – wild

Uses The wood, known as 'mvanda' in Cameroon and 'mvana' in Gabon, is used for joinery and tool handles. It is suitable for heavy construction, heavy flooring, interior trim, ship building, vehicle bodies, mine props, furniture, sporting goods, toys, novelties, agricultural implements, railway sleepers, carvings and turnery.

In traditional medicine the bark is used as antidote against poisoning and as a mouthwash to treat toothache. Bark decoctions are administered to treat sterility in women and to induce labour, as aphrodisiac, and also against infections of the respiratory tract and venereal diseases.

Properties The heartwood is yellowish white to pale brown, sometimes with a pink tinge, and is not distinctly demarcated from the sapwood. The grain is straight, texture moderately fine.

The wood is heavy, with a density of about 900 kg/m^3 at 12% moisture content. The rates of shrinkage upon air drying are high, from green to oven dry 5.9% radial and 10.3% tangential. At 12% moisture content, the modulus of rupture is 244 N/mm^2, modulus of elasticity 17,440 N/mm^2, compression parallel to grain 91 N/mm^2, shear 10.5 N/mm^2, cleavage 17 N/mm and Chalais-Meudon side hardness 8.4.

With appropriate equipment, the wood saws fairly well despite its hardness. It has been recommended to quarter-sawn the timber before further processing. Machining and planing show good results with a nice finish. The wood has good nailing properties, but pre-boring is needed. It is moderately durable, being moderately resistant to termite and pinhole borer attacks, but susceptible to *Lyctus* and marine borers. It is resistant to impregnation with preservatives.

The presence of tannins has been recorded for bark and roots. From an aqueous leaf extract 1,3,4,5-tetragalloylapiitol has been isolated. This compound was found to be a potent inhibitor of HIV RNase H enzymatic activity in vitro.

Botany Medium-sized to fairly large tree up to 40(–55) m tall; bole branchless for up to 25 m, straight and cylindrical, up to 100(–150) cm in diameter, with many, thin and often branched buttresses, in young trees bole with spines; bark surface smooth, pale grey to greenish yellow, on buttresses often with horizontal grooves, inner bark thin, fibrous, pinkish to brown, with little reddish exudate; twigs short-hairy.

Leaves alternate, imparipinnately compound with 8–15 leaflets; stipules large and sheath-like, 2–6 cm × c. 0.5 cm, caducous, leaving conspicuous circular scars; petiole and rachis together 5–18 cm long; petiolules 3–4 mm long; leaflets alternate, oblong-lanceolate to oblong-elliptical, 4–15 cm × 1.5–5.5 cm, acuminate at apex, glabrous, with some translucent dots, pinnately veined with up to 20 pairs of lateral veins connected into a marginal vein. Inflorescence an axillary or terminal panicle 4–8 cm long, short-hairy; bracts broadly ovate, up to 1 cm in diameter. Flowers bisexual, slightly zygomorphic; pedicel 3–5 mm long; sepals 4, free, slightly unequal, ovate to lanceolate, 4–5 mm long, whitish to pinkish; petals absent; stamens 10, free, 5–8 mm long; ovary superior, sessile, c. 3 mm long, glabrous, 1-celled, style c. 3 mm long. Fruit an oblong to narrowly obovate papery pod 6–12 cm × 1.5–3.5 cm, reticulately veined, indehiscent, 1(–4)-seeded in apical part of fruit. Seed smooth, brown, with hard seed coat. Seedling with epigeal germination; hypocotyl 3.5–5 cm long, epicotyl 4–5.5 cm long; first leaves alternate, with 1–2 pairs of leaflets.

The mean annual growth in bole diameter of *Hylodendron gabunense* trees in natural forest has been estimated at 3–4 mm. Young foliage is pinkish. In Gabon fruits are produced in December to February. They are dispersed by wind over distances of sometimes over 200 m. The fruits are eaten by rodents and, especially in times of fruit scarcity, by gorillas. Seedlings are often quite abundant in the forest.

Hylodendron comprises a single species. It is classified in the tribe *Detarieae*, in which its position is still unresolved.

Ecology *Hylodendron gabunense* occurs in lowland rainforest, where it is usually found scattered, but it may occur in small groups in secondary forest and formerly cultivated land.

Management In Cameroon the average number of trees with a bole diameter above 15 cm has been estimated at 0.6 per ha, with an average wood volume of 1.1 m^3/ha. The average wood volume in Gabon has been estimated at 0.3 m^3/ha. The wood volume of a bole 23 m long and 76 cm in diameter was 6.7 m^3.

Genetic resources and breeding *Hylodendron gabunense* is not threatened by genetic erosion because it is fairly widespread and is commonly found in secondary forest.

Prospects With its rather low growth rates resulting in hard and heavy wood, the prospects of *Hylodendron gabunense* as a timber tree of commercial importance are probably limited. It may remain of local importance, especially for heavy construction.

Major references Bolza & Keating, 1972; Fouarge & Gérard, 1964; Takada et al., 2007; Takahashi, 1978; Vivien & Faure, 1985.

Other references Aubréville, 1968; Aubréville, 1970; Burkill, 1995; de Saint-Aubin, 1963; Gassita et al. (Editors), 1982; Neuwinger, 2000; Raponda-Walker & Sillans, 1961; White & Abernethy, 1997; Wilczek et al., 1952; Wilks & Issembé, 2000.

Authors R.H.M.J. Lemmens

HYMENOCARDIA ULMOIDES Oliv.

Protologue Hook.f., Icon. pl. 12: t. 1131 (1873).

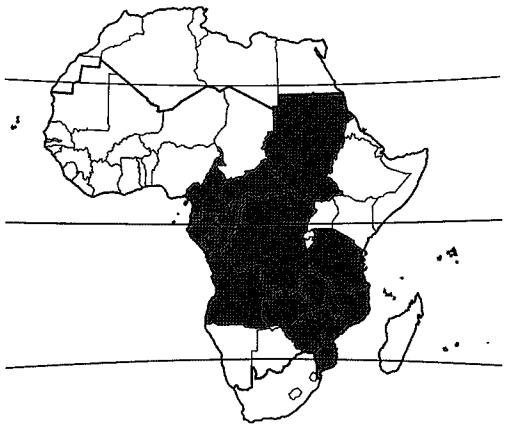
Family Euphorbiaceae (APG: Phyllanthaceae)

Synonyms *Hymenocardia capensis* (Pax) Hutch. (1920).

Vernacular names Small red-heart tree, lesser red heart (En). Mteti (Sw).

Origin and geographic distribution *Hymenocardia ulmoides* occurs from Cameroon eastward to southern Sudan and Tanzania, and south to Angola, Zimbabwe, Mozambique and northern South Africa.

Uses The wood is used in construction, e.g. for beams and wall and roofing laths, for fence posts, fish traps, as firewood, and for making charcoal. The bark is used for tanning hides and to dye cloth yellow or brownish. Bark decoctions are taken as astringent and against headache and cough, and decoctions of young leaves are used as astringent and to treat stomach-ache, cramps, intercostal neuralgia,



Hymenocardia ulmoides – wild

epilepsy, tuberculosis, diarrhoea and cough. A decoction of the root bark is taken against anaemia. The bark is also used to treat gonorrhoea. The leaves, roots and bark enter in treatments of bronchitis, asthma, genito-urinary infections, haemorrhoids, fever, epilepsy, oral and throat problems, worms, stiffness of the limbs, rheumatism, threatened abortion and abscesses. The young twigs and leaves taste refreshingly sour and are eaten as a vegetable. The plants also serve as feed for goats and sheep. Formerly, salt was made from the ashes. Because of its attractive foliage and fruits the tree has ornamental value. Edible caterpillars are collected from the tree.

Properties The wood is pinkish brown, darkening to orange-brown upon drying, with a straight grain and fine texture, hard and strong but elastic. It is durable, being resistant against insect attack. The bark contains 14–16% tannin.

Botany Dioecious shrub or small to medium-sized tree up to 20(–30) m tall, with bole up to 60(–75) cm in diameter; bark surface smooth or longitudinally fissured, grey or greyish brown; crown spreading; twigs short-hairy, becoming glabrous. Leaves alternate, simple and entire, yellow-orange or reddish when young; stipules linear to lanceolate, 3–6 mm long, caducous; petiole (0.2–)0.5–1 cm long, short-hairy; blade ovate to elliptical, 1–5.5 cm × 0.5–4 cm, cuneate to rounded at base, obtuse to acuminate at apex, thick-papery or thin-leathery, glabrous except for tufts of hairs in the vein axils beneath, with sparse gland dots beneath, pinnately veined with 4–8 pairs of inconspicuous lateral veins. Inflorescence axillary, usually on a short lateral shoot, 1–3 cm long, hairy, bracts up to 3 mm long; male inflorescence a lax spike often arranged in a panicle, many-flowered; female inflorescence a short raceme, up to 5-flowered. Flowers unisexual, regular, calyx with (4–)5(–8) lobes, petals and disk absent; male flowers sessile, with cup-shaped, greenish white calyx c. 1.5 mm long, stamens opposite the calyx lobes, c. 2 mm long, rudimentary ovary c. 1 mm long; female flowers with c. 1.5 mm long pedicel extending to up to 1 cm in fruit, calyx lobes nearly free, linear, 2–3 mm long, ovary superior, obovoid to oblong-ellipsoid, c. 1 mm long, glabrous, with a few glands, 2-celled, styles 2, up to 5(–15) mm long, reddish. Fruit a nearly orbicular, flat, 2-celled capsule, almost completely surrounded by a wing, 1.5–2.5 cm × 1–2.5 cm, with 1–4 mm long stipe at base, notched at the apex, glabrous, whitish to brown, yellow or reddish, indehiscent or splitting into 2 parts, each 1-seeded. Seeds semicircular-oblong, 7–9 mm × 2–4 mm, smooth, purplish brown to blackish. Seedling with epigeal germination; hypocotyl 2–3.5 cm long; cotyledons leafy, elliptical, 1–1.5 cm long; first leaves alternate.

In the Central African Republic flowering occurs in October–November, in central Congo in January–February. In southern Africa flowering is mainly in November–December, and fruit ripening peaks in March–April. Seed is dispersed by wind.

Hymenocardia comprises about 6 species, 5 of which occur in continental Africa and 1 in South-East Asia. It has been placed in a family of its own, *Hymenocardiaceae*.

Hymenocardia lyrata Tul. is a shrub or small tree up to 15 m tall, occurring from Senegal to Ghana, mainly in gallery forest and savanna. Its hard and pinkish brown wood is probably used for similar purposes as that of *Hymenocardia ulmoides*, and also as firewood. In Sierra Leone root decoctions are taken to relieve stomach-ache and to hasten child delivery.

Ecology *Hymenocardia ulmoides* occurs in riverine and coastal thickets, high-rainfall woodland, gully forest on rocky outcrops, wooded grassland and disturbed localities, up to 1500 m altitude. In DR Congo it is locally common in closed forest and disturbed forest. It is often found on sandy soils.

Management *Hymenocardia ulmoides* can be coppiced, but often regrows to a bushy form.

Genetic resources and breeding *Hymenocardia ulmoides* is widespread and locally common. There are no indications that it is in danger of genetic erosion.

Prospects *Hymenocardia ulmoides* does not seem to have prospects as a timber tree of commercial importance because the size of the bole is usually small. It will probably remain of some importance for construction purposes because its wood is durable. Research is warranted on phytochemistry and pharmacological activities because several plant parts are commonly used in local medicine.

Major references Adjanohoun et al. (Editors), 1988; Coates Palgrave, 2002; Gaugris et al., 2007; Latham, 2004; Radcliffe-Smith, 1996.

Other references Aubréville, 1950; Burkill, 1994; Carter & Radcliffe-Smith, 1988; Favier, de Namur & Dubois, 2004; Latham, 2003; Lebbie & Guries, 1995; Léonard & Mosango, 1985; Lovett, Ruffo & Gereau, 2003; Neuwinger, 2000; Raponda-Walker & Sillans, 1961.