subtribe *Dialiinae*, and it has been suggested that it is related to the genera *Eligmocarpus* and *Mendoravia* from Madagascar and *Poeppigia* from tropical America.

The wood of *Baudouinia louvelii* R.Vig., an evergreen small tree up to 15 m tall with a limited distribution in the central part of eastern Madagascar, is used for carpentry, flooring and outdoor joinery. The wood is heavy, with a density of about 950 kg/m^3 at 12% moisture content, and very hard. It has high shrinkage rates during drying, but is stable in service. It is very resistant to fungi and moderately resistant to termites and dry-wood borers.

The wood of *Baudouinia rouxevillei* H.Perrier, a small tree up to 15 m tall restricted to a small area in south-western Madagascar, is much sought after. The bole and branches of this species are deeply folded and channelled, with dark brown wood except for the outermost edges of the folds where it is whitish. This gives a very decorative effect and the wood is in high demand for making ornaments, lamp stands and walking-sticks. It is also used for charcoal production. *Baudouinia rouxevillei* has become endangered due to over-exploitation, possibly being even close to extinction.

Ecology *Baudouinia fluggeiformis* occurs in deciduous forest and woodland, also in dry woodland and scrubland, up to 500(–700) m altitude. It is said to prefer sandy and alluvial soils, but in the dry forest near Morondava it is mainly found on slopes and is more rare on clayey soils in valleys.

Genetic resources and breeding *Baudouinia fluggeiformis* is widespread in Madagascar in a wide variety of habitats and not endangered by genetic erosion. However, it is locally threatened by selective exploitation, e.g. in Bongolava forest, where it suffers also from uncontrolled burning. Other species of *Baudouinia* all have very limited areas of distribution where they are more or less confined to a specific habitat, and could easily become endangered.

Prospects *Baudouinia fluggeiformis* will remain of local importance for its very hard and probably durable wood that is in demand for posts and poles. It deserves more attention in research because little is known on nearly all aspects. Research on other *Baudouinia* spp. should focus more on protection than on exploitation.

Major references du Puy et al., 2002; Rakotovao et al., en préparation; Razafimahaleo, 1992.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Lewis et al., 2005; Neuwinger, 2000.

Authors R.H.M.J. Lemmens

BAUHINIA PODOPETALA Baker

Protologue Journ. Linn. Soc., Bot. 25: 313 (1890).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Origin and geographic distribution *Bauhinia podopetala* is endemic to northern and western Madagascar, from Antsiranana in the north, south to Morondava.

Uses The wood is used for house construction, especially for poles, and for fences. It is suitable for joinery, interior trim, boxes and crates. It is also used as firewood.

Properties The wood of *Bauhinia* spp. from Madagascar is medium-weight, with a density of about 680 kg/m^3 at 12% moisture content, and moderately hard. It is easy to dry with moderate shrinkage rates. It is fairly stable in service. It is easy to work and not durable, but moderately easy to treat with preservatives.

Botany Deciduous shrub or small tree up to 15 m tall; bole up to 20 cm in diameter; bark surface smooth and reddish brown, slightly peeling; twigs glabrous, with lenticels. Leaves alternate, simple; stipules triangular, c. 2 mm long; petiole slender, (1.5–)2–4(–4.5) cm long; blade 2-lobed to about the middle, 5.5–9.5(–12) cm × 5–9(–12) cm, truncate to rounded at base, lobes acute to acuminate at apex, nearly glabrous, 7(–9)-veined from the base. Inflorescence a terminal raceme 2–7 cm long, often

Bauhinia podopetala – wild

branched and panicle-like, many-flowered, the flowers opening sequentially. Flowers bisexual, zygomorphic, 5-merous; pedicel 0.5–1.5 cm long; calyx spathe-like, 3.5–4.5 cm long, with beak or teeth at apex, glabrous; petals free, 5–8 cm long, with long greenish claw and ovate to elliptical, pale salmon-pink blade, upper petal slightly longer and narrower than other ones and with a large pale yellow blotch at base; stamens 5, 4–7 cm long, staminodes 5, 1–2 cm long; ovary superior, elongated, c. 1.5 cm long, glabrous, style c. 2.5 cm long, with head-shaped stigma. Fruit a linear-oblong, flattened pod 20–25 cm long, with stipe c. 2 cm long at base and beaked at apex, glabrous, dehiscent with 2 valves, 10–20-seeded. Seeds disk-shaped to oblong, 10–11 mm long, blackish brown.

Bauhinia is a widespread tropical genus with 150–250 species, depending on the demarcation of the genus. It is well known for its ornamental shrubs and trees, planted in parks and gardens, and as roadside tree. In Madagascar about 15 species are found, all but one endemic. The wood of some of these is used for similar purposes as that of *Bauhinia podopetala*.

Bauhinia grandidieri Baill. is a shrub up to 3 m tall, occurring in dry woodland and scrubland in southern Madagascar. The stems are used as poles in house construction, and as firewood. Plants of *Bauhinia grandidieri* with their lilac-blue to whitish flowers are occasionally traded as ornamental, also as bonsai tree.

Bauhinia hildebrandtii Vatke is a shrub or small tree up to 10 m tall, with bole up to 30 cm in diameter, found in more humid deciduous woodland in northern and north-western Madagascar, and also in Comoros. The bole and branches are used as posts and poles in house construction, and for fences and cattle enclosures.

Bauhinia madagascariensis Desv. is a shrub or small tree up to 6(–10) m tall from south-western and southern Madagascar, occurring in more humid to dry deciduous woodland and scrubland. Its stems are used as posts in house construction, whereas the bark is used as rope. Seeds are occasionally offered for sale, to grow the plants with their reddish flowers.

Bauhinia morondavensis Du Puy & R.Rabev. is a shrub or small tree up to 7 m tall, also occurring in deciduous woodland and scrubland in south-western and southern Madagascar. Its stems are used as poles in house construction and as firewood; the bark is used as rope.

Ecology *Bauhinia podopetala* occurs in deciduous woodland, often along rivers or in valleys, up to 300 m altitude. It is found on sandy and alluvial soils.

Genetic resources and breeding *Bauhinia podopetala* is quite widespread in Madagascar and does not seem to be liable to genetic erosion at present.

Prospects *Bauhinia podopetala* and other *Bauhinia* spp. from Madagascar do not have prospects as commercial timber trees because their boles are too small and too poorly shaped. They will remain of limited importance for local house building and for firewood production as long as they occur in sufficient quantities. With their often large and conspicuous flowers, they may be interesting ornamental shrubs and trees like several other *Bauhinia* spp., but research is needed on propagation and planting.

Major references du Puy et al., 2002; Rakotovao et al., en préparation; Schatz, 2001.

Other references Lewis et al., 2005.

Authors R.H.M.J. Lemmens

BEGUEA APETALA Capuron

Protologue Mém. Mus. natl. Hist. nat., sér. B, Bot. 19: 105 (1969).

Family Sapindaceae

Origin and geographic distribution *Beguea apetala* is endemic to Madagascar, where it is found in the northern and eastern parts of the island.

Uses The wood of *Beguea apetala* is primarily used for boat building, as is the case for several other *Sapindaceae* species.

Botany Dioecious medium-sized tree up to 25 m tall; bole up to 50 cm in diameter; young

Beguea apetala – wild

twigs yellowish brown to reddish brown hairy, soon becoming glabrous. Leaves alternate, paripinnately compound with 3–7 pairs of leaflets; stipules absent; petiole 2.5–7 cm long, rachis 3–17 cm long; petiolules 2–5 mm long; leaflets opposite to alternate, elliptical to lanceolate, 3–16 cm × 1.5–4.5 cm, cuneate at base, usually acuminate at apex, margins entire, glabrous, pinnately veined with many lateral veins. Inflorescence a slender, axillary raceme up to 25 cm long, densely short-hairy. Flowers unisexual, regular; pedicel 2–5 mm long; calyx 1.5–3 mm in diameter, with 5–8 short lobes, short-hairy outside; petals absent; stamens 6–8, up to 8.5 mm long, filaments pink, anthers purple; disk thick, cushion-shaped; ovary superior, c. 2 mm long, 3-celled, style c. 2.5 mm long; male flowers with rudimentary ovary, female flowers with reduced stamens. Fruit a globose to obovoid berry up to 2 cm long, indehiscent, 1-seeded. Seed globose to obovoid, c. 12 mm long, brown, enclosed by fleshy, translucent aril.
Beguea comprises about 7 species and is endemic to Madagascar.

Ecology *Beguea apetala* occurs in subhumid and humid evergreen forest from sea-level up to 1000 m altitude.

Genetic resources and breeding *Beguea apetala* is fairly widespread and there are no indications that it is threatened, but monitoring its populations will be meaningful in view of the reduction of natural forest areas in eastern Madagascar.

Prospects As is the case for other *Sapindaceae* species with similar use and wood quality, proper management of populations of *Beguea apetala* is needed to ensure sustainable use, but data are lacking to do adequate recommendations.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Capuron, 1969; Schatz, 2001.

Other references Buerki et al., 2009; Buerki et al., 2010; TransMad, 2004.

Authors C.H. Bosch

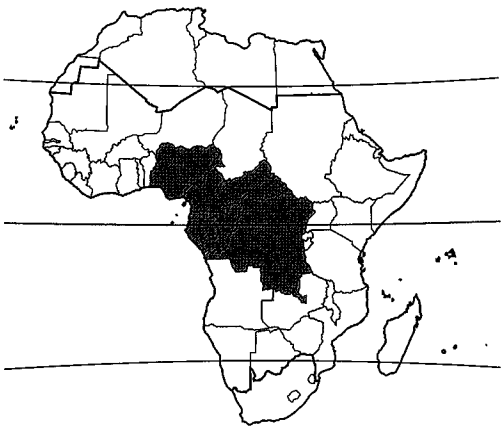
BERLINIA BRACTEOSA Benth.

Protologue Trans. Linn. Soc. London 25: 309 (1866).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Macroberlinia bracteosa* (Benth.) Hauman (1952).

Origin and geographic distribution *Berlinia bracteosa* occurs from south-eastern Nigeria east to the Central African Republic and western DR Congo, and south to Cabinda (Angola).



Berlinia bracteosa – wild

Uses The wood, often traded together with other *Berlinia* spp. as 'ebiara', is commonly used for construction, flooring, joinery, interior trim, panelling, furniture, vehicle bodies, agricultural implements, railway sleepers, draining boards and turnery. It is suitable for boat building, veneer, plywood and pulpwood. It is also used as firewood.
In traditional medicine, bark decoctions are used as purgative and to treat oedema, jaundice, toothache and caries. In Central Africa they are administered as an enema to treat diarrhoea and vomiting in children. *Berlinia bracteosa* is occasionally planted as ornamental village shade tree.

Production and international trade The wood of *Berlinia bracteosa* and other *Berlinia* spp. is currently traded in small amounts only on the international market. In Gabon the export of 'ebiara' (*Berlinia* spp.) logs increased from 200 m³ in 1991 to 6400 m³ in 1999 and to 12,200 m³ in 2005. The export from Cameroon was 500 m³ in 1998, but only 15 m³ in 1999.

Properties The heartwood is pinkish brown to reddish brown, often with darker streaks, and distinctly demarcated from the up to 10 cm wide, greyish white or pinkish sapwood. The grain is straight to slightly interlocked, texture medium to coarse. The wood has a distinct odour when freshly cut, and gum ducts are often present.
The wood is medium-weight, with a density of 610–720 kg/m³ at 12% moisture content. It air

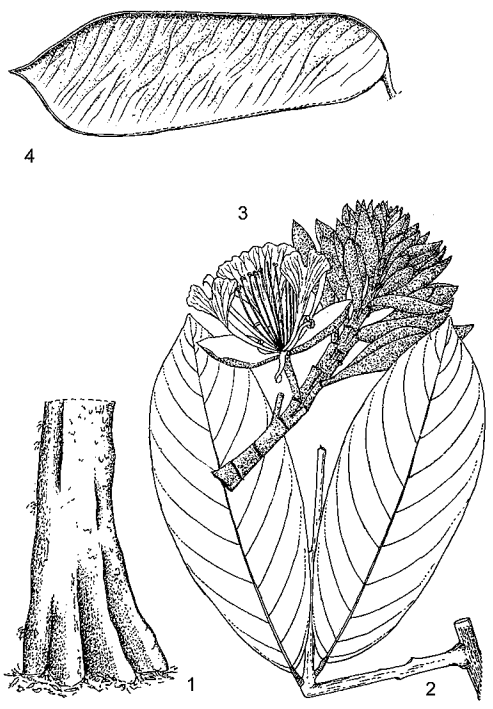
dries slowly with a slight risk of distortion. The rates of shrinkage are moderate, from green to oven dry about 2.8% radial and 7.4% tangential. Quarter-sawing of logs before drying is recommended. Once dry, the wood is stable in service.

At 12% moisture content, the modulus of rupture is 95–159 N/mm², modulus of elasticity 8820 N/mm², compression parallel to grain 48–73 N/mm², shear 8–12 N/mm², cleavage 11–16 N/mm, Janka side hardness 6310 N, Janka end hardness 7645 N and Chalais-Meudon side hardness 2.5–4.6.

The wood generally works and saws fairly easily with ordinary hand and machine tools. The blunting effect on saw teeth and cutting edges is moderate. The wood surfaces take an excellent polish, but picking up of interlocked grain may occur in planing. The wood holds nails and screws well, but pre-boring is needed. The gluing, slicing, peeling and bending properties are all satisfactory. The heartwood is durable. It is fairly resistant to fungi, dry wood borers and termites. The heartwood is resistant to impregnation with preservatives, but the sapwood is permeable.

Adulterations and substitutes The wood of *Berlinia bracteosa* closely resembles that of *Berlinia confusa* Hoyle and has similar uses. The wood of these two species is often mixed in trade under the name 'ebiara'.

Description Small to medium-sized tree up to 30(–35) m tall; bole usually short, branchless for up to 15 m, often irregular, up to 100 cm in diameter, often with low buttresses, sometimes slightly fluted at base; bark surface smooth to scaly, greyish to yellowish, inner bark fibrous, creamy to pale brown, strongly scented; crown spherical, dense; twigs angular, glabrous. Leaves alternate, paripinnately compound with (3–)4–5(–6) pairs of leaflets; stipules large, silvery hairy, caducous; petiole 2–7 cm long, rachis up to 30 cm long; petiolules stout, 0.5–1.5 cm long; leaflets opposite or nearly so, oblong-elliptical to oblong-obovate, 10–28(–44) cm × 4–9(–12.5) cm, obtuse to cuneate at base, short-acuminate at apex, leathery, minutely hairy below, pinnately veined with 10–15 pairs of lateral veins. Inflorescence a solitary stout terminal raceme up to 30 cm long, densely golden brown short-hairy, many-flowered; bracts 5–10 cm long. Flowers bisexual, zygomorphic, 5-merous, scented, with 2 bracteoles up to 7.5 cm × 2 cm at base; pedicel 1–3 cm long; hypanthium c. 1 cm long, nearly glabrous; sepals linear, 2.5–4 cm long; petals free, 5–9 cm long, 1 much broader than other 4, with long claw at base, 2-lobed at apex, white; stamens 10, 4–7.5 cm long, 9 fused at base, 1 free; ovary superior, stiped, densely short-hairy, style slender, about as long as stamens. Fruit a large, woody, oblong, flattened pod up to 40 cm × 10 cm, with stipe c. 2 cm long, glabrous, slightly shiny brownish to black, with indistinct diagonal veins, dehiscing with 2 valves, c. 4-seeded. Seeds flat, rounded, c. 6 cm in diameter. Seedling with epigeal germination; hypocotyl very short; cotyledons thick, dark green, spreading just above ground level.



Berlinia bracteosa – 1, base of bole; 2, part of leaf; 3, inflorescence; 4, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Berlinia* comprises about 20 species and is confined to tropical Africa with nearly all species occurring in West and Central Africa. Many species closely resemble each other, and identification may be problematic. *Berlinia bracteosa* belongs to section *Macroberlinia*, characterized by petals of nearly similar length and large bracts.

Berlinia occidentalis Keay also belongs in this section. It is a small to medium-sized tree up to 25(–40) m tall with often irregular bole up to 80 cm in diameter, and occurs from Sierra Le-

one to Ghana. The wood is used for house construction, joinery and furniture. The bark is used in traditional medicine in Côte d'Ivoire to treat fever and haematuria, and as a tonic. *Berlinia occidentalis* is included in the IUCN Red List as vulnerable.

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); 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: 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. 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; 115: 4–12 rays per mm. Secretory elements and cambial variants: 131: intercellular canals of traumatic origin. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(C. Essien, A.A. Oteng-Amoako & P. Baas)

Growth and development In Congo the annual growth rate of young trees has been reported to be less than 1 m. In Gabon leaves fall in May–July and subsequently vivid coppery-red new foliage develops. The young leaves, flowers and seeds are eaten by monkeys such as colobus. The presence of ectomycorrhizae has been demonstrated for the roots.

Ecology *Berlinia bracteosa* grows in moist forest types, and is particularly characteristic of lowland evergreen forest, where it may also occur in secondary formations. It is often found along rivers, and occasionally occurs in gallery forest in savanna areas.

Propagation and planting The germination rate of seeds has been recorded to be over 75%.

Management *Berlinia bracteosa* occurs locally frequently, e.g. in western Gabon, where the average volume of bole wood is 1.5 m^3/ha.

Harvesting In Gabon the minimum bole diameter for harvesting has been set at 50 cm.

Yield A tree with a bole of 12 m long and 70 cm in diameter yielded 2.8 m^3 of wood.

Handling after harvest The often poor shape of the bole and the thick sapwood frequently cause much waste in sawing operations.

Genetic resources *Berlinia bracteosa* is fairly widespread and there are no indications of current overexploitation in its range of distribution. It is therefore not threatened by genetic erosion.

Prospects Little information is available on *Berlinia bracteosa*, especially concerning its growth rates, propagation and planting and suitable management measures. Research is needed to be able to determine possibilities for larger-scale commercial exploitation on a sustainable basis. However, the often poor shape of the bole is a serious drawback, which might be overcome by selecting superior tree types and developing proper methods of vegetative propagation.

Major references ATIBT, 1986; Aubréville, 1970; Bolza & Keating, 1972; Christy et al., 2003; CIRAD Forestry Department, 2008; de Saint-Aubin, 1963; Keay, Onochie & Stanfield, 1964; Mackinder & Harris, 2006; Takahashi, 1978; Vivien & Faure, 1985.

Other references Aubréville, 1968; Bibani, Jonkers & Essama, 1986; Burkill, 1995; Chuyong, Newbery & Songwe, 2002; Holmgren et al., 2004; Maisonneuve & Manfredini (Editors), 1988a; Neuwinger, 2000; Raponda-Walker & Sillans, 1961; Sallenave, 1955; Sallenave, 1964; Tailfer, 1989; Teillier, 1994; White & Abernethy, 1997; Wilczek et al., 1952; Wilks & Issembé, 2000.

Sources of illustration Aubréville, 1968; Wilks & Issembé, 2000.

Authors R.B. Jiofack Tafokou

BERLINIA CONFUSA Hoyle

Protologue Bull. Misc. Inform. Kew 1934(5): 184 (1934).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $n = 12$

Vernacular names Red oak (En). Melegba (Fr).

Origin and geographic distribution *Berlinia confusa* occurs from Sierra Leone east to Cameroon and south to Gabon.

Uses The wood, often traded with other *Berlinia* spp. as 'ebiara', 'berlinia' or 'melegba', is used for construction, flooring, interior trim, joinery, ship building, vehicle bodies, canoes, furniture, cabinet making, mortars, agricultural implements, precision equipment and turnery. It is suitable for railway sleepers, draining boards, veneer and plywood.

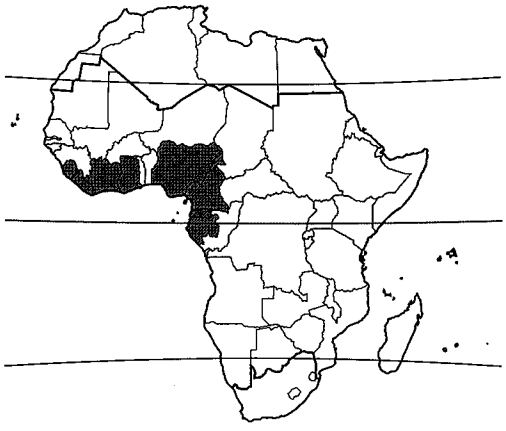
In Sierra Leone leaves are used in sauce preparation, and fruits for making soap. In Liberia bark sap is applied in traditional medicine as ear drops, and the seeds are used as bait for rodents. In Côte d'Ivoire leaf preparations are administered to promote childbirth and to improve blood circulation, and as tonic, and in Ghana to treat intestinal complaints and as an enema to treat constipation. *Berlinia confusa* is sometimes planted as a shade tree in coffee plantations.

Production and international trade In Gabon the export of 'ebiara' timber (*Berlinia* spp.) as logs increased from 200 m^3 in 1991 to 6400 m^3 in 1999 and to 12,200 m^3 in 2005. In Cameroon the export was 500 m^3 in 1998, but only 15 m^3 in 1999. The wood of *Berlinia confusa* and other *Berlinia* spp. is currently traded in small amounts only on the international market.

Properties The heartwood is reddish brown, and distinctly demarcated from the wide, whitish to greyish sapwood. The grain is usually interlocked, texture rather coarse.

The wood is medium-weight with a density of 690–720 kg/m^3 at 12% moisture content. It air dries slowly, but usually with little degrade. The rates of shrinkage are high, from green to oven dry about 4.5% radial and 9.7% tangential. At 12% moisture content, the modulus of rupture is 105–150 N/mm^2, modulus of elasticity 10,780–11,760 N/mm^2, compression parallel to grain 53–55 N/mm^2, shear 9–15 N/mm^2, cleavage 18–20 N/mm, Janka side hardness 6050 N and Chalais-Meudon side hardness 3.5. The wood is moderately easy to saw and work, but has a tendency to split. It can be polished to a good finish, but picking up of interlocked grain may occur in planing, which should be done with care. The wood has moderate nailing properties. The slicing and peeling properties are satisfactory, as well as the gluing properties. The wood is moderately durable, being susceptible to pinhole borer and marine borer attacks, but slightly resistant to termite attack. The heartwood is moderately resistant to preservative treatment, but the sapwood is permeable. The wood is liable to staining in contact with iron.

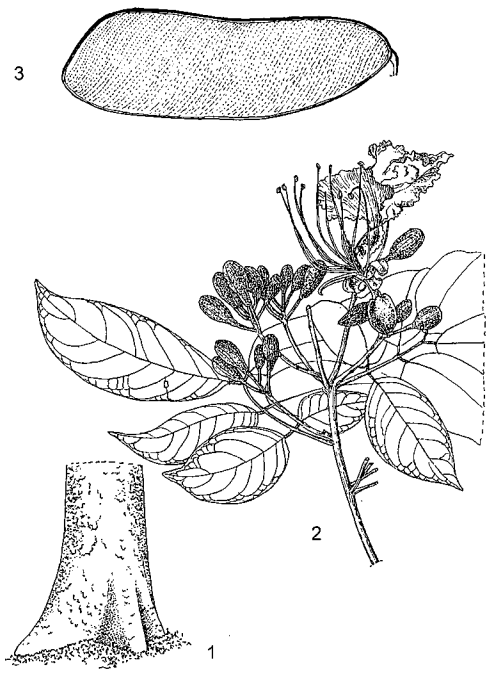
Leaf extracts contain saponins, tannins, anthraquinones and glycosides.



Berlinia confusa – wild

Adulterations and substitutes The wood of *Berlinia confusa* is often mixed with that of other *Berlinia* spp. with similar properties and uses, especially *Berlinia bracteosa* Benth.

Description Evergreen medium-sized to fairly large tree up to 35(–40) m tall; bole branchless for up to 25 m, often irregular, sometimes straight and cylindrical, up to 100 cm in diameter, often with low buttresses, sometimes fluted at base; bark surface smooth to scaly, pale grey to yellowish brown, inner bark fibrous, yellowish to pale pinkish brown, slightly sticky, strongly scented; crown obconical, dense; twigs whitish to greyish, glabrous. Leaves alternate, paripinnately compound with 3–5 pairs of leaflets; stipules large, caducous; petiole 1.5–5 cm long, rachis up to 15 cm long; petiolules 0.5–1 cm long; leaflets opposite or nearly so, ovate-elliptical to obovate, asymmetrical, 5–15(–17) cm × 2.5–7(–9) cm, rounded to cuneate at base, acute to acuminate at apex, papery to thin-leathery, minutely hairy below, pinnately veined with 4–9 pairs of lateral veins. Inflorescence an axillary or terminal few-branched panicle or raceme up to 16 cm long, densely reddish brown short-hairy, many-flowered; bracts small, caducous. Flowers bisexual, zygomorphic, 5-merous, scented, with 2 bracteoles up to 3.5(–4.5) cm × 1.5 cm at base; pedicel 1.5–3 cm long; hypanthium up to 1.5 cm long,



Berlinia confusa – 1, base of bole; 2, flowering twig; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

usually glabrous; sepals linear, c. 1.5 cm long; petals free, 1 large, 4–6 cm long, with long claw at base, slightly notched at apex, other 4 c. 1.5 cm long, white; stamens 10, 5–6.5 cm long, 9 fused at base, 1 free; ovary superior, stiped, densely short-hairy, style slender, about as long as stamens. Fruit a large, woody, oblong, flattened pod up to 35 cm × 11 cm, with short stipe, glabrous, dull brownish to black, with indistinct diagonal veins, dehiscing with 2 valves, c. 4-seeded. Seeds flat, rounded to ellipsoid, up to 5 cm in diameter, brown. Seedling with epigeal germination; hypocotyl very short, epicotyl 15–30 cm long; cotyledons thick, spreading just above ground level.

Other botanical information *Berlinia* comprises about 20 species and is confined to tropical Africa with nearly all species occurring in West and Central Africa. Many species closely resemble each other, and identification may be problematic. *Berlinia confusa* belongs to section *Berlinia*, characterized by petals that are very unequal in length and small bracts. It has been confused with several other species from this section, especially *Berlinia auriculata* Benth., *Berlinia congolensis* (Baker f.) Keay, *Berlinia coriacea* Keay and *Berlinia grandiflora* (J.Vahl) Hutch. & Dalziel. The wood of all these species, and probably some other, is mixed in trade.

Berlinia auriculata Benth. is a shrub or small to medium-sized tree up to 20(–30) m tall, with a bole diameter up to 75 cm. It is found in Nigeria, Cameroon, Gabon and Congo. Its wood is probably used for similar purposes as that of *Berlinia confusa*.

Berlinia congolensis (Baker f.) Keay is a small to medium-sized tree up to 20(–30) m tall, with a bole diameter up to 65(–120) cm. It is found in Nigeria, Cameroon, Equatorial Guinea, Gabon, Congo, DR Congo and northern Angola. Its reddish brown wood can be used for similar purposes as that of *Berlinia confusa*, especially for joinery, furniture, vehicle bodies, railway sleepers, veneer and plywood. The wood is medium-weight with a density of 620–710 kg/m^3 at 12% moisture content. In Congo the bark is used in traditional medicine to treat skin complaints.

Berlinia coriacea Keay is a small to medium-sized tree up to 25 m tall, with a bole diameter up to 30 cm. It is confined to Nigeria and Cameroon. Its wood is probably used for similar purposes as that of *Berlinia confusa*, and *Berlinia coriacea* may have value as an ornamental tree.

Berlinia craibiana Baker f. is a shrub or small to medium-sized tree up to 30(–40) m tall, with a bole diameter up to 40(–80) cm. It is found in Nigeria, Cameroon and Gabon. Its wood is probably used for similar purposes as that of *Berlinia confusa*.

Berlinia giorgii De Wild. is a small tree up to 15(–20) m tall, with a bole diameter up to 50 cm, occurring in DR Congo, Burundi, Zambia and Angola. The wood is occasionally used, e.g. to make drums.

Berlinia viridicans Baker f. is a small tree up to 10 m tall, occurring in Gabon, Congo, southwestern DR Congo and Cabinda (Angola). The wood, with a density of about 670 kg/m^3 at 12% moisture content, is similar to that of *Berlinia confusa* and used for similar purposes.

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); 27: intervessel pits large (≥ 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; 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: 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: (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; 115: 4–12 rays per mm. Secretory elements and cambial variants: (131: intercellular canals of traumatic origin). Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; (143: prismatic crystals in fibres).
(C. Essien, H. Beeckman & P. Baas)

Growth and development In a sample plot in Sierra Leone, the mean annual diameter increment of trees with a bole diameter of about 30 cm was only 2 mm. In West Africa old leaves often fall around November, followed by new flushes of leaves about one week later. The young leaves are initially orange-red, changing to purplish and then pale green. In Sierra Leone and Ghana flowering trees have been mainly recorded in March–May, in Liberia and Côte d'Ivoire in January–April; ripe fruits are found in Liberia in July–September, in Côte d'Ivoire in February and August–September, in Ghana in September–December. Fruits open explosively, scattering the seeds over some distance.

Ecology *Berlinia confusa* occurs in a variety of lowland forest types, from wet evergreen forest to dry semideciduous forest, including secondary forest. It seems to prefer well-drained sites, but has often been recorded in valleys and along watercourses.

Propagation and planting Seeds are normally shed gregariously around mother trees, and they often germinate abundantly but soon die off. In Liberia it has been reported that saplings are most common in secondary forest close to mature forest. There are about 130 seeds per kg. Germination takes 8–21 days, and the germination rate is high.

Management Larger trees are usually found scattered in the forest. In Gabon an average wood volume of 0.6 m³/ha has been recorded, but this may include also some other *Berlinia* spp. Trees normally sprout well from stumps.

Genetic resources *Berlinia confusa* is widespread and although it usually occurs scattered in the forest and regenerates rather poorly, it does not seem to be threatened by genetic erosion at present.

Prospects As is the case for many other *Berlinia* spp., little information is available on *Berlinia confusa*, especially concerning its growth rates, propagation and planting and suitable management measures. Research is needed to be able to determine possibilities for larger-scale commercial exploitation on a sustainable basis. However, the irregular shape of the bole is a serious drawback, which might be overcome by selecting superior tree types and developing proper methods of vegetative propagation.

Major references ATIBT, 1986; Aubréville, 1970; Bolza & Keating, 1972; Burkill, 1995; Irvine, 1961; Keay, Onochie & Stanfield, 1964; Mackinder & Harris, 2006; Siepel, Poorter & Hawthorne, 2004; Takahashi, 1978; Voorhoeve, 1979.

Other references Aubréville, 1959b; Aubréville, 1968; Bouquet & Debray, 1974; Christy et al., 2003; CIRAD Forestry Department, 2008; Cooper & Record, 1931; de Koning, 1983; de la Mensbruge, 1966; de Saint-Aubin, 1963; Fouarge & Gérard, 1964; Hawthorne, 1995; Keay, 1954f; Onanga et al., 1999; Savill & Fox, 1967; Sonde, 2002; Taylor, 1960; Vivien & Faure, 1985; Wilks & Issembé, 2000.

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

Authors E.A. Obeng

BERLINIA GRANDIFLORA (Vahl) Hutch. & Dalziel

Protologue Bull. Misc. Inform. Kew 1928(10): 398 (1928).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $n = 12$

Synonyms *Berlinia acuminata* Sol. ex Hook.f. (1849), *Berlinia heudelotiana* Baill. (1865).

Vernacular names Melegba des galeries

(Fr).

Origin and geographic distribution *Berlinia grandiflora* is widespread from Guinea and Mali east to the Central African Republic, and south to DR Congo.

Uses The wood is used for construction in house building, planks, flooring, joinery and food containers. It is suitable for interior trim, ship building, vehicle bodies, furniture, cabinet making, railway sleepers, stakes, draining boards, turnery, veneer and plywood.

Bark sap is applied to sores and wounds, and bark decoctions are administered to treat haemorrhoids and liver complaints, and as a vermifuge. A decoction of leafy twigs is used as febrifuge, cholagogue and anti-emetic; however, it is also reported to be used as emetic and purgative. Leaf decoctions are taken as a tonic.

Berlinia grandiflora is sometimes planted as ornamental tree and shade tree in villages, and as a shade tree in coffee plantations. It is occasionally browsed by livestock, especially sheep and goats.

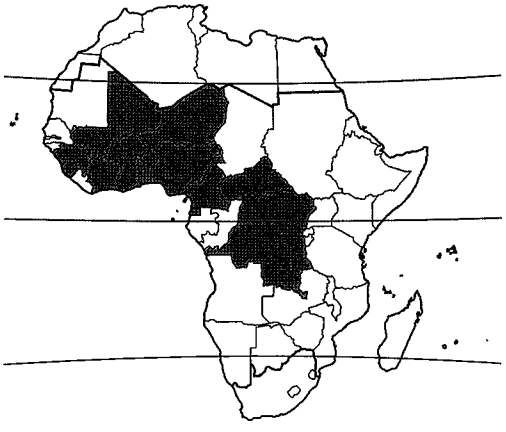
Production and international trade The wood of *Berlinia grandiflora* is mainly used locally and rarely traded on the international market as 'melegba'.

Properties The heartwood is pinkish brown to reddish brown with purplish streaks, and distinctly demarcated from the pinkish white, wide sapwood. The grain is interlocked, texture medium to coarse. The wood is odourless and tasteless when dry.

The wood is medium-weight to moderately heavy, with a density of 690–820 kg/m^3 at 12% moisture content. It air dries rather slowly but well, with occasionally slight distortion. The rates of shrinkage are rather high, from green to oven dry 5.9–6.0% radial and 8.5–10.4% tangential. At 12% moisture content, the modulus of rupture is 110–180 N/mm^2, modulus of elasticity 10,780–12,350 N/mm^2, compression parallel to grain 51–73 N/mm^2, shear 11–15 N/mm^2, cleavage 12–18 N/mm, Janka side hardness 6050 N and Chalais-Meudon side hardness 3.6–6.7.

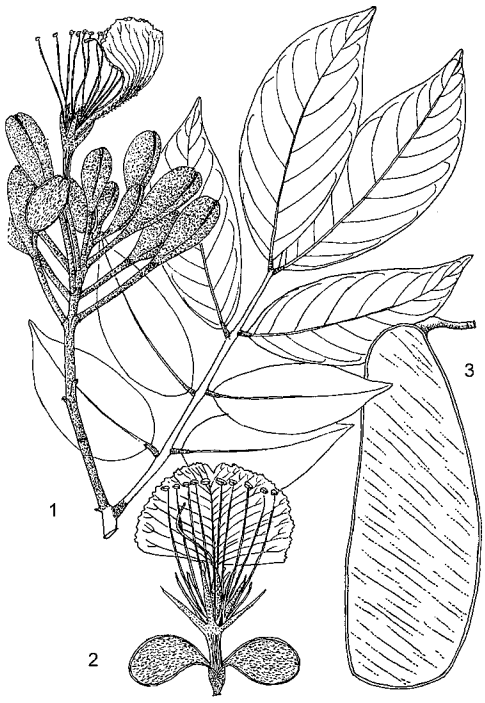
The wood works and saws moderately well, but occasionally rapid blunting of saw teeth and cutting edges may occur. Picking-up of grain at planed surfaces can be problematic. The nailing and screwing properties are satisfactory, as well as gluing and bending characteristics. The staining and polishing properties are reportedly variable. The wood is moderately durable, being moderately resistant to termite attacks, but liable to pinhole and marine borer attacks. The sapwood is easily treated with preservatives, but the heartwood is resistant.

In bark extracts, the presence of alkaloids, tannins, flavonoids, triterpenes and glycosides has been demonstrated. Methanolic bark extracts showed acute toxicity in mice, with a LD50 of 37 mg/kg using intraperitonial injection. They significantly increased pentobarbitone-induced sleeping time in mice and showed analgesic effect. They induced a dose-dependent contraction of isolated guinea-pig ileum. Bark extracts showed anthelmintic activity in rats infected with *Nippostrongylus brasiliensis* and against the free-living soil nematode *Caenorhabditis elegans*. Betulinic acid was identified as active component.



Berlinia grandiflora – wild

Description Small to medium-sized tree up to 25(–30) m tall; bole often short, often irregular, sometimes straight and cylindrical, up to 50(–70) cm in diameter, without buttresses; bark surface scaly, dark grey to brown, inner bark pale brown to reddish brown, sometimes exuding a yellowish resin; crown rounded, dense, with spreading branches; twigs brown, glabrous. Leaves alternate, paripinnately compound with (2–)3–4(–5) pairs of leaflets; stipules large, caducous; petiole 2–4(–6.5) cm long; petiolules stout, 0.5–1 cm long; leaflets opposite or nearly so, oblong-elliptical to obovate, asymmetrical, 7–22 cm × 3–11.5 cm, obtuse to rounded at base, usually short-acuminate at apex, papery to thin-leathery, glabrous to short-hairy below, pinnately veined with 7–12 pairs of lateral veins. Inflorescence a terminal much-branched panicle, densely reddish brown short-hairy, many-flowered; bracts small, caducous. Flowers bisexual, zygomorphic, 5-merous, scented, with 2 bracteoles up to 3.5(–



Berlinia grandiflora – 1, flowering twig; 2, flower; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

6.5) cm × 2 cm at base, silvery hairy inside; pedicel 2–5 cm long; hypanthium up to 1.5 cm long, usually glabrous; sepals linear, c. 1 cm long; petals free, 1 large, 3.5–6.5 cm long, with long claw at base, slightly notched at apex, other 4 c. 1 cm long, white; stamens 10, 5–6 cm long, 9 fused at base, 1 free; ovary superior, stiped, densely short-hairy, style slender, about as long as stamens. Fruit a large, woody, oblong, flattened pod up to 30 cm × 7 cm, with short stipe, densely golden short-hairy, yellowish brown to brown, with indistinct diagonal veins, dehiscing with 2 valves, c. 4-seeded. Seeds flat, rounded to ellipsoid, up to 4 cm in diameter, dark brown.

Other botanical information *Berlinia* comprises about 20 species and is confined to tropical Africa with nearly all species occurring in West and Central Africa. Many species closely resemble each other, and identification may be problematic. *Berlinia grandiflora* belongs to section *Berlinia*, characterized by petals that are very unequal in length and by small bracts. It has been confused with several other species from this section, especially *Berlinia auriculata* Benth., *Berlinia congolensis* (Baker f.) Keay, *Berlinia confusa* Hoyle and *Berlinia coriacea* Keay.

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); (27: intervessel pits large (≥ 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); 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: 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. 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); 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(C. Essien, H. Beeckman & P. Baas)

Growth and development Trees often flower at the end of the dry season. In Côte d'Ivoire flowering of trees has been recorded in January–May and in Ghana in January–July. Fruits ripen about 6 months later.

Ecology *Berlinia grandiflora* occurs mostly in gallery forest in savanna areas, up to 700 m altitude. It can also be found in edges of semi-deciduous forest patches in savanna regions. It prefers deep and well-drained soils.

Genetic resources *Berlinia grandiflora* is widespread and moderately common locally. It is unlikely to be threatened by genetic erosion.

Prospects *Berlinia grandiflora* will remain of local importance for its wood and medicine. Very little is known about its growth and development, propagation and planting and proper management measures. It deserves more attention as a multipurpose species that

could be useful in agroforestry systems.

Major references Arbonnier, 2004; ATIBT, 1986; Aubréville, 1970; Bolza & Keating, 1972; Burkill, 1995; Irvine, 1961; Keay, 1989; Mackinder & Harris, 2006; Takahashi, 1978; Taylor, 1960.

Other references Adjanohoun et al., 1979; Asuzu, Nwelle & Anaga, 1993; Aubréville, 1959b; CIRAD Forestry Department, 2008; de la Estrella et al., 2006; de Saint-Aubin, 1963; Enwerem et al., 2001; Keay, 1954f; Kerharo & Bouquet, 1950; Lawal et al., 2010; Neuwinger, 2000; Oliver, 1871; Oteng-Amoako (Editor), 2006; Sallenave, 1955; Sallenave, 1964; Taïta, 2000; Vivien & Faure, 1985.

Sources of illustration Aubréville, 1970.

Authors R.B. Jiofack Tafokou

BIKINIA CORIACEA (J.Morel ex Aubrév.) Wieringa

Protologue Wageningen Agric. Univ. Pap. 99(4): 204 (1999).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Monopetalanthus coriaceus* J.Morel ex Aubrév. (1968).

Vernacular names Andoung de Morel (Fr).

Origin and geographic distribution *Bikinia coriacea* has a very small area of distribution, being endemic to north-western Gabon and possibly also occurring in central Gabon.

Uses The wood, traded from Gabon as 'andoung' together with other *Bikinia* spp., *Aphanocalyx* spp. and some other *Caesalpiniaceae*, is used for light construction, joinery, furniture, vehicle bodies, ladders, sporting goods, toys, novelties, tool handles, boxes, crates, matches, veneer, plywood and pulpwood. It is also suitable for light flooring, interior trim, ship building and railway sleepers.

Bikinia coriacea – wild

Production and international trade The export of 'andoung' logs from Gabon increased from 2700 m^3 in 1991 to 47,000 m^3 in 1999. However, the contribution of *Bikinia coriacea* was probably small because of its limited area of distribution. At present, the export of 'andoung' timber from Gabon seems insignificant.

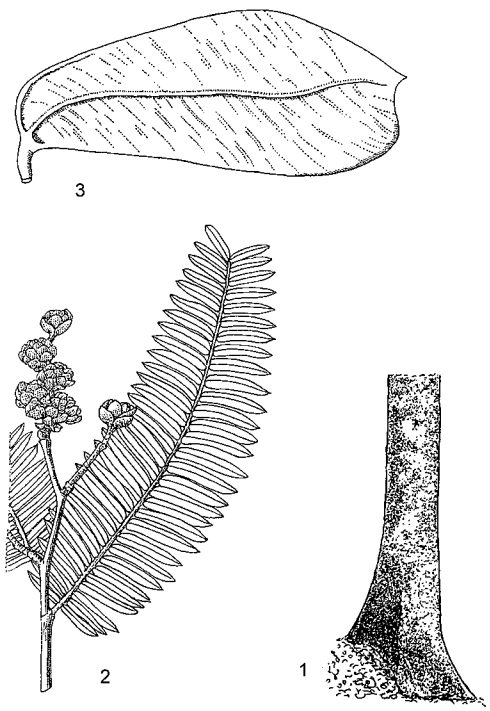
Properties The heartwood is pale pinkish brown with small stripes, darkening upon exposure, and not distinctly demarcated from the up to 12.5 cm wide sapwood. The grain is interlocked, texture fine and even.

The wood is medium-weight, with a density of 530–670 kg/m^3 at 12% moisture content, and rather soft but tough. It air dries fairly well with little degrade, but some care is needed. The rates of shrinkage are moderate to rather high, from green to oven dry 3.7–4.5% radial and 7.1–9.5% tangential. Once dry, the wood is stable in service.

At 12% moisture content, the modulus of rupture is 109–163 N/mm^2, modulus of elasticity 8240–13,630 N/mm^2, compression parallel to grain 48–55 N/mm^2, shear 5–10.5 N/mm^2, cleavage 13–20 N/mm and Chalais-Meudon side hardness 2.1–4.1.

The wood works well with both machine and hand tools. In planing operations rough patches may occur due to the interlocked grain. The wood holds screws and nails well. Gluing properties are good and the wood paints well and takes a satisfactory finish. Boring and peeling characteristics are good. The wood is moderately durable, being quite resistant to termite attack, but susceptible to pinhole borer and *Lyctus* attacks. The heartwood is resistant to impregnation with preservatives, but the sapwood is permeable.

Description Large tree up to 53 m tall; bole straight, cylindrical, branchless for up to 26 m, up to 100(–120) cm in diameter, with buttresses up to 2 m high; bark surface smooth to fissured, greyish brown with reddish brown lenticels, inner bark fibrous, orange-brown; crown hemispherical; twigs greyish brown with brown lenticels, yellowish brown hairy. Leaves arranged spirally, paripinnately compound with 19–36 pairs of leaflets; stipules free, obovate, up to 7 cm long, early caducous leaving annular scars on twigs; petiole 2–7 mm long, rachis up to 20 cm long, slightly grooved above; leaf-



Bikinia coriacea – 1, base of bole; 2, twig with flower buds; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

lets opposite, sessile, narrowly oblong to linear, asymmetrical, 0.5–5 cm × 0.1–0.8 cm, leathery, glabrous. Inflorescence an axillary compound raceme 3–8 cm long, brown short-hairy, with up to 6 lateral branches up to 1.5 cm long; bracts up to 1 cm long. Flowers bisexual or male, zygomorphic, scented, at base with 2 ovate bracteoles up to 8 mm long; pedicel 0.5–4 mm long, hairy; sepals 5, small, up to 1 mm long, 2 fused into a 2-lobed band; petals 3–5, white, one up to 6 mm long, others up to 1 mm long; stamens 10, 9 fused at base, 1 free, anthers purplish; ovary superior, with c. 2 mm long stipe, hairy, 1-celled, style c. 5 mm long, hairy at base; male flowers with reduced ovary. Fruit an obovate, flat pod 10–14 cm × 4–6 cm, with 0.5–1 cm long stipe, short-pointed at apex, narrowly winged at upper suture, with a longitudinal vein near the middle of the lateral sides, 1–2-seeded. Seeds lens-shaped, c. 3 cm long, with very thin seed coat. Seedling with epigeal germination; hypocotyl 6–8.5 cm long, epicotyl 15–19 cm long; first two leaves opposite, with 14–16 pairs of leaflets, subsequent leaves alternate.

Other botanical information *Bikinia* comprises 10 species and is confined to rainforest and gallery forest of western Central Africa. It is most closely related to *Aphanocalyx* and *Tetraberlinia.*

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; (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; 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); 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. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E. Ebanyenle, P. Baas & H. Beeckman)

Growth and development An average annual growth rate of 2 cm in bole diameter has been estimated for a 47-years-old tree with a bole diameter of 105 cm in an arboretum in Gabon.
Flowering trees have been recorded in July and October. Pollination is probably by insects such as bees, flies, butterflies and moths, and perhaps also by sunbirds. The seeds, having a very thin seed coat, are susceptible to desiccation, which necessitates immediate germination after seed shedding. Seedlings probably need ectomycorrhizal fungi for proper growth.

Ecology *Bikinia coriacea* occurs in dryland rainforest up to 300 m altitude. It usually oc-

curs scattered in the forest, but important stands have been reported in some regions in north-western Gabon.

Handling after harvest Logs are susceptible to insect and fungal attacks after felling; they should be removed from the forest as soon as possible or treated with preservatives. Fresh logs float in water and thus can be transported by river.

Genetic resources *Bikinia coriacea* may become threatened by genetic erosion because it has a small distribution area. It does not seem to be logged much at present, but more intensified logging operations in the future might easily endanger this species.

Prospects *Bikinia coriacea* provides wood of good quality, and, like some other *Bikinia* spp., it may have good prospects for planting in timber plantations because it seems to grow quite rapidly into large, straight and cylindrical boles, even on poor soils. However, much research is still needed, especially on propagation and growth in relation to mycorrhizal relationships.

Major references Aubréville, 1968; Bolza & Keating, 1972; de Saint-Aubin, 1963; Détienne, 2001; Sallenave, 1964; Sallenave, 1971; Takahashi, 1978; Wieringa, 1999.

Other references CIRAD Forestry Department, 2008; Normand & Paquis, 1976.

Sources of illustration Aubréville, 1968; de Saint-Aubin, 1963.

Authors E.A. Obeng & S. Britwum Acquah

BIKINIA DURANDII (F.Hallé & Normand) Wieringa

Protologue Wageningen Agric. Univ. Pap. 99(4): 207 (1999).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Monopetalanthus durandii* F.Hallé & Normand (1960).

Vernacular names Andoung de Durand (Fr).

Origin and geographic distribution *Bikinia durandii* has a small area of distribution, being endemic to Gabon.

Uses The wood, traded from Gabon as 'andoung' together with other *Bikinia* spp., *Aphanocalyx* spp. and some other *Caesalpiniaceae*, is used for light construction, joinery, furniture, vehicle bodies, ladders, sporting goods, toys, novelties, tool handles, boxes, crates, matches, veneer, plywood and pulpwood. It is also suitable for light flooring, interior trim, ship building and railway sleepers.

Bikinia durandii – wild

Production and international trade The export of 'andoung' logs from Gabon increased from 2700 m^3 in 1991 to 47,000 m^3 in 1999 and then decreased to 10,300 m^3 in 2009. The contribution of *Bikinia durandii* was probably moderate.

Properties The heartwood is pinkish brown, slightly darkening upon exposure, and rather indistinctly demarcated from the sapwood. The grain is usually interlocked, texture fine and even.

The wood is medium-weight, with a density of 520–710 kg/m^3 at 12% moisture content, and only moderately hard. It air dries fairly well with little degrade, but some care is needed. The rates of shrinkage are moderate to rather high, from green to oven dry 3.2–6.2% radial and 6.7–11.0% tangential.

At 12% moisture content, the modulus of rupture is 82–159 N/mm^2, modulus of elasticity 10,200–16,180 N/mm^2, compression parallel to grain 39–66 N/mm^2, shear 5.5–8 N/mm^2, cleavage 10.5–22 N/mm and Chalais-Meudon side hardness 2.3–4.4.

The wood works well with both machine and hand tools. In planing operations woolly surfaces may occur due to the interlocked grain; cutting edges should be kept sharp. The wood holds screws and nails well. Gluing properties are good and the wood takes a satisfactory finish. Boring and peeling characteristics are good. The wood is moderately durable, being quite resistant to termite attack, but susceptible to pinhole borer, longhorn beetle and *Lyctus* attacks. The heartwood is resistant to impreg-

nation with preservatives, but the sapwood is permeable.

Description Large to very large tree up to 60 m tall; bole straight, cylindrical, branchless for up to 30 m, up to 130(–150) cm in diameter, with buttresses up to 2.5 m high; bark surface smooth to rough, greyish brown to reddish brown, with reddish lenticels, inner bark fibrous, brownish yellow becoming purplish upon exposure, with a dark red exudate; crown rather narrow, irregular; twigs greyish brown with few pale brown lenticels, yellowish brown hairy to glabrous. Leaves arranged spirally, paripinnately compound with (6–)9–16 pairs of leaflets; stipules free, narrowly obovate, up to 6 cm long, early caducous leaving annular scars on twigs; petiole 7–24 mm long, rachis up to 23 cm long, slightly grooved above; leaflets opposite, sessile, oblong, asymmetrical, (0.5–)1.5–10.5 cm × 0.5–3.5 cm, leathery, glabrous. Inflorescence an axillary compound raceme 5–22 cm long, pale brown short-hairy, with up to 12 lateral branches up to 4.5 cm long; bracts up to 1 cm long. Flowers bisexual or male, zygomorphic, scented, at base with 2 ovate bracteoles up to 13 mm long; pedicel 4–8 mm long, hairy; sepals 3(–5), small, up to 3 mm long, 2 fused into a 2-lobed band; petals 1–3, white, one up to 7.5 mm long, others up to 2 mm long; stamens 10, 9 fused at base, 1 free, anthers purplish; ovary superior, up to 5 mm long, with 3–5 mm long stipe, hairy, 1-celled, style 9–11 mm long, hairy except at apex; male flowers with reduced ovary. Fruit an obovate, flat pod 9–21 cm × 3.5–8.5 cm, with 1–2 cm long stipe, short-pointed at apex, very narrowly winged at upper suture, with a longitudinal vein near the middle of the lateral sides, 1–2-seeded. Seeds lens-shaped, 3–4 cm long, with very thin, dark brown seed coat. Seedling with epigeal germination; hypocotyl 8–11 cm long, epicotyl 21–30 cm long; first two leaves opposite, with 4–6 pairs of leaflets, subsequent leaves alternate.

Other botanical information *Bikinia* comprises 10 species and is confined to rainforest and gallery forest of western Central Africa. It is most closely related to *Aphanocalyx* and *Tetraberlinia*.

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; 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; (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: 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. Secretory elements and cambial variants: 131: intercellular canals of traumatic origin. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E. Ebanyenle, P. Baas & H. Beeckman)

Growth and development Flowering trees have been recorded in September. Pollination is by insects such as bees (honey-bees and carpenter bees have been recorded to visit the flowers), but probably also by sunbirds. Fruits take about 5 months to mature. The seeds, having a very thin seed coat, are susceptible to desiccation, which necessitates immediate germination after seed shedding. Seedlings probably need ectomycorrhizal fungi for proper growth.

Ecology *Bikinia durandii* occurs in dry-land rainforest up to 600 m altitude. It usually occurs in small groups of about 10 mature trees in the forest, but nearly pure stands of trees with variable bole diameter have also been reported.

Handling after harvest Logs are susceptible to insect and fungal attacks after felling; they should be removed from the forest as soon as possible or treated with preservatives. Large numbers of longhorn beetles have been recorded on freshly felled boles. Fresh logs float in water and thus can be transported by river.

Genetic resources *Bikinia durandii* may become threatened by genetic erosion because it has a small distribution area. It does not seem to be logged much at present, but more intensified logging operations in the future might easily endanger this species. *Bikinia durandii* is included in the IUCN Red List of threatened species as vulnerable, but its status needs updating.

Prospects *Bikinia durandii* provides wood of good quality, and, like some other *Bikinia* spp., it may have good prospects for planting in timber plantations because it seems to grow quite rapidly into large, straight and cylindrical boles, even on poor soils. However, much research is still needed, especially on propagation and growth, also in relation to mycorrhizal relationships.

Major references Aubréville, 1968; Bolza & Keating, 1972; de Saint-Aubin, 1963; Détienne, 2001; Sallenave, 1964; Sallenave, 1971; Takahashi, 1978; Wieringa, 1999; World Conservation Monitoring Centre, 1998.

Other references CIRAD Forestry Department, 2008; Normand & Paquis, 1976.

Sources of illustration de Saint-Aubin, 1963; Hallé & Normand, 1960.

Authors E.A. Obeng

BIKINIA LE-TESTUI (Pellegr.) Wieringa

Protologue Wageningen Agric. Univ. Pap. 99(4): 222 (1999).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Monopetalanthus le-testui* Pellegr. (1942).

Vernacular names Andoung de Le Testu (Fr).

Origin and geographic distribution *Bikinia le-testui* occurs in western Cameroon, Equatorial Guinea, Gabon and south-western Congo.

Uses The wood, traded from Cameroon as 'ekop' or 'mayo' and from Gabon as 'andoung' together with other *Bikinia* spp., *Aphanocalyx* spp. and some other *Caesalpiniaceae*, is used for light construction, joinery, furniture, vehicle bodies, ladders, sporting goods, toys, novelties, tool handles, boxes, crates, matches, veneer, plywood and pulpwood. It is also suitable for light flooring, interior trim, ship building and railway sleepers.

Production and international trade *Bikinia le-testui* timber is exported from Cameroon in small quantities, mixed with the timber of other species classified as 'ekop' or 'mayo', but statistics are not available. The export of 'andoung' logs from Gabon increased from 2700 m^3 in 1991 to 47,000 m^3 in 1999 and then decreased to 10,300 m^3 in 2009. The contribution of *Bikinia le-testui* was probably moderate because this species is usually not found in large numbers in Gabon. The export from Cameroon was 3600 m^3 in 2009.

Bikinia le-testui – wild

Properties The heartwood is pale pinkish brown to pale brown, darkening upon exposure to reddish brown, and not distinctly demarcated from the up to 12 cm wide sapwood. The grain is usually interlocked, texture moderately fine and even.

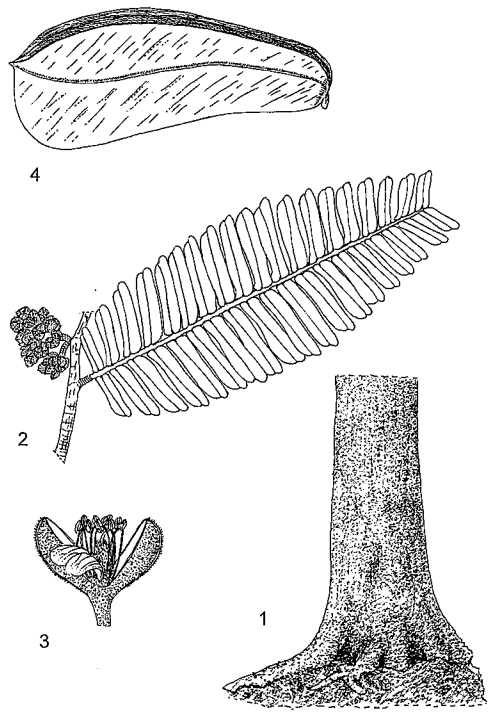
The wood is medium-weight, with a density of 550–750 kg/m^3 at 12% moisture content, and rather soft to moderately hard. It air dries fairly well with little degrade when proper care is taken; slow drying is recommended, especially in kiln drying. The rates of shrinkage are moderate to rather high, from green to oven dry 3.5–6.0% radial and 7.8–11.5% tangential. Once dry, the wood is only moderately stable in service.

At 12% moisture content, the modulus of rupture is 101–170 N/mm^2, modulus of elasticity 9500–13,340 N/mm^2, compression parallel to grain 41–56 N/mm^2, shear 4.5–9.5 N/mm^2, cleavage 11–28 N/mm and Chalais-Meudon side hardness 2.0–4.1.

The wood saws and works well with both machine and hand tools. In planing operations woolly surfaces may occur due to the interlocked grain; cutting edges should be kept sharp and a cutting angle of 15° is recommended. The wood takes a nice polish upon finish-

ing. It holds screws and nails well. Gluing properties are good and the wood takes paint, varnish and wax well. Boring, slicing and peeling characteristics are good. The results of rotary peeling are usually satisfactory for fresh logs, but for logs of about 60 cm in diameter steaming at 80°C is recommended. The quality of the resulting veneer may be influenced by exudate production and rough surfaces because of interlocked grain. Careful drying of the veneer is needed to avoid splitting and deformation. The wood is moderately durable, being susceptible to fungal and insect attacks. The heartwood is resistant to impregnation with preservatives, but the sapwood is permeable.
The wood contains 44–48% cellulose, 27–28% lignin, 16.5–19.5% pentosan, 0.5–0.7% ash and traces of silica. The solubility is 2.7–6.3% in alcohol-benzene, 1.2–1.7% in hot water and 12.7–14.4% in a 1% NaOH solution.

Description Large tree up to 55 m tall; bole straight, cylindrical, branchless for up to 30 m, up to 200(–260) cm in diameter, with buttresses up to 2 m high; bark surface smooth to slightly rough, greyish red to reddish brown with reddish lenticels, inner bark fibrous, yellow to yellowish brown; crown hemispherical; twigs greyish brown to greyish green with brown lenticels, glabrous to slightly hairy. Leaves arranged spirally, paripinnately compound with (9–)13–24(–28) pairs of leaflets; stipules free, ovate to obovate, up to 5.5 cm long, early caducous leaving annular scars on twigs; petiole 2–7 mm long, rachis up to 15(–21) cm long, flattened above; leaflets opposite, sessile, oblong, asymmetrical, 0.5–3.5(–5.5) cm × 0.2–1(–1.5) cm, leathery, glabrous to sparsely hairy. Inflorescence an axillary compound raceme 2–9 cm long, brown hairy, with up to 10 lateral branches up to 3 cm long; bracts up to 6 mm long. Flowers bisexual or male, zygomorphic, scented, at base with 2 obovate bracteoles up to 1 cm long; pedicel 1.5–7 mm long, hairy; sepals 3(–5), small, up to 3 mm long, 2 fused into a 2-lobed band; petals 1(–5), white, one up to 9.5 mm long, others, if present, up to 1 mm long; stamens 10, 9 fused at base, 1 free, anthers purplish; ovary superior, up to 5.5 mm long, with 1–3 mm long stipe, hairy, 1-celled, style 6–11 mm long, hairy at base; male flowers with reduced ovary. Fruit an oblong-obovate, flat pod 7–14 cm × 3–6 cm, with 0.5–1 cm long stipe, short-pointed at apex, usually densely hairy, broadly winged at upper suture, with a longitudinal vein near the middle of the lateral sides, 1–2-seeded. Seeds lens-shaped, 2.5–3.5 cm long, with thin, glossy brown seed coat. Seedling with epigeal germination; hypocotyl 2.5–8 cm long, epicotyl 6–17 cm long; first two leaves opposite, with 9–14(–16) pairs of leaflets, subsequent leaves alternate.



Bikinia le-testui – 1, base of bole; 2, part of twig with flower buds; 3, flower; 4, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Bikinia* comprises 10 species and is confined to rainforest and gallery forest of western Central Africa. It is most closely related to *Aphanocalyx* and *Tetraberlinia*.
Two subspecies of *Bikinia le-testui* have been distinguished: subsp. *le-testui* and subsp. *mayumbensis* Wieringa, the latter restricted to south-western Congo.
Bikinia pellegrinii (A.Chev.) Wieringa (synonym: *Monopetalanthus pellegrinii* A.Chev.), also a large tree up to 50 m tall with bole up to 200 cm in diameter, closely resembles *Bikinia le-testui*, mainly differing in slightly smaller leaflets, flowers and fruits, narrower petals, and less hairy fruits with narrowly winged upper suture. Its distribution area is nearly similar, although it seems to avoid coastal regions. The two species are much confused, and their timber, which is indistinguishable, has similar properties and is used for similar purposes, is

traded in mixed consignments, especially from southern Cameroon, often called collectively 'ekop rouge'. Intermediates have been reported, which may be hybrids.

The wood of *Bikinia breynei* (Bamps) Wieringa (synonym: *Monopetalanthus breynei* Bamps), a medium-sized to large tree up to 45 m tall with a bole diameter up to 200 cm, is occasionally used in western DR Congo in house construction and for charcoal production.

The wood of *Bikinia congensis* Wieringa, a medium-sized tree up to 30 m tall with a bole diameter up to 100 cm, is occasionally used in western DR Congo for joinery. The bark is used in traditional medicine as vermifuge.

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; 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; (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; (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; 116: ≥ 12 rays per mm. Secretory elements and cambial variants: (128: axial canals in short tangential lines); (131: intercellular canals of traumatic origin). Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; 143: prismatic crystals in fibres.

(E. Ebanyenle, P. Baas & H. Beeckman)

Growth and development An average annual growth rate of 1.3 cm in bole diameter has been estimated for a tree with a bole diameter of 180 cm in Gabon. However, from Cameroon an average annual growth rate of only 0.5 cm in bole diameter has been recorded.

Flowering trees have been recorded in Cameroon and northern Gabon in March and April, in southern Gabon in August–October. Pollination is probably by insects such as bees, flies, longhorn beetles, butterflies and moths, and perhaps also by sunbirds. Fruits ripen in 5–10 months. The seeds, having a very thin seed coat, are susceptible to desiccation, which necessitates immediate germination after seed shedding. Seedlings need ectomycorrhizal fungi for proper growth.

Ecology *Bikinia le-testui* occurs in dry-land rainforest up to 900 m altitude, often on hill crests and hill sides, in regions with a mean annual rainfall of 1500–3000 mm and mean annual temperature of 23–25°C. It usually occurs on sandy soils, in small clusters of less than 10 mature trees in the forest.

Management In southern Cameroon the average density of trees with a bole diameter of more than 15 cm has been reported as 0.14 per ha, with an average wood volume of 0.63 m^3/ha.

Harvesting In Cameroon the minimum bole diameter for harvesting is 60–90 cm depending on the density of stands, and in Gabon 60 cm. In Cameroon the felling cycle in natural forest where *Bikinia le-testui* occurs is 30 years.

Handling after harvest Logs are susceptible to insect and fungal attacks after felling; they should be removed from the forest as soon as possible or treated with preservatives. A large log of 7 m long and 260 cm in diameter, comprising 40 m^3 of wood, harvested in Gabon was recorded to sink in water.

Genetic resources *Bikinia le-testui* is fairly widespread and not uncommon in many regions within its distribution area. There is no reason to consider it as threatened. It does not seem to be logged much at present, and mostly in coastal areas, from where the logs can be easily transported.

Prospects *Bikinia le-testui* provides wood of good quality, and, like some other *Bikinia* spp., it may have good prospects for planting in timber plantations, even on poor soils. However, much research is still needed, especially on propagation and growth in relation to mycorrhizal relationships.

Major references Aubréville, 1968; Bolza & Keating, 1972; CTFT, 1961c; de Saint-Aubin, 1963; Détienne, 2001; Sallenave, 1964; Sallenave, 1971; Takahashi, 1978; Vivien & Faure, 1985; Wieringa, 1999.

Other references Aubréville, 1970; CIRAD Forestry Department, 2008; CIRAD-CTFT, 1990; Gérard et al., 1998; Normand & Paquis, 1976.

Sources of illustration Aubréville, 1968; de Saint-Aubin, 1963.

Authors V.A. Kémeuzé & M.G. Meikeu Kamdem

BISCHOFIA JAVANICA Blume

Protologue Bijdr. fl. Ned. Ind. 17: 1168 (1827).

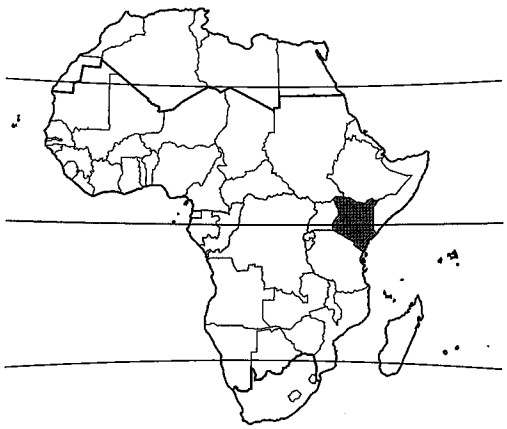
Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 98$

Vernacular names Bishopwood, Java cedar, Javanese bishopwood, toog tree, koka (En).

Origin and geographic distribution The natural occurrence of *Bischofia javanica* extends from India and the lower Himalayas through China, southern Japan and tropical Asia to north-eastern Australia and the Pacific. It is locally planted in its natural area of distribution and elsewhere, including East Africa and South Africa. In Kenya it is planted as a plantation species, e.g. in the Kakamega area. Locally it has become naturalized in evergreen forest.

Uses Bishopwood is used in construction for beams, posts, docks, bridges and decking, and also for flooring, joinery, interior finish, mine props, railway sleepers, furniture, lining, agricultural implements, carving, pencils and billiard cue butts. It is a potential source of long fibres for pulp and paper production, and is also suitable for the production of veneer and plywood. It is not a good firewood, but suitable for making charcoal.



Bischofia javanica – planted and naturalized

In Polynesia a red dye is extracted from the bark. The bark also contains tannin, used for toughening nets and ropes. The young soft leaves are cooked and eaten as a vegetable. In southern Laos the leaves are eaten after dipping into chilli sauce. The seed oil is used as lubricant. In India and the Pacific *Bischofia javanica* is considered an excellent shade tree, e.g. in coffee and cardamom plantations. It has been widely planted as a roadside tree and for landscaping, but its superficial roots may lift sidewalks and in some areas this use is now discouraged. In China the roots are used as a medicine against rheumatic pain and malaria. In India the bark is used for the treatment of tuberculosis, body ache, stomach ulcers, mouth ulcers and inflammatory conditions.

Production and international trade Bishopwood is mostly consumed locally, but is a commercial hardwood in Papua New Guinea. No information is available on international trade.

Properties The heartwood is purplish brown to reddish brown, darkening upon exposure; it is sharply demarcated from the narrow, pale brown to pale reddish brown sapwood. The grain is generally interlocked, texture moderately fine to rather coarse and even. The wood surface is rather dull to slightly glossy. Fresh wood smells of vinegar.

Bishopwood is medium-weight to moderately heavy and moderately hard to hard. The density is (550–)670–845 kg/m^3 at 12% moisture content. The wood is difficult to air dry because of its tendency to check, split and warp, especially in back-sawn boards. Defects may be diminished by quarter sawing. The rates of shrinkage are moderate, from green to oven dry 3.1–3.9% radial and 7.5–7.9% tangential. Air drying of 2 cm thick boards from green to 30% moisture content takes 2 months. Kiln drying requires a mild schedule.

At 12% moisture content, the modulus of rupture is 102–111 N/mm^2, modulus of elasticity 10,500–11,455 N/mm^2, compression parallel to grain 46–60 N/mm^2, shear 17–21 N/mm^2, Janka side hardness 7450–8200 N and Janka end hardness 9600–11,300 N.

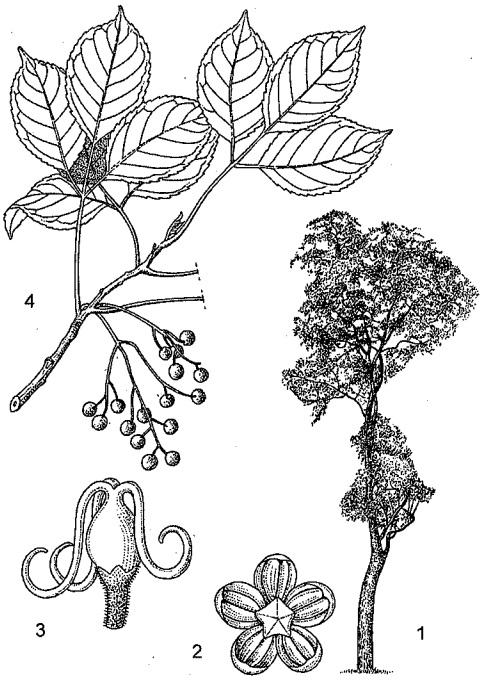
The wood is rather difficult to saw when dry, but more easy before drying. Planing, shaping, mortising, boring, turning and sanding give good to very good results. Good veneer can be produced at a peeling angle of 92° without pretreatment, but the veneer is wavy after drying. Gluing the veneer with urea-formaldehyde produces a plywood of fair quality.

Bishopwood is classified as moderately durable. It is susceptible to *Lyctus* and termite attacks, whereas its susceptibility to wood-rotting fungi varies from not resistant to resistant. Longhorn and ambrosia beetles have also been recorded. The heartwood is difficult to treat with copper-chrome-arsenic preservative by the vacuum-pressure process, but the sapwood can be easily penetrated by preservatives.

The wood contains 49–51% cellulose, 23–42% lignin, 9.7–14.4% pentosan, 0.4–1.1% ash and 0.4–1.7% silica. The solubility is 1.4–8.0% in alcohol-benzene, 4.1% in cold water, 5.0–5.8% in hot water and 11.1–29.4% in a 1% NaOH solution. Sulphate pulping yields a pulp with a high overall strength; hence a strong paper can be manufactured from bishopwood.

The bark contains about 16% tannin. *Bischofia javanica* has been shown to have anti-ulcer, anthelmintic and antidysenteric activities. The seed contains about 20% oil with an approximate fatty acid composition of: linolenic acid 51%, linoleic acid 12%, oleic acid 23% and saturated acids 14%.

Botany Evergreen or deciduous, dioecious, medium-sized to fairly large tree up to 35(–50) m tall; bole straight or poorly shaped, branchless part usually short but sometimes up to 20 m long, up to 80(–170) cm in diameter, sometimes with steep buttresses up to 3 m high; bark surface fissured and scaly with small thick shaggy scales, reddish brown to purplish brown, inner bark fibrous, spongy, pink, exuding a red sap; crown dense and rounded. Leaves arranged spirally, compound with 3 leaflets, glabrous; stipules oblong-triangular, 7–22 mm long, papery, falling early; petiole 8–20 cm long; petiolules long and slender, longest in terminal leaflet; leaflets elliptical to ovate, 6–16 cm × 3–10 cm, base rounded to broadly cuneate, apex acuminate, margin finely toothed, pinnately veined. Inflorescence an axillary panicle up to 27 cm long. Flowers unisexual, regular, 5-merous, small, greenish, corolla and disk absent; male flowers with sepals fused at base, hooded, stamens free, opposite to the calyx lobes, ovary rudimentary; female flowers with sepals falling early, stamens strongly rudimentary, ovary superior, globose, 3(–4)-celled, style short, with 3 long stigmas. Fruit a globose drupe 1–1.5 cm in diameter, bluish black, with a horny to leathery skin and fleshy pulp, 3–6-seeded. Seeds oblong to obovoid, c. 5 mm long, brown. Seedling with epigeal germination; cotyledons leafy, petiolate; first few leaves simple, subsequent ones with 1 leaflet, and from about the 10th leaf with 3 leaflets. The seedlings show fast root growth. The taproot is tuberous for a short length and then tapers quickly. Thin but long secondary roots are present below the collar region. Growth is comparatively slow during the first 3 years, becoming fairly rapid in subsequent years. In India, 7-months-old seedlings attained a height of 50–80 cm. Under normal conditions, an average annual diameter increment of 1.0 cm and an average annual height increment of 1 m can be obtained. Exceptions have been reported, e.g. a diameter at breast height of 41 cm for 18-year-old trees and a height of 7.5 m for 3-year-old trees and of 10 m for 6-year-old trees. The tree flowers every year from an age of about 8 years onward.



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

Bischofia comprises 2 species, one of which only occurs in China.

Ecology *Bischofia javanica* prefers areas with a humid climate with a more or less distinct dry season. Its altitudinal range is from sea-level to 1800 m. In its natural area of distribution it is fairly common, but usually found

scattered in primary and old secondary forest, from dry and deciduous to evergreen forest. It is most frequent on river banks, shady ravines and prefers deep, loose soils with sufficient water content. In Kenya it has become naturalized locally as an understorey tree in evergreen forest at 1500–1800 m altitude.

Management *Bischofia javanica* is well suited for large-scale plantations. It can be propagated by seed, wildlings and stem cuttings. One kg contains 60,000–90,000 dry seeds. Seed may be collected in large quantities and can be stored for up to 6 months. It is tolerant of drying, but not of freezing. Seed may be sown under shade or in full sunlight, provided watering is adequate. Germination starts 1–3 weeks after sowing and after 5–6 weeks about 70% of the seed has germinated. Young plants need plenty of water; therefore, direct sowing in the field is not appropriate. Containerized and bare-rooted seedlings planted under shade in the field showed 90% and 50–70% survival, respectively.

Stumps should be robust and at least 2.5 cm in diameter, to give a survival of close to 100%. Recommended shoot and root length are 20 cm and 30 cm, respectively. The survival rate drops sharply when thinner stumps are used.

In Java bishopwood has been planted in pure stands at 2 m × 3 m, and in mixed plantations in alternating rows with *Calophyllum inophyllum* L. and *Bombax ceiba* L. at 1 m × 3 m, and with *Acacia mearnsii* De Wild. at 2.5 m × 5 m.

Self-pruning of thick branches is good once the canopy closes, which takes at least 5 years at a spacing of 2 m × 3 m. Planting at a closer spacing is recommended to reduce this period. Pruning wounds heal very well; the tree may survive girdling involving the removal of a strip of bark 30 cm wide.

Bischofia javanica has become a weed in Florida. Roots spread superficially and the tree resprouts vigorously after cutting, making it difficult to eradicate.

In Java young trees are heavily attacked by top and twig borers, causing forked stems and even failure of plantations in less suitable locations. On favourable sites, the trees can grow rapidly and survive attack. Several fungi and insects attack the tree in its natural habitat, but little is known about diseases and pests in Africa. In China *Pseudocercospora bischofiae* is host-specific to bishopwood and appears to be a candidate agent for biological control for *Bischofia javanica*.

In Java an 8-year-old pure plantation on a moderately fertile soil and with a planting space of 2 m × 3 m yielded 12 m³/ha of clear-bole wood.

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

Prospects Because it frequently contains defects and has interlocked grain, bishopwood is less suitable for sawn wood applications. However, it is useful for bridge building and for other outdoor applications. Good-quality plywood and paper can be manufactured from it and bishopwood shows several positive features for the establishment of plantations, in pure or mixed stands. Selection or breeding of borer-resistant trees would make it more worthwhile to plant *Bischofia javanica* on less favourable soils. More research is needed into silvicultural aspects. For landscaping, better alternatives are generally available. Some caution is needed in using *Bischofia javanica* for timber plantations because it may behave as a weed that is difficult to eradicate.

Major references CAB International, 2005; Carter & Radcliffe-Smith, 1988; Kiefer & Bussmann, 2008; Sunarno, Martawijaya & Wheeler, 1995; World Agroforestry Centre, undated.

Other references Bolza & Kloot, 1972; Burgess, 1966; Eddowes, 1977; Kathriarachchi et al., 2005; Martawijaya et al., 1992; Tanaka et al., 1995; Whitmore, 1983; WHO, 2009; Yang, Lin & Kuo, 2006; Zheng et al., 2004.

Sources of illustration Sunarno, Martawijaya & Wheeler, 1995.

Authors L.P.A. Oyen

Based on PROSEA 5(2): Timber trees: Minor commercial timbers.

BIVINIA JALBERTII Tul.

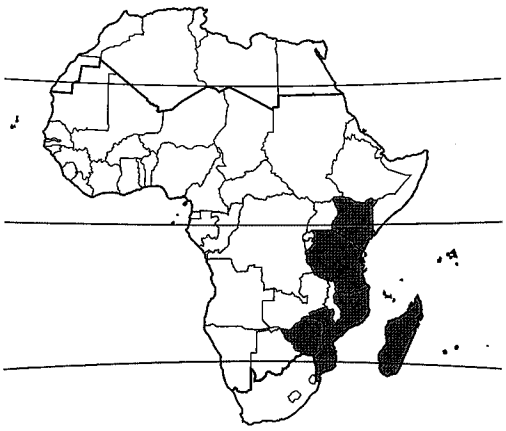
Protologue Ann. Sci. Nat., Bot., sér. 4, 8: 78 (1857).

Family Flacourtiaceae (APG: Salicaceae)

Vernacular names Cobweb tree (En).

Origin and geographic distribution *Bivinia jalbertii* occurs in restricted, dispersed localities from Kenya to Mozambique and in Madagascar, often in coastal regions.

Uses The wood is used in construction for poles, bridges and hydraulic works, and for heavy-duty flooring, indoor and outdoor join-



Bivinia jalbertii – wild

ery, interior trim and vehicle bodies. It is suitable for ship building, ladders, sporting goods, railway sleepers, toys, novelties, tool handles, boxes and crates. The tree has ornamental value.

Properties The heartwood is yellowish white and indistinctly demarcated from the up to 5 cm wide sapwood. Wood from Madagascar is medium-weight, with a density of 700–810 kg/m^3 at 12% moisture content, and rather hard. It air dries fairly well with little degrade. The rates of shrinkage are moderate, from green to oven dry 3.6–4.1% radial and 7.9–8.6% tangential. Once dry, the wood is stable in service. At 12% moisture content, the modulus of rupture is 156–165 N/mm^2, modulus of elasticity 9900–10,100 N/mm^2, compression parallel to grain 57–62 N/mm^2, and Chalais-Meudon side hardness 5.6–6.3.

The wood saws and works well with both machine and hand tools. It holds nails and screws well. The gluing properties are good and the wood paints well and takes a nice finish. It is reported to be resistant to borers and moderately resistant to termites.

Botany Deciduous shrub or small to medium-sized tree up to 30 m tall; bole branchless for up to 16 m, straight and cylindrical, up to 80(–100) cm in diameter; bark surface smooth, pale grey; branchlets greyish brown, with pale lenticels, short-hairy when young. Leaves alternate, simple; stipules absent; petiole up to 1.5 cm long, bright red; blade ovate to elliptical or slightly obovate, 4.5–10(–13) cm × 2.5–4(–6) cm, base broadly cuneate, apex acuminate, toothed, thinly papery, slightly hairy particularly at the midrib and veins but becoming glabrous, reddish below, pinnately veined with 7–8 pairs of lateral veins. Inflorescence a cylindrical, densely flowered raceme 5–12 cm long, short-hairy. Flowers bisexual, regular, greenish yellow; pedicel slender, 2–3(–4) mm long, jointed near the middle; sepals 4–6, ovate-deltoid, 2–3 mm long, short-hairy, with a gland at the base of each sepal; petals absent; stamens many, in fascicles of c. 10 alternating with the sepals, 3–4 mm long; ovary superior, globose, white hairy, styles 4–6. Fruit a globose capsule c. 3 mm in diameter, short-hairy, with persistent styles, dehiscing with 4–6 valves, few-seeded. Seeds almost cylindrical, c. 2 mm × 1 mm, dark brown, covered with white hairs up to 4 mm long.

Bivinia jalbertii grows moderately fast. In Zimbabwe it starts flowering when about 10 years old. In Madagascar it flowers in October–December; in Zimbabwe fruits ripen in November–May.

Bivinia comprises a single species; it closely resembles *Calantica*, which mainly differs in the presence of petals.

Ecology *Bivinia jalbertii* occurs in deciduous and semi-deciduous forest and coastal bushland, locally also in evergreen forest on rocky hills, up to 300 m altitude. In Zimbabwe it grows on hills with high rainfall and some dry-season mists north of the Limpopo River.

Management *Bivinia jalbertii* has been planted in Zimbabwe on a trial basis as a forestry species and as garden ornamental. It is easily propagated by seed. Young plants require ample water, but no special care. Trees coppice well.

Genetic resources and breeding *Bivinia jalbertii* has long been protected in Zimbabwe and is listed in the IUCN Red List as lower risk/near threatened, but its status needs revision. It is known from restricted localities in Zimbabwe and Mozambique, but is a little more widespread in Kenya, Tanzania and Madagascar. The relationship between the mainland African and Madagascan populations should be investigated as they could be genetically different.

Prospects The remaining stands of *Bivinia jalbertii* need protection. Controlled felling for timber seems justified only in locations were it is more common. Too little is known to assess its value as a plantation species.

Major references Coates Palgrave, 2002; Parant, Chichignoud & Rakotovao, 1985; Rakotovao et al., en préparation; Wild, 1960; World Conservation Monitoring Centre, 1998.

Other references Perrier de la Bâthie, 1946c; Schatz, 2001; Sleumer, 1975; Timberlake, 1996; Wild & Vidigal, 1973.

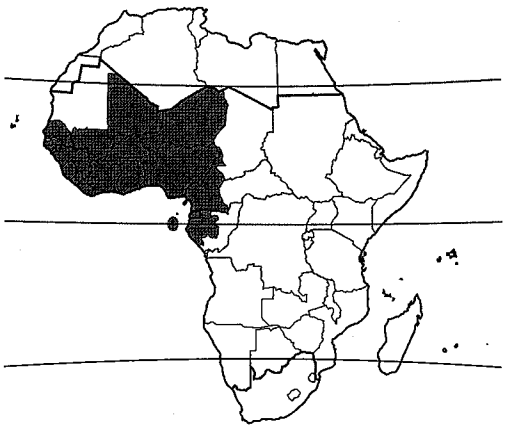
Authors D. Louppe & L.P.A. Oyen

BLIGHIA SAPIDA K.D.Koenig

Protologue Ann. Bot. 2: 571, t. 16–17 (1806).
Family Sapindaceae
Chromosome number $2n = 32$
Vernacular names Ackee, akee, akee apple, savory akee tree (En). Aki, fisanier, blighia savoureuse, fausse anacarde, pommier d'aki, arbre fricassé (Fr). Castanheiro de Africa, castanha de Africa, huevo vegetal castanha (Po).

Origin and geographic distribution *Blighia sapida* occurs naturally from Senegal to Cameroon and Equatorial Guinea, and possibly also in Gabon. It is commonly planted in its natural area of distribution, as fruit tree and ornamental shade tree. It has been introduced in many other tropical countries and in some subtropical regions such as Florida (United States) and is widely cultivated as fruit and ornamental tree in India and tropical America. It had already been introduced in tropical America by the end of the 18th century, and has since become locally naturalized.

Uses Wood of *Blighia sapida*, known as 'achin' or 'tsana', is mainly used for light construction and furniture, but sometimes also for casks, boxes, crates, food containers, packing cases, tool handles, paddles, pestles, mortars, handicrafts, carving and turnery. It is suitable for interior trim, joinery and railway sleepers. In Ghana, it is used as a substitute for niangon (*Heritiera utilis* (Sprague) Sprague). The wood is also used as firewood and for charcoal production.



Blighia sapida – wild and planted

Blighia sapida is commonly planted as ornamental shade tree. It is considered useful for soil improvement and erosion control. In traditional medicine, sap from terminal buds is instilled in the eyes to treat ophthalmia and conjunctivites. Bark and leaf decoctions are administered to treat oedema, intercostal pain, dysentery and diarrhoea. In Ghana, bark ground-up with capsicum pepper (*Capsicum annuum* L.) is rubbed on the body as stimulant and pulp of ground leafy twigs is rubbed on the forehead to treat migraine. In Côte d'Ivoire and Nigeria, ground leaves are applied as a paste together with plant salts to treat yaws and ulcers. In traditional medicine in Côte d'Ivoire, *Blighia sapida* is widely used for the treatment of yellow fever, epilepsy and oedema, and as a laxative and diuretic. The seeds are taken in Ghana to control nausea and vomiting. In Benin, leaves are used in the treatment of fever and vertigo, and twigs to treat hepatitis, cirrhosis and amygdalitis. In Togo, decoctions of bark or fruit walls are applied to wounds, and the fruit pulp to treat whitlow. Pounded bark is administered as an antidote to snake and scorpion bites, and pounded seeds to treat stomach complaints. Aqueous seed extracts are administered to expel parasites in Brazil. The pounded fruit is used as fish poison. Green fruits lather in water and are used by the Krobo people of Ghana as soap for washing and as a mordant for dyeing. Dried fruit husks are rich in potash and the ashes are used in making soap. Seeds of *Blighia sapida* yield a yellowish oil, believed to be edible. In Nigeria the seeds are used in making traditional soap.

Mature seed arils are eaten. They are not largely consumed in Africa, but considered a delicacy in some other parts of the world where *Blighia sapida* has been introduced. Ackee is also the national fruit of Jamaica. Boiled arils are an ingredient of a popular traditional dish in Jamaica, together with salt fish. In West Africa arils are sometimes eaten raw, fried or roasted. However, the arils of unripe seeds are toxic, as well as the seeds. An ink for tattoos is made from the seeds.

Production and international trade *Blighia sapida* timber has no importance on the international market, and even local importance seems to be limited because in many areas within its distribution area it occurs in low densities. However, in a study in south-western Nigeria, *Blighia sapida* was found to

be one of the most commonly logged and processed timber species.

The arils are commercially traded, mainly from Jamaica to American and European markets. Canned arils form the major product, in 2001 about 1.7 million kg, with frozen arils much less important with 13,000 kg. Orchards of *Blighia sapida* have also been established in Florida (United States), Mexico and Costa Rica. In 2005 total production of arils was valued at US$ 400 million. In Africa, the trade is local. In 1992 in northern Côte d'Ivoire, the price of 3 arils was about 10 FCFA.

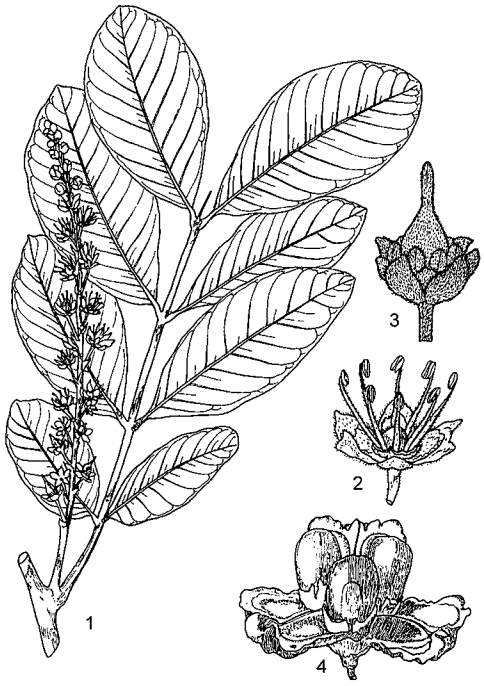
Properties The heartwood of *Blighia sapida* is orange-brown or reddish brown, and distinctly demarcated from the whitish sapwood. The texture is moderately coarse. The wood has little lustre. It is moderately heavy and hard. It is easy to work with both machine and hand tools. The wood moulds and sands well and takes an attractive finish. It is suitable for turnery. It is moderately durable and is quite resistant to termite attack.

The composition of 100 g of raw aril is approximately: water 58 g, protein 9 g, fat 19 g, carbohydrate 10 g, fibre 3.5 g, Ca 83 mg, P 98 mg, Fe 5.5 mg, thiamin 0.1 mg, riboflavin 0.2 mg, niacin 3.7 mg and ascorbic acid 65 mg.

A water-soluble and heat-stable toxic compound, hypoglycin A, is present in the aril of unripe seeds, as well as in the seed and in the pinkish to reddish tissue at the base of the aril. The Jamaican vomiting sickness is associated with this compound and is characterized by vomiting, generalized weakness, altered consciousness and sometimes even death. Hypoglycemia and depression of the central nervous system are common. The aril of fully ripe seeds after natural dehiscence of the fruit is nearly free of the toxic compound. The consumption of unripe seed arils has probably caused many cases of encephalopathy in children in Burkina Faso and other West African countries. The seeds contain about 26% of oil which is suitable for industrial applications.

Extracts of unripe fruits produced neutropenia and thrombocytopenia in mice, suggesting that they may be useful in the treatment of diseases such as chronic myeloid leukaemia, essential thrombocythaemia and polycythaemia.

Description Usually evergreen, dioecious, small to medium-sized tree up to 25(–30) m tall; bole branchless for up to 15 m and straight and cylindrical, but often much shorter and crooked or twisted, up to 80(–120) cm in diameter, often with small buttresses; bark surface



Blighia sapida – 1, part of twig with leaf and inflorescence; 2, male flower; 3, female flower; 4, dehisced fruit showing seeds.
Source: Flore analytique du Bénin

usually smooth but with lenticels in horizontal lines, grey to pale brown, inner bark granular, yellow to brown or pinkish, often mottled orange; crown dense and rounded; young twigs grooved, yellow-orange hairy, becoming glabrous. Leaves alternate, paripinnately compound with 3–5 pairs of leaflets; stipules absent; petiole 0.5–2.5 cm long, slightly winged, rachis up to 20 cm long; petiolules stout, up to 6 mm long; leaflets opposite, elliptical to obovate, 5–15 cm × 3.5–8 cm, lowest pair smallest, cuneate to rounded at base, rounded to short-acuminate at apex, margins entire or slightly wavy, papery or thinly leathery, dark green, slightly hairy below, pinnately veined with 8–14 pairs of lateral veins. Inflorescence an axillary, slender false raceme up to 20 cm long, hairy. Flowers probably functionally unisexual, regular, 5-merous, greenish white to greenish yellow, sweet-scented; pedicel up to 6 mm long, elongating up to 10 mm in fruit; calyx with tube about as long as lobes, 2–3 mm long; petals free, rhomboid, 3–4 mm long, hairy, with a 2-lobed scale on the inner face; stamens 6–10, free, filaments up to 6 mm long, hairy in lower

part; ovary superior, hairy, usually 3-lobed and 3-celled, style short; male flowers with rudimentary ovary, female flowers with reduced stamens. Fruit an obovoid to pear-shaped capsule 3.5–10 cm × 3–5 cm, slightly 3-lobed, yellow to red when ripe, glabrous, dehiscing with 3 woody valves hairy inside, usually 3-seeded. Seeds ovoid, 2–2.5 cm long, glossy black, with cream-coloured to yellow cup-shaped aril up to 2 cm long at base. Seedling with hypogeal germination; epicotyl c. 15 cm long, hairy; first 2 leaves opposite, with 3 elliptical or obovate leaflets up to 10 cm × 3.5 cm.

Other botanical information *Blighia* comprises 3 species and originates from tropical Africa. *Blighia sapida* can be distinguished from the other two species by its large fruits with rounded lobes.

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); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; (36: helical thickenings in vessel elements present); (37: helical thickenings throughout body of vessel element); (38: helical thickenings only in vessel element tails); 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; 65: septate fibres present; (66: non-septate fibres present); 69: fibres thin- to thick-walled; (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. Rays: 97: ray width 1–3 cells; 104: all ray cells procumbent; 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 138: prismatic crystals in procumbent ray cells.
(S. N'Danikou, P.E. Gasson & E.A. Wheeler)

Growth and development Initial growth of *Blighia sapida* is fast on moderately fertile soils. Seedlings grow best in gaps in the forest canopy, with a mean annual height increment of 70 cm. *Blighia sapida* is classified as a non-pioneer light demander. It has an extensive rooting system. In pure stands at a spacing of 3.5 m × 3.5 m in northern Côte d'Ivoire, the fastest growing trees reached 4 m tall 3 years after planting and the canopy was closed after 4.5 years. In Cameroon, young trees raised from seed started flowering after 5 years and first fruits developed after 7 years. In Florida, trees raised from seedlings start producing fruit after 3–6 years, while grafted trees produce fruit in 1–2 years.
Blighia sapida has been recorded to flower twice a year, first at the end of the dry season and a second time at the end of the rainy season. Fruits mature about 6 months after flowering, but in orchards fruit development may take only 2 months. It has been recorded that only about 4% of female or apparently bisexual flowers develop into a mature fruit. All-year-round flowering and fruiting have been recorded in tropical America. The flowers are pollinated by insects such as bees. Although trees in the natural area of distribution seem to be dioecious (male and female flowers on different trees), it has been reported in Jamaica that they are andro-monoecious (with male and bisexual flowers produced on the same tree). The seeds are probably dispersed by animals such as large birds and monkeys.

Ecology *Blighia sapida* occurs most commonly in semi-deciduous forest, but can also be found in evergreen forest as well as in forest outliers in savanna regions. In Côte d'Ivoire, it is most common in the transition zone between dry and moister forest and in gallery forest. It has been planted successfully in villages in much drier zones in Mali and Burkina Faso. The natural habitat of the species is obscured by the common planting around villages and further spread from there into the forest. It prefers well-drained deep fertile soils, but occurs also on non-fertile sandy soils and limestone. In drier regions it is often found on termite mounds. It does not tolerate waterlogged soils and cannot withstand flooding. It shows some resistance to fire.

Propagation and planting Generally, *Blighia sapida* regenerates fairly well naturally. The weight of a seed is about 3 g. Seeds are sensitive to desiccation and are considered short-lived. It is recommended to sow them within a few days after extraction from the fruit. However, seeds can be kept for 3 months in moist storage at 21°C. Germination starts after 2–4 weeks, with a germination rate of 80%. In Florida, seeds are sown in germination boxes and germination is said to take normally 2–3 months. Seedlings should be watered regularly in the nursery before transplanting. It is

recommended to transplant in full sunlight and at a spacing of 4 m for timber production and 6–9 m for fruit production.
For planting, *Blighia sapida* is usually propagated by seed, but cuttings can also be used; these readily develop roots under proper conditions. Propagation by grafting and air layering was also successful.

Management In areas with occasional flooding, mounds of 60–90 cm high are made before transplanting of seedlings to ensure plant survival. In Florida and other regions where *Blighia sapida* is planted for commercial fruit production, young trees are fertilized every 1–2 months during the first year. Topping the main shoot at a height of about 5 m is recommended to facilitate fruit harvesting. It is recommended to control tree form by pruning several times when the tree is grown for timber production. Trees often sprout vigorously from stumps.
In Benin, the most common management practices to improve fruit production are pruning, protection against livestock, fire protection, mulching of seedlings and saplings, and association with annual crops. In northern Côte d'Ivoire, trees have generally a private owner, whereas most other trees are collective property.

Diseases and pests In Florida, an attack by *Verticillium dahliae* has been recorded, causing wilt and dieback. In Jamaica, stem galls are common.

Harvesting Arils for fresh consumption should be picked from dehisced fruits, which ensures that the seeds and arils are fully ripe and that arils do not contain serious amounts of toxin. Another appropriate method is to collect unopened but ripe fruits from the tree and lay them on racks in the sun. Arils can be harvested from the fruits when they have opened after about 3 days.

Yield In Florida, a tree may produce 45–68 kg of fruits per year.

Genetic resources There seems to be no reason to consider *Blighia sapida* to be under threat of genetic erosion. It is quite widespread and is commonly planted. Research in Benin showed that *Blighia sapida* has moderate levels of genetic diversity in Benin and little differentiation among populations and climatic zones. Nine distinct criteria, mostly related to fruit characteristics, have been used to differentiate between types.

Breeding In Jamaica, some different fruit types of *Blighia sapida* have been developed, mainly differing in the aril, which may be soft and yellow or firm and cream-coloured.

Prospects Wood of *Blighia sapida* is currently not commercially important, but it is a multipurpose tree, being a source of edible fruits (arils) and traditional medicine, and being popular for planting as ornamental shade tree. *Blighia sapida* is a nice ornamental tree, especially when decorated with the brightly coloured fruits. It is also considered useful for planting to improve soil fertility and to reduce erosion through its large rooting system. In 2003 *Blighia sapida* emerged as a high-priority species for domestication in Benin after a national survey.
Extensive research has been carried out on the toxicity of different parts of the fruit. The edible arils certainly offer possibilities for economic development in tropical Africa, but lessons learnt from tropical America and Burkina Faso regarding the toxicity of compounds should be taken into serious consideration. Educational campaigns are needed to prevent fatalities. More pharmacological studies are recommended in view of the wide applications of different plant parts in traditional medicine. The seed oil is promising for industrial use, especially as lubricant and speciality surfactant.

Major references Akintayo, Adebayo & Arogundade, 2002; Aubréville, 1959c; Burkill, 2000; Ekué et al., 2009; Janick & Paull (Editors), 2006; Meda et al., 1999; Omobuwajo, Sanni & Olajide, 2000; Oteng-Amoako (Editor), 2006; Vivien & Faure, 1985; World Agroforestry Centre, undated.

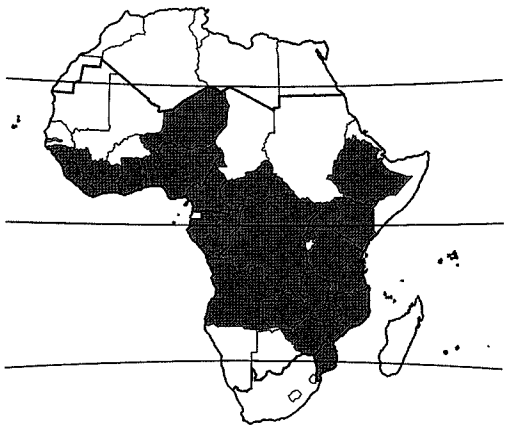
Other references Akoègninou, van der Burg & van der Maesen (Editors), 2006; Arbonnier, 2004; Barceloux, 2009; Crane & Balerdi, 2008; Fouilloy & Hallé, 1973a; Gardner et al., 1996; Goldson, 2005; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Irvine, 1961; Keay, 1958j; Keay, 1989; Kennedy, 1936; Kyari, 2008; Liu et al., 2008a; McMillan, Graves & Wood, 2003; Morton, 1987; Neuwinger, 2000; Oke & Oyedare, 2008; Vivien & Faure, 1996.

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

Authors A. Asamoah, C. Antwi-Bosiako, K. Frimpong-Mensah, A. Atta-Boateng, C.S. Montes & D. Louppe

BLIGHIA UNIJUGATA Baker

Protologue Oliv., Fl. trop. Afr. 1: 427 (1868).
Family Sapindaceae
Chromosome number $2n = 32$



Blighia unijugata – wild

Vernacular names Triangle tops (En). Mwakamwatu, mkivule (Sw).

Origin and geographic distribution *Blighia unijugata* is widespread in tropical Africa, extending from Guinea Bissau eastwards to Ethiopia and Kenya, and through DR Congo southwards to Angola, Zimbabwe and Mozambique. It is also found in South Africa.

Uses The wood of *Blighia unijugata* is commonly used for light construction, light flooring, interior trim, joinery, furniture, mine props, toys, novelties, agricultural implements, musical instruments, boxes, crates, turnery and carving. It is suitable for ship building, veneer, plywood and pulpwood. It is also used as firewood and for charcoal production.

The leaves are eaten as a vegetable in Nigeria. Various parts of the tree are considered to have sedative and analgesic properties. They are used in traditional medicine for the treatment of rheumatism, kidney pain and stiffness, and they are reputed to have oxytocic action in childbirth. Bark pulp is applied as an enema or a bark decoction is taken to treat fever, and as purgative. In Côte d'Ivoire leaf pulp is administered as an embrocation to serve as rejuvenant and relaxant. In Congo the leaves are used in vapour baths for the treatment of fever in children, and as tonic. Fruits have been used in Nigeria for the treatment of nausea and vomiting. In the Central African Republic seed oil is used in medicinal ointments and a leaf decoction to treat vertigo. Macerated twigs, leaves, flowers and fruits are used as fish poison. In Sierra Leone the seeds are reported to be edible. In South Africa the pleasantly scented flowers are sometimes soaked in water to make a fragrant cosmetic lotion.

Blighia unijugata is commonly planted as a village shade tree. In Kenya and Ethiopia, the trees are often left after land clearance or sometimes planted to provide shade in coffee plantations. The flowers provide nectar and pollen for honey bees.

Production and international trade The wood of *Blighia unijugata* is used locally and only occasionally traded on the international market.

Properties The heartwood is pale reddish brown and indistinctly demarcated from the yellowish white sapwood. The grain is fairly straight, texture medium to fine.

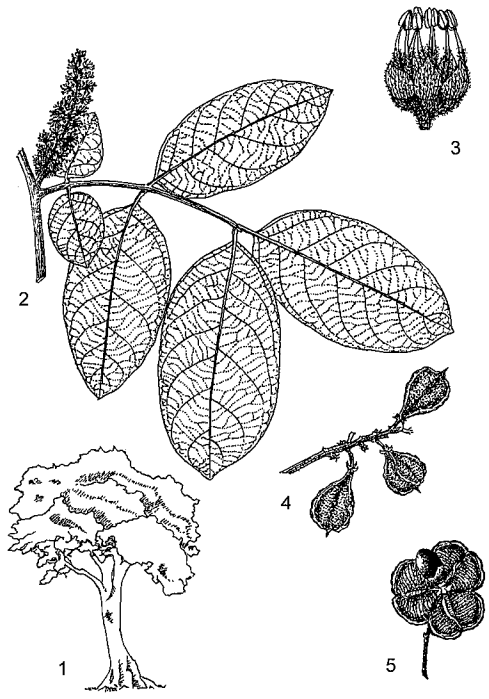
The wood is medium-weight, with a density of 560–640 kg/m^3 at 12% moisture content, and fairly hard. It air dries slowly but usually well with little degrade. However, the shrinkage rates are quite high, from green to oven dry 5.1% radial and 8.1% tangential. At 12% moisture content, the modulus of rupture is 92 N/mm^2, modulus of elasticity 11,170 N/mm^2, compression parallel to grain 49 N/mm^2 and shear 15.5 N/mm^2.

The wood works well with machine tools, but blunting of tools is rather rapid. It is difficult to work by hand, but takes a good finish and polishes well. Splitting is common during nailing and pre-boring is recommended. It is also recommended to give good support at the exit face on mortising and boring. The wood is somewhat difficult to glue. The heartwood is moderately durable, but the sapwood is susceptible to *Lyctus* attack. The heartwood is moderately resistant to preservative treatment, the sapwood is permeable.

Tests in Nigeria showed an oil yield of 51% in the aril and 14% in the seed. The composition of the aril is: water 3.3%, protein 20%, fat 51%, carbohydrate 9% and fibre 11%; and of the seed: water 6.1%, protein 14%, fat 14%, carbohydrate 54% and fibre 6%. The oils from arils and seeds were found to be rich in macronutrients and appear to be a good source of minerals. Triacylglycerol is the dominant lipid compound in the oils, with 88% and 91% respectively for aril and seed.

Ethanol extracts of roots, bark and leaves showed antibacterial activity, with pronounced activity against *Staphylococcus aureus*. In all the extracts the presence of steroids, saponins and tannins has been demonstrated.

Description Dioecious, small to medium-sized tree up to 30(–35) m tall; bole often quite short, usually straight, up to 180(–200) cm in



Blighia unijugata – 1, tree habit; 2, part of twig with leaf and inflorescence; 3, male flower; 4, fruits; 5, dehisced fruit showing seed. Redrawn and adapted by Iskak Syamsudin

diameter, slightly fluted at base; bark surface fairly smooth, but often with horizontal ridges and warts, grey to dark green, inner bark thin, brittle, granular, white to pale red or brown with white streaks; crown dense and rounded; young twigs finely orange-brown hairy, becoming glabrous. Leaves alternate, paripinnately compound with (1–)2–4(–5) pairs of leaflets; stipules absent; petiole up to 4 cm long, flattened above, rachis up to 10 cm long; petiolules up to 2 mm long; leaflets opposite, elliptical to oblong or obovate, up to 30 cm × 13 cm but often small in lowest pair, cuneate to obtuse at base, acuminate at apex, margins entire or slightly wavy, glabrous except for tufts in the axils of lateral veins, pinkish red or whitish when young, later becoming glossy dark green above and dull green below, pinnately veined with 6–10(–12) pairs of prominent lateral veins. Inflorescence an axillary false raceme up to 10 cm long. Flowers unisexual, regular, 5-merous, whitish or yellowish, sweet-scented; pedicel up to 5 mm long, elongating up to 10 mm in fruit; calyx with tube about as long as lobes, c. 2 mm long; petals free, rhomboid, c. 2 mm × 2 mm, hairy, with a 2-lobed scale on the inner face; stamens 6–10, free, filaments c. 4 mm long, hairy in lower part; ovary superior, golden-hairy, usually 3-lobed and 3-celled, style short; male flowers with rudimentary ovary, female flowers with reduced stamens. Fruit a top-shaped, usually 3-gonous capsule 2–3 cm × 2.5–3 cm, pointed at apex, red when ripe, slightly hairy, dehiscing with 3 woody recurving valves pink inside with yellow margins, usually 3-seeded. Seeds ovoid, 1–2 cm long, glossy dark brown to black, with yellow cup-shaped aril up to 1 cm long at base. Seedling with hypogeal germination; epicotyl c. 6 cm long, hairy; first 2 leaves opposite, with 3 obovate leaflets up to 4 cm × 2 cm.

Other botanical information *Blighia* comprises 3 species and is restricted to tropical Africa. *Blighia unijugata* can be distinguished from the other two species by its leaflets having tufts of hairs in the axils of lateral veins and its fruits which are up to 3 cm long (at least 4 cm long in the other species).

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); 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; 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. 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. Rays: 96: rays exclusively uniseriate; (97: ray width 1–3 cells); (100: rays with multiseriate portion(s) as wide as uniseriate portions); 104: all ray cells procumbent; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 138: prismatic crystals in procumbent ray cells. (S. N'Danikou, A.A. Oteng-Amoako & P. Baas)

Growth and development In general, *Blighia unijugata* is considered to grow rapidly. The tree is attractive, with its decoratively

coloured new leaves and red fruits. In Ghana and Nigeria, flowering is from December to April and ripe fruit is found around March. In Côte d'Ivoire trees have been reported to flower twice a year, January–April and September–October; ripe fruits have been recorded in March and October. In southern Africa flowering occurs from September to October and fruits are found from September to February. The flowers attract large numbers of flies, which probably serve as pollinators. The seeds with their yellow aril are eaten by birds, duikers, monkeys such as mangabeys, and chimpanzees, which may be important seed dispersers.

Ecology *Blighia unijugata* occurs mostly in moist evergreen forest, but also in semi-deciduous forest, in more dry areas in riverine forest, and in wooded grassland and then often associated with termite mounds, up to 1900 m altitude.

Propagation and planting Natural regeneration of *Blighia unijugata* usually occurs in disturbed forest. For planting, it is propagated by seeds and wildlings. Seeds germinate readily. It is recommended to sow in pots before transplanting. Pretreatment of seeds before sowing is not necessary. Dried seeds can be stored for considerable time in sealed containers in a cool and dry place. Thin stem cuttings may root in sand and can also be used for propagation.

Management *Blighia unijugata* can be managed by coppicing and pollarding.

Diseases and pests The larvae of the butterfly gold-banded forester (*Euphaedra neophron*) are reported to feed on leaves of *Blighia unijugata* in Mozambique. In Tanzania infestation by the parasitic plant *Tapinanthus bangwensis* (Engl. & K.Krause) Danser has been recorded as locally problematic in plantations of *Blighia unijugata* mixed with other tree species.

Genetic resources *Blighia unijugata* is widespread and in many regions within its geographical range common. It is unlikely that it suffers from genetic erosion. However, in several countries in southern Africa, e.g. Zambia and South Africa, it is uncommon.

Prospects *Blighia unijugata* is a useful local source of wood and traditional medicine. Although little is known about growth rates, it seems to be a fast growing tree and is considered suitable for commercial plantations. It is promising for planting in agroforestry systems. Further research is warranted on the potentials of the seeds, which could be considered for use as feed supplements and in the food industry.

Major references Ayodele, Ajayi & Adewuyi, 2008; Bekele-Tesemma, 2007; Bolza & Keating, 1972; Burkill, 2000; Chikamai et al., undated; Davies & Verdcourt, 1998; Katende, Birnie & Tengnäs, 1995; Maundu & Tengnäs (Editors), 2005; Neuwinger, 2000; Takahashi, 1978.

Other references Aubréville, 1959c; Coates Palgrave, 1983; Exell, 1966; Fowden et al., 1972; Hauman, 1960; Hyde & Wursten, 2009; Ilesanmi, 2006; Irvine, 1961; Keay, 1958j; Keay, Onochie & Stanfield, 1964; Krief, Hladik & Haxaire, 2005; Lekunze & Hassan, 2001; Liu et al., 2008b; Masette, 2006; Muoghalu, 2006; Oderinde, Ajayi & Adewuyi, 2009; Okafor & Fernandes, 1987; Starratt & Caveney, 1995; White, 1962; Wieczkowski & Kinnaird, 2008.

Sources of illustration Exell, 1966; Katende, Birnie & Tengnäs, 1995.

Authors E.A. Obeng

BLIGHIA WELWITSCHII (Hiern) Radlk.

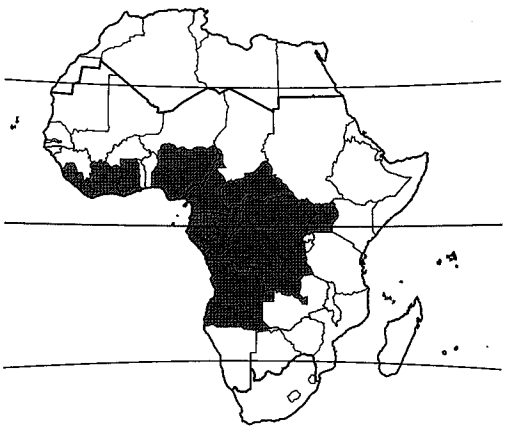
Protologue Engl., Pflanzenr. IV 165: 1146 (1933).

Family Sapindaceae

Chromosome number $2n = 32$

Origin and geographic distribution *Blighia welwitschii* occurs from Sierra Leone eastward to Uganda and south to DR Congo and northern Angola. It is only occasionally planted, for instance in botanical gardens.

Uses The wood, traded as 'tsana', is commonly used for light construction, light flooring,



Blighia welwitschii – wild

joinery, interior trim, furniture, poles, piles, mine props, toys, novelties, boxes, crates, pestles, mortars, agricultural implements, oars and turnery. It is suitable for ship building, railway sleepers, veneer, plywood and pulpwood.

In DR Congo the bark is used as a revulsive on the skin to relieve kidney, costal and lumbago pain. A bark decoction is taken as a purgative and to treat cough. Powdered leaves are eaten with ripe banana as an aphrodisiac. In Côte d'Ivoire and Nigeria, leaf decoctions are taken as cholagogue. In Congo leaf sap is applied to treat ear inflammations. In Sierra Leone the bark, young leaves, fruits and seeds are used as fish poison.

In Liberia the fragrant young leaves are used for flavouring soup. Mature seed arils are eaten, but the arils of unripe seeds may be toxic, as well as the seeds.

Production and international trade The wood is locally used and rarely traded on the international market.

Properties The heartwood is pale brown to reddish brown, often with white specks, and usually distinctly demarcated from the white to pinkish yellow, about 10 cm wide sapwood. The grain is straight or interlocked, texture usually moderately fine. Quarter-sawn material usually shows a ribbon stripe of narrow vertical bands alternately yellow and brown. The wood is moderately lustrous.

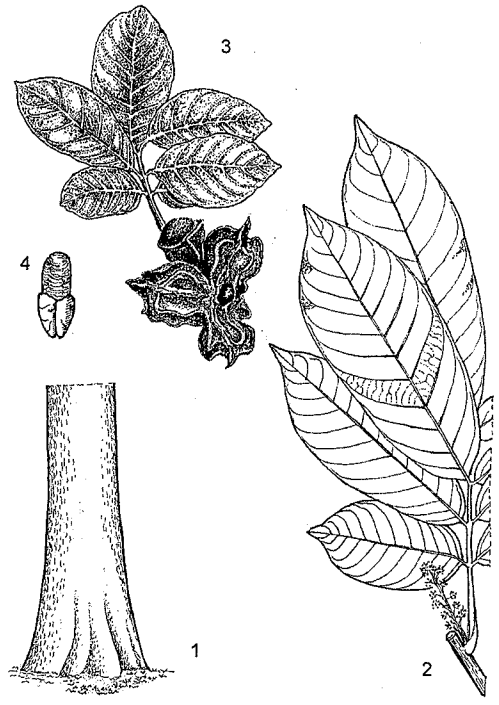
The wood is moderately heavy to heavy with a density of 730–950 kg/m^3 at 12% moisture content, and very strong, tough and quite hard. The rates of shrinkage are high, from green to oven dry 6.5–7.0% radial and 10.3–11.5% tangential. It is recommended to quarter-saw logs immediately after felling to prevent checking during drying. Once dry, the wood is rather unstable in service.

At 12% moisture content, the modulus of rupture is 112–205 N/mm^2, modulus of elasticity 15,000 N/mm^2, compression parallel to grain 69–84 N/mm^2, cleavage 25–36 N/mm and Chalais-Meudon side hardness 6.4–7.4.

The wood saws well but slowly, and works easily with both machine and hand tools despite its high density. It polishes and sands to an attractive finish. It has good nailing and screwing properties and hold nails firmly, and glues moderately well. The wood is moderately durable and quite resistant to insect attacks, but it is susceptible to *Lyctus* attack. It is difficult to treat with preservatives.

Several saponins have been isolated from the fruits, some of which showed insecticidal activity against *Spodoptera frugiperda* and toxicity in the brine shrimp test.

Description Evergreen, dioecious, medium-sized to fairly large tree up to 40(–50) m tall; bole branchless for up to 30 m, cylindrical, usually straight, up to 100(–180) cm in diameter, slightly fluted at base or sometimes with small, thick buttresses; bark surface smooth to slightly fissured or flaky, grey to brown, inner bark hard, granular, yellow to orange, often yellow-brown mottled; crown often dense, with ascending branches, dark green; young twigs orange-hairy, soon becoming glabrous and dark brown. Leaves alternate, paripinnately compound with 2–4 pairs of leaflets; stipules absent; petiole up to 8(–16) cm long, narrowly winged, rachis up to 15 cm long; petiolules up to 1 cm long; leaflets opposite, narrowly elliptical to oblong-elliptical, up to 25(–40) cm × 8.5(–10) cm but often much smaller in lowest pair, cuneate to obtuse and sometimes asymmetrical at base, short-acuminate at apex, margins entire or slightly wavy, leathery, nearly glabrous,



Blighia welwitschii – 1, base of bole; 2, part of twig with leaf and inflorescence; 3, leaf and fruits; 4, seed.
Redrawn and adapted by Isaac Ossei Agyekumhene

pale brown when young, later becoming olive green, pinnately veined with 7–14(–20) pairs of lateral veins. Inflorescence an axillary false raceme up to 12(–15) cm long. Flowers unisexual, regular, 5-merous, white or greenish white, sweet-scented; pedicel up to 8 mm long, elongating up to 10 mm in fruit; calyx with tube much shorter than lobes, c. 2 mm long; petals free, rhomboid, up to 5 mm × 3 mm, hairy, with a large scale on the inner face; stamens 7–8, free, filaments c. 5 mm long, hairy; ovary superior, hairy, usually 3-lobed and 3-celled, style about as long as ovary; male flowers with rudimentary ovary, female flowers with reduced stamens. Fruit a top-shaped or pear-shaped, usually 3-gonous capsule 3.5–8 cm × 2.5–4.5 cm, pointed at apex, orange to red when ripe, glabrous, dehiscing with 3 woody recurving valves hairy inside, up to 3-seeded. Seeds ovoid to ellipsoid, 2–3 cm long, glossy dark brown to purplish black, with yellow cup-shaped aril up to 2 cm long at base. Seedling with hypogeal germination; epicotyl 10–15 cm long, hairy; first 2 leaves opposite, with 3 obovate leaflets up to 12 cm × 4 cm.

Other botanical information *Blighia* comprises 3 species and is restricted to tropical Africa. *Blighia welwitschii* can be distinguished from the other two species by its fairly large fruits with sharp-edged lobes. Var. *bancoensis* Aubrév. & Pellegr. has been described from Côte d'Ivoire and is characterized by comparatively small fruits (3.5–4 cm long).

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; (7: vessels in diagonal and/or radial pattern); 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; 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: 75: axial parenchyma absent or extremely rare; 78: axial parenchyma scanty paratracheal; (79: axial parenchyma vasicentric); (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; 104: all ray cells procumbent; (106: body ray cells procumbent with one row 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.
(S. N'Danikou, A.A. Oteng-Amoako & P. Baas)

Growth and development In Côte d'Ivoire *Blighia welwitschii* trees have been recorded to flower between August and May, but most commonly in November. They develop ripe fruits about 6 months after flowering; in Côte d'Ivoire and Gabon fruits mature most commonly in December to February. The seeds with their yellow aril are probably dispersed by animals such as large birds and monkeys. In Gabon they are a favorite food of the African grey parrot.

Ecology *Blighia welwitschii* occurs mostly in moist evergreen forest, in primary as well as secondary forest, but it can also be found in semi-deciduous forest. In Uganda it is found up to 1150 m altitude.

Management In general *Blighia welwitschii* occurs at low density in the forest. Locally in Cameroon, an average density of 2.7 trees of more than 15 cm in bole diameter per ha has been recorded, with an average wood volume of 2.1 m^3/ha.

Diseases and pests In Côte d'Ivoire *Blighia welwitschii* has been reported to be a host of okra mosaic virus. *Blighia welwitschii* showed symptoms that were similar to that of the infected vegetables, i.e. leaves with chlorosis near the veins, and was considered to pose a risk when planted close to okra fields.

Genetic resources *Blighia welwitschii* is widespread and not extensively logged. Therefore, it does not seem to be liable to genetic erosion at present.

Prospects *Blighia welwitschii* is a useful local source of wood and traditional medicine. Research is warranted on growth rates, regeneration and propagation, as well as management requirements for sustainable production, before any judgement can be made about its potential role in commercial timber production. Investigations on the possible toxicity of young leaves and seed arils are needed to guarantee safe consumption by humans.

Major references Aubréville, 1959a; Bolza & Keating, 1972; Burkill, 2000; Davies & Verdcourt, 1998; de Koning, 1983; Hauman, 1960; Savill & Fox, 1967; Takahashi, 1978; Vivien & Faure, 1985; Wilks & Issembé, 2000.

Other references Fouarge & Gérard, 1964; Fouilloy & Hallé, 1973a; Fouilloy & Hallé, 1973b; Givord, 1978; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Hubrecht et al., 1989; Irvine, 1961; Keay, 1958j; Keay, Onochie & Stanfield, 1964; Neuwinger, 2000; Oteng-Amoako (Editor), 2006; Penders & Delaude, 1994; Penders et al., 1989; Sallenave, 1955; White & Abernethy, 1997.

Sources of illustration Aubréville, 1959a; Vivien & Faure, 1985; White & Abernethy, 1997; Wilks & Issembé, 2000.

Authors E.A. Obeng

BOBGUNNIA FISTULOIDES (Harms) J.H.Kirkbr. & Wiersema

Protologue Brittonia 49(1): 3 (1997).

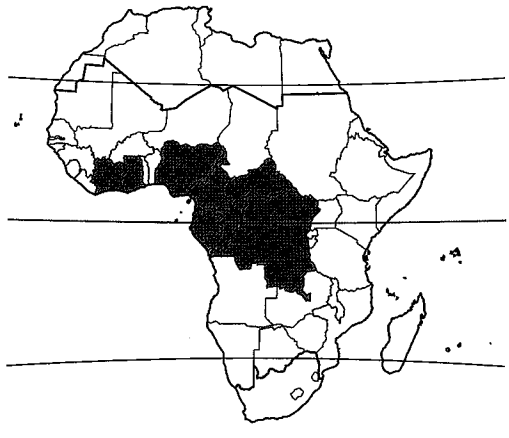
Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 16$

Synonyms *Swartzia fistuloides* Harms (1910).

Origin and geographic distribution *Bobgunnia fistuloides* occurs in Côte d'Ivoire and Ghana and from Nigeria and Cameroon southward to Cabinda (Angola).

Uses The wood of *Bobgunnia fistuloides*, named 'pau rosa' or 'boto' in trade, is traditionally used for house posts, percussion instruments, mortars, pestles and carvings. It is also used for cabinet work and for barrels and containers for acid products. It is suitable for heavy flooring, interior trim, mine props, ship building, furniture, sporting goods, toys, novelties, musical instruments, boxes, crates, agricultural implements, tool handles, turnery and veneer. It is a good firewood.



Bobgunnia fistuloides – wild

The bark is used as fish poison. In traditional medicine in Gabon and Congo, young children are bathed in a warm decoction of the bark to treat fever. In Congo a bark macerate is used as a bath to treat skin diseases and filariasis of the eye. A decoction of the bark mixed with sweet peppers is taken by nursing mothers to stimulate milk production. In Congo a bark extract is taken by men against gonorrhoea and by women against various menstrual problems. In Gabon bark decoctions are drunk against diarrhoea.

Production and international trade The wood of *Bobgunnia fistuloides* has been traded internationally as 'pau rosa', sometimes as a substitute of rosewood (*Dalbergia* spp.), but trade is insignificant since the species has become more rare. Gabon exported on average 1600 m^3 of logs per year from 1994 to 1999 and 3150 m^3/year in 2000–2003.

Properties The heartwood is pale red, turning purplish upon exposure, with yellowish or reddish brown stripes on quarter-sawn surfaces, and clearly demarcated from the 1–2 cm thick, whitish or yellowish sapwood. The grain is wavy or slightly interlocked, texture fine to coarse and even.

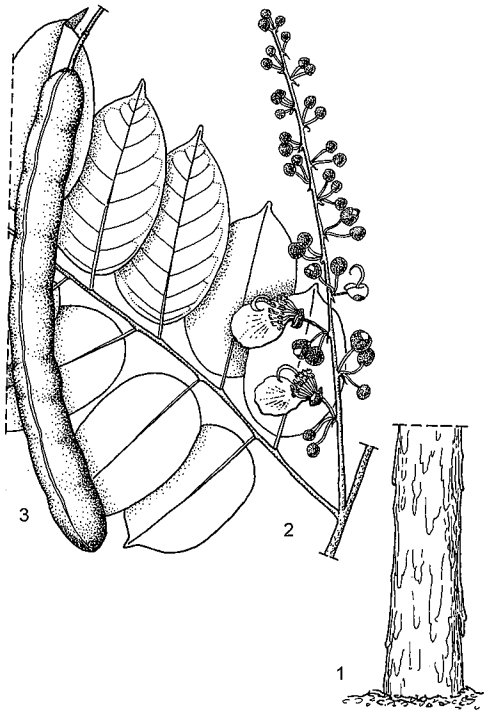
The wood is very heavy, with a density of about 1020 kg/m^3 at 12% moisture content, and very hard. It dries slowly but fairly well, with little risk of distortion but a high risk of surface checking and some end checking. The shrinkage rates are moderate, from green to oven dry 3.8–4.8% radial and 5.7–6.2% tangential. Once dry the wood is moderately stable to unstable in service. At 12% moisture content, the modulus of rupture is (149–)166–223 N/mm^2, modulus of elasticity 16,475–17,840(–21,290) N/mm^2, compression parallel to grain 90–95 N/mm^2, shear 11–12 N/mm^2, cleavage 20–40 N/mm and Chalais-Meudon side hardness 8.7–9.5.

Considerable force is required for sawing; saw blades may vibrate or overheat. The wood works well with machine tools. For such a hard and dense wood, the blunting effect on cutting edges is only average and special alloy tools are not required. The wood planes and finishes fairly well, but sometimes surfaces are slightly woolly. The nailing and screwing properties are good, but pre-boring is required. The wood has a tendency to char upon boring. It glues satis-

factorily. The slicing properties are good but the wood is not suitable for rotary peeling. It is durable, being resistant to fungal, dry-wood borer and termite attacks, but damage by pinhole borers in the sapwood has been reported. The wood is suitable for use in contact with the ground or fresh water. The heartwood is resistant to impregnation with preservatives. Sawdust may be irritating to mucous membranes in wood workers.

The wood is resistant to some acid products. It contains 32–35% cellulose, 26–28% lignin, 12.5–16.5% pentosan, 0.1–0.4% ash and little silica. The solubility is 16.0–25.5% in alcohol-benzene, 1.8–2.3% in hot water and 13.2–18.1% in a 1% NaOH solution.

Description Medium-sized tree up to 25(–40) m tall; bole often slightly sinuous or twisted, up to 80(–120) cm in diameter, base slightly swollen and fluted; bark surface slightly fissured, scaly leaving large irregular patches, greenish yellow to whitish grey, inner bark fibrous, creamy to yellowish with yellowish brown streaks, with watery exudate; crown often large, with sinuous branches; twigs glabrous. Leaves alternate, imparipinnately compound with (5–)8–20 leaflets; stipules minute, persistent; petiole 2–6.5 cm long, rachis 14–27 cm long, nearly glabrous; petiolules c. 0.5 cm long, wrinkled, slightly hairy; leaflets alternate, elliptical to ovate, 5–12.5 cm × 3–6.5 cm, usually increasing in size towards leaf apex, base obtuse, apex acuminate, nearly glabrous, pinnately veined. Inflorescence an axillary false raceme up to 30 cm long, many-flowered, glabrous to slightly hairy, with flowers in groups of 1–4. Flowers bisexual, zygomorphic, sweet scented; pedicel 1–2 cm long; calyx irregularly 2–4(–7)-lobed; petal 1, nearly round to broadly obovate, 2–3 cm × 1.5–2 cm, pinkish white with yellow patch at base inside, crinkled, short-hairy outside, with short claw at base; stamens numerous, unequal, up to 2.5 cm long, bright orange; ovary superior, c. 1 cm long, glabrous, on up to 1 cm long stipe, style short. Fruit a woody, cylindrical pod up to 30(–80) cm × 1.5–3 cm, straight or curved, shiny reddish brown to dark brown or black when ripe, indehiscent, many-seeded. Seeds oblong to kidney-shaped, flattened, c. 1 cm × 1 cm, shiny brown or greyish. Seedling with epigeal germination; hypocotyl 3–4(–7) cm long, epicotyl c. 2 cm long, hairy; cotyledons leafy, rounded, c. 3 cm long; first leaves alternate, simple.



Bobgunnia fistuloides – 1, base of bole; 2, part of flowering twig; 3, fruit.
Redrawn and adapted by G.W.E. van den Berg

Other botanical information *Bobgunnia* comprises 2 species and is confined to mainland tropical Africa. It has been separated from *Swartzia*, a genus of over 100 species in tropical America, mainly on the basis of seed characteristics, but flower structure is similar and molecular studies also point to inclusion in *Swartzia*.

Traditionally, *Bobgunnia* and *Swartzia* are 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.

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); 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; 70: fibres very thick-walled. Axial parenchyma: 80: axial parenchyma aliform; (81: axial parenchyma lozenge-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; 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; 116: ≥ 12 rays per mm. Storied structure: 118: all rays storied; 120: axial parenchyma and/or vessel elements storied. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; (143: prismatic crystals in fibres).
(E. Ebanyenle, P.E. Gasson & E.A. Wheeler)

Growth and development Flowering is reported in May in Côte d'Ivoire and in July in Ghana, but in Gabon flowering and fruiting are asynchronous throughout the year. Fruits have a strong yeasty smell and are eaten by elephants, which serve as the main seed dispersers. Seedlings are commonly found in elephant dung.

Ecology *Bobgunnia fistuloides* is usually a tree of the second storey of rainforest and semi-deciduous forest, up to 500 m altitude.

Propagation and planting Good natural regeneration has been observed in logged-over forest in Gabon. There are 3000–5000 seeds per kg. The seeds start germinating 5–10(–20) days after sowing, and the germination rate is high. In Congo seeds are extracted from the fruits and dried in the sun for 2–4 days; germination started after 7–8 days and the germination rate was up to 96%.

Management Larger trees of *Bobgunnia fistuloides* occur scattered in the forest and are generally uncommon. In forest in Cameroon an average density of 0.01 tree with a bole diameter of more than 60 cm has been recorded per ha, with an average wood volume of 0.1 m^3/ha. In Gabon a mean wood volume of 0.4 m^3/ha has been reported.

Harvesting The minimum bole diameter for harvesting is 50 cm in Cameroon, 60 cm in Gabon and 70 cm in the Central African Republic.

Handling after harvest Logs do not float in water and cannot be transported by river.

Genetic resources *Bobgunnia fistuloides* is classified as endangered in the IUCN Red list. Although widespread in West and Central Africa, it only occurs in closed forest and is exploited at a moderately high level for its decorative timber, and its population is estimated to have been reduced by 80% during the last 3 generations. Its natural regeneration may be hampered locally by the absence of its main seed disperser, the forest elephant.

Prospects *Bobgunnia fistuloides* yields an excellent decorative timber, but due to exploitation, loss of habitat and poor regeneration it is classified as endangered. Regulation of the trade of its wood under CITES regulations is recommended. It deserves more research attention, especially on propagation methods and silvicultural management to judge its prospects for sustainable production of its valuable timber. Of its traditional uses, the medicinal ones may remain most important.

Major references African Regional Workshop, 1998; Aubréville, 1968; Bolza & Keating, 1972; Burkill, 1995; CIRAD Forestry Department, 2008; de la Mensbruge, 1966; de Saint-Aubin, 1963; Kirkbride & Wiersema, 1997; Takahashi, 1978; Vivien & Faure, 1985.

Other references Aubréville, 1959b; Aubréville, 1970; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Hepper, 1958; Irvine, 1961; Keay, 1989; Neuwinger, 2000; Normand & Paquis, 1976; Sallenave, 1955; Savard, Besson & Morize, 1954; Tailfer, 1989; White & Abernethy, 1997; Wilczek et al., 1952; Wilks & Issembé, 2000.

Sources of illustration Aubréville, 1970; Wilks & Issembé, 2000.

Authors L.P.A. Oyen

BOBGUNNIA MADAGASCARIENSIS (Desv.) J.H.Kirkbr. & Wiersema

Protologue Brittonia 49(1): 7 (1997).

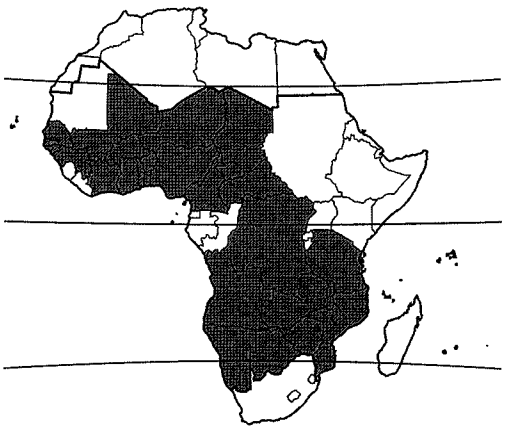
Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 16$

Synonyms *Swartzia madagascariensis* Desv. (1826).

Vernacular names Snake bean tree (En). Pau ferro, pau rosa (Po). Msekeseke (Sw).

Origin and geographic distribution *Bobgunnia madagascariensis* is widely distributed in semi-arid tropical Africa, from Senegal and Gambia eastward to the Central African Republic, and south of the rainforest belt from DR Congo to Tanzania and southward to the Caprivi strip in Namibia, northern Botswana



Bobgunnia madagascariensis – wild

and Mozambique. It is occasionally cultivated in South Africa. In spite of its scientific name, it does not occur in Madagascar.

Uses The wood, traded as 'pau ferro', 'kasanda', or 'msekeseke', is used traditionally for poles and posts for houses, fences and kraals, and is sought after for cabinet work, musical instruments, novelties, tool handles and for carving utensils such as pestles. It is suitable for heavy construction and flooring, joinery, mine props, ship building, railway sleepers, furniture, sporting goods, toys, vats, agricultural implements, turnery and veneer. For carving it is used as a substitute for African blackwood (*Dalbergia melanoxylon* Guill. & Perr.). The wood is an excellent slow-burning firewood, and it is so popular for charcoal making that it is called 'charcoal tree' in parts of coastal Tanzania and Mozambique. Powdered heartwood soaked in hot water produces a reddish dye.

In Malawi the bark was formerly used to make bark-cloth and it provides fibre used for various purposes. When flowering the plants provide nectar for honey bees. The fruits yield a glue used to fix axe and hoe handles.

The powdered fruits, seeds and sometimes roots are widely used as poison to stupefy fish and make them easy to catch; leaves have a similar but weaker effect on fish. Powdered fruits and leaves can be used as an insecticide and insect repellent. Powdered fruits are applied in grain storage bins to protect the grain from termites and weevils. The potency of the powder on insects has also been shown on mosquito larvae. A hot-water extract can be used as insecticide for spraying around seedlings to protect them from termites. Powdered fruits and leaves are used to control slugs and snails that damage crops. Powdered fruits have been used to kill rodent pests. Bushmen people mix powdered fruits with larvae of the Bushman arrow-poison beetle (*Diamphidia*) to make an arrow poison. However, when fruit powder was injected subcutaneously into a cat, it produced no effect. Leaves are also used for control of bilharzia snails. The fruits are a nitrogen-rich livestock feed and cattle have been seen butting the boles of the trees to shake down the fruits, but the milk and butter from cows which have eaten the fruits is tainted. In several areas the fruits are believed to be poisonous to cattle, and Fula herdsmen prevent their cows from eating them.

Various parts of the tree are used in traditional medicine. A decoction of the fruits has been used to induce vomiting to remove poison from the stomach, and to treat bilharzia, leprosy and ear-ache. Roots are used to induce abortion, counteract venomous stings and bites, kill or expel intestinal worms and treat leprosy. A warm root infusion is used to treat venereal diseases and dysentery. Chopped roots are shaken in water which is then used to treat cataract of the eye. Roots can be taken raw as sexual stimulant. Leaves are chewed to relieve headache and used as cough medicine. A bark decoction is drunk to slow down heart palpitations in cases of extreme fatigue and to treat leprosy. A warm infusion of bark along with that of *Diospyros lycioides* Desf. is used to clean cuts. The bark has been used to treat diarrhoea, dysentery and as febrifuge.

Production and international trade The wood of *Bobgunnia madagascariensis* is mainly traded locally and only occasionally enters the international market. In 2003 about 2800 m^3 of wood was exported from Tanzania, as short logs of 1–2 m long. The export of logs from Tanzania was permitted until mid-2004, but still 880 m^3 were exported in the second half of 2005, most of it to China, at an average price of US$ 590/m^3.

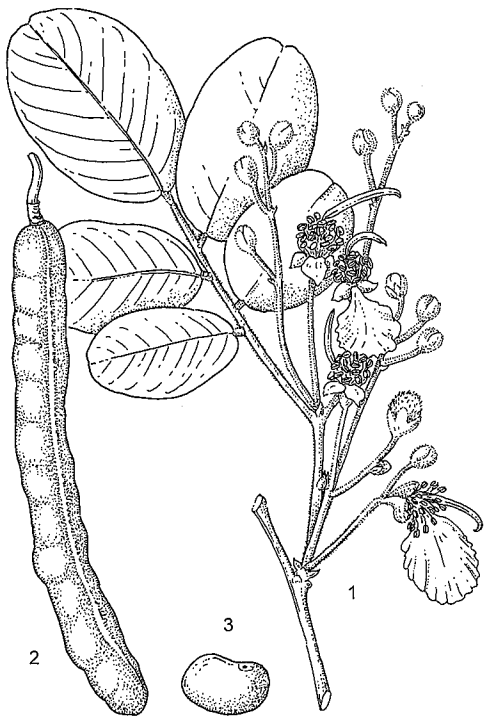
Properties The heartwood is dark reddish brown or purplish with bands varying in colour from yellow to dark brown, and clearly demarcated from the yellow, 2–3 cm wide sapwood. Growth rings form variable bands in a zigzag arrangement that makes the heartwood very decorative. The grain is wavy or interlocked, texture medium to fine and even.

The wood is very heavy, with a density of 960–1110 kg/m^3 at 12% moisture content, and very

hard. It dries slowly, but with only slight surface checking and end splitting. The shrinkage rates are low to moderate, from green to oven dry about 3.5% radial and 5.8% tangential. Once dry, the wood is unstable in service. Because of its extreme density and hardness, the wood is difficult to saw. It planes satisfactorily. The wood works to a fine finish and takes a high polish. Pre-boring is necessary for nailing and screwing. The wood glues and turns well. It takes vanish well, but stains do not always penetrate sufficiently. The resonance characteristics make it suitable for various musical instruments. The heartwood is very durable, being resistant to fungal, termite and borer attacks. The heartwood contains pterocarpans, a group of flavonoid phytoalexins, with powerful fungicidal properties. The compounds are related to the dyes found in the wood of *Pterocarpus* spp.

Several quinone-methide cassane-type diterpenes with powerful fungicidal activity, e.g. against *Candida albida*, have been discovered in the roots. In an assay of medicinal plants of Mali, an extract of the root bark has shown significant activity in mice against leishmaniasis. In Burkina Faso extracts of the root bark have shown some antimalarial activity. Powdered fruits contain saponins that are lethal to the freshwater snails that transmit bilharzia (schistosomiasis), and also to *Cyclops*, which is a host for guinea worm larvae. The saponins can be water-extracted from fruits without need for expensive equipment or highly skilled personnel. Powdered bark and chloroform or methanol extracts of the bark are effective against red flour beetle (*Tribolium castaneum*) in stored grain.

Description Semi-deciduous shrub or small tree up to 10(–15) m tall, multi-stemmed or with a single bole up to 40(–60) cm in diameter; bark surface deeply furrowed and ridged, flaking off in irregular pieces, grey-black, inner bark yellowish white, exuding a crimson-black mucilage; crown dense and rounded, with often twisted and contorted branches; twigs densely, brownish hairy. Leaves alternate, imparipinnately compound with (3–)5–9(–13) leaflets; stipules linear to narrowly ovate, 2–7 mm × 0.5–1.5 mm, persistent; petiole 2–4 cm long, rachis 5–15.5 cm long, short-hairy; petiolules 3–5 mm long; leaflets alternate, elliptical, 2–10 cm × 1–5.5 cm, increasing in size towards leaf apex, rounded at both ends, apex often slightly notched, usually hairy beneath, pinnately veined. Inflorescence a terminal or axillary



Bobgunnia madagascariensis – 1, flowering twig; 2, fruit; 3, seed.
Redrawn and adapted by W. Wessel-Brand

raceme or fascicle up to 5(–8) cm long, 2–14-flowered, densely hairy; peduncle up to 7 cm long. Flowers bisexual, zygomorphic, sweet-scented; pedicel 0.5–5(–7) cm long; calyx irregularly 2–4-lobed; petal 1, broadly elliptical, 1.5–3.5 cm × 2–3 cm, white with grey margin and yellow patch at base inside, crinkled, with c. 0.5 cm long claw at base; stamens numerous, unequal, up to 2.5 cm long, orange-yellow; ovary superior, c. 1 cm long, glabrous, on a c. 1 cm long stipe, style short. Fruit a woody, cylindrical pod up to 20(–30) cm × 2 cm, often curved, shiny dark brown to black when ripe, indehiscent, 10–15-seeded. Seeds oblong to kidney-shaped, flattened, 7–8 mm × 5–7 mm, shiny brown or greyish. Seedling with epigeal germination.

Other botanical information *Bobgunnia* comprises 2 species and is confined to mainland tropical Africa. It has been separated from *Swartzia*, a genus of over 100 species in tropical America, mainly on the basis of seed characteristics, but flower structure is similar and molecular studies also point to inclusion in

Swartzia.
Traditionally, *Bobgunnia* and *Swartzia* are 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.

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); 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: 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 78: axial parenchyma scanty paratracheal; 80: axial parenchyma aliform; (81: axial parenchyma lozenge-aliform); 82: axial parenchyma winged-aliform; 83: axial parenchyma confluent; 85: axial parenchyma bands more than three cells wide; 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; 120: axial parenchyma and/or vessel elements storied. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; (143: prismatic crystals in fibres).
(E. Ebanyenle, P.E. Gasson & E.A. Wheeler)

Growth and development Seedlings grow slowly; they are only 2.5–5 cm tall after 4 months. They reportedly often die when they have reached a height of about 30 cm. In southern Burkina Faso seedlings reached on average 53 cm tall after 30 months, and in northern Côte d'Ivoire 109 cm tall after 5.5 years with a survival rate of only 22%. In southern Africa flowering occurs together with the appearance of young leaves in September–November, sometimes continuing till January and occasionally in March–May. In Ghana flowering occurs in April–May, in Cameroon in February–April. In southern Africa, fruits mature in March–August. Seeds are released from the gummy yellow tissue inside the fruits when these have fallen to the ground and rot.

Ecology *Bobgunnia madagascariensis* occurs widely scattered, but rarely abundant, in open deciduous woodland and grassland in the Sudano-Guinean savanna zone and is a characteristic tree of *Brachystegia* woodland in southern Africa. It is found at 150–1750 m altitude, often on sandy or clay-loam soils in valleys and flood plains.

Propagation and planting Propagation of *Bobgunnia madagascariensis* by seed is quite difficult. The weight of 1000 seeds is about 400 g. Seeds can be stored for several years with little loss of viability provided they are kept dry and insect free. Seeds germinate in 3–4 weeks. To promote germination they are best soaked in hot water for 10 minutes and allowed to cool for 24 hours. Reports on germination rates are variable. In Tanzania a germination rate of 70% in 3 weeks was reported. In Côte d'Ivoire seeds were soaked in concentrated sulphuric acid for 45 minutes and subsequently in water for 72 hours; the germination rate was 77% in 19 days. Regular cutting of the roots in the nursery increases the survival rate after transplanting, but mortality is still high.
Experiments showed that propagation by stem cuttings is possible; a concentration of 300 ppm indole-3-butyric acid showed best rooting results of the cuttings. *Bobgunnia madagascariensis* can also be propagated by root suckers.

Management *Bobgunnia madagascariensis* responds well to coppicing and pruning.

Genetic resources There are no indications that *Bobgunnia madagascariensis* is in danger of genetic erosion, because it is widespread and common throughout large parts of semi-arid tropical Africa. However, harvesting the trees for timber, firewood and charcoal, and roots and fruits for medicinal purposes is widespread throughout its range and this may make it locally vulnerable. The demand for these products is likely to increase further. The situation may be aggravated by the facts that the species grows very slowly and is difficult to cultivate, whereas procedures for its wide-scale propagation are lacking.

Prospects *Bobgunnia madagascariensis* is an important tree with multiple uses widespread in Africa. Despite its importance, there is little information on its technical wood properties and silvicultural characteristics. Therefore, research into the potential of the wood and appropriate silvicultural management systems, and the development of appropriate ways to propagate and cultivate this species are needed. The insecticidal, molluscicidal and me-

dicinal properties of the various parts of the tree deserve further investigation.

Major references Amri, 2011; Aubréville, 1970; Bolza & Keating, 1972; Brenan, 1967; Brummitt et al., 2007a; Burkill, 1995; Coates Palgrave, 2002; Fanshawe, 1972; Kirkbride & Wiersema, 1997; Palmer & Pitman, 1972–1974.

Other references Aubréville, 1959b; Borel & Hostettmann, 1987; Cunningham, 1997; Fanshawe, 1962; Hepper, 1958; Irvine, 1961; Jiménez-González et al., 2008; Keay, 1989; Koné et al., 2004; Lungu, undated; Mbuya et al., 1994; Minjas & Sarda, 1986; Neuwinger, 2000; Ross, 1977; Sarda, Chhabra & Minjas, 1986; Schaller et al., 2000; Schaller et al., 2001; Stevenson, Nyirenda & Veitch, 2010; Suter et al., 1986; Thokozani et al., 2011.

Sources of illustration Brenan, 1967.

Authors W. Mojeremane

BRACHYLAENA HUILLENSIS O.Hoffm

Protologue Bot. Jahrb. Syst. 32: 149 (1902).

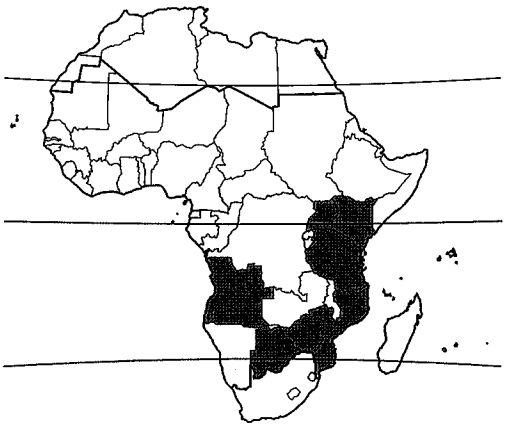
Family Asteraceae (Compositae)

Synonyms *Brachylaena hutchinsii* Hutch. (1910).

Vernacular names Lowveld silver oak, silver oak (En). Muhuhu, mkarambati, mvumo (Sw).

Origin and geographic distribution *Brachylaena huillensis* occurs from Kenya and Uganda south to north-eastern South Africa, and also in Angola.

Uses The wood, commonly traded as 'muhuhu' is mainly used for construction, first-grade flooring, joinery, interior trim, furniture, fence posts, toys, novelties, boxes, crates, tool handles, carving and turnery. In Kenya it is one of the most highly favoured woods for carving, in Tanzania also for fence posts. In South Africa it is popular for main posts of local houses. It is also suitable for bridges, hydraulic works, poles, piles, cabinet work and railway sleepers. It is considered an excellent firewood and is used for charcoal production.



Brachylaena huillensis – wild

In traditional medicine, root decoctions are used to treat schistosomiasis and leaves to treat diabetes. The aromatic oil extracted from the wood is used for perfumery. In Kenya *Brachylaena huillensis* is planted as ornamental and boundary tree around dwellings. Male flowering trees are a source of pollen for honey bees.

Production and international trade *Brachylaena huillensis* wood has been exported as short logs from Kenya to India for use as a substitute of sandalwood (from *Santalum album* L.). It is currently traded locally and across borders, especially between Kenya and Tanzania, but the trade is mainly illegal and consists of billets for wood carving. The annual volume of wood consumed in Kenya by the carving industry has been estimated in 2001 at 15,000 m^3, of which 57% was contributed by *Brachylaena huillensis*.

Properties The heartwood is greyish yellow to yellowish brown or greenish brown and distinctly demarcated from the 1.5–4 cm wide, creamy white to greyish white sapwood. The grain is straight to interlocked, texture fine and even. The wood has a persistent spicy odour. Quarter-sawn surfaces have a faint stripe figure.

The wood is heavy with a density of 830–990 kg/m^3 at 12% moisture content. In small dimensions it air dries rapidly and well with little or no degrade, although serious checking may occur in boards of over 25 mm thick; mild drying conditions are recommended for thick material. The rates of shrinkage are low to moderate, from green to oven dry about 3.3% radial and 4.7% tangential. Once dry, the wood is very stable in service.

At 12% moisture content, the modulus of rupture is 100–112 N/mm^2, modulus of elasticity 10,100 N/mm^2, compression parallel to grain 51–70 N/mm^2, shear 23 N/mm^2, cleavage 18 N/mm, Janka side hardness 9740–11,100 N and Janka end hardness 12,900 N.

The wood is difficult to saw and work with hand tools, but works well with machines. It has moderate blunting effect on cutting edges and saw teeth, but teeth tend to collect gum. A 15° cutting angle is recommended in planing

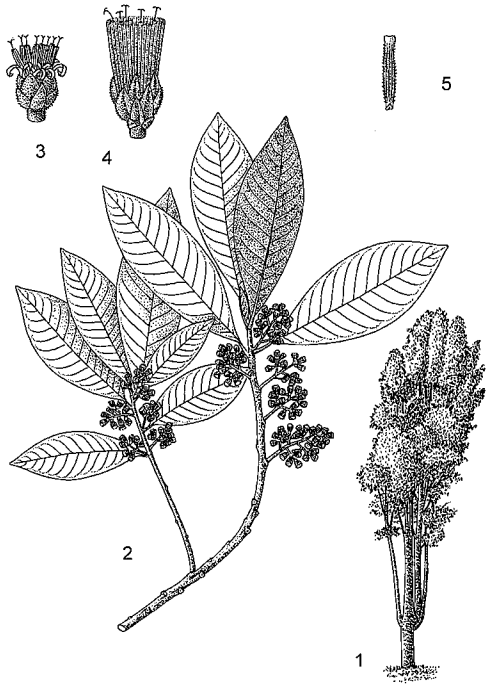
operations. The wood sands easily and takes a fine polish and smooth surface. Boring and mortising properties are less favourable with a tendency of splitting at exits. The wood moulds and turns well, but is difficult to nail and glue. It is not suitable for veneer and plywood. The steam bending properties are moderate to poor. The wood is very durable with an expected outdoor service life of 25–50 years. It is highly resistant to all insect and fungal attacks and is also durable in sea water, where it is resistant to marine borers. The heartwood is extremely resistant to impregnation by preservatives.

Fresh leaves have 5% essential oil that can be isolated by hydrodistillation. The main components of the oil are the sesquiterpene hydrocarbons caryophyllene (19%), β-cubebene (15.5%), cis-calamenene (10.5%) and α-copaene (9%). The oil exhibited antibacterial activity against *Proteus mirabilis* comparable that of the widely used antibiotic gentamicin. It has also shown some activity against *Bacillus cereus*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Micrococcus luteus* and *Enterococcus faecalis*.

The methanol extract from the bark yielded ketoaldehyde sesquiterpenes and corresponding ketoalcohols. The ketoaldehyde sesquiterpenes showed some antibacterial activity against gram-positive bacteria, particularly *Streptococcus mutans* and *Brevibacterium ammoniagenes*.

Adulterations and substitutes The wood of *Androstachys johnsonii* Prain is quite similar to that of *Brachylaena huillensis* and used for similar purposes. The wood of *Brachylaena huillensis* has often been traded to India as an inferior substitute of sandalwood for use in funeral ceremonies.

Description Evergreen or deciduous, dioecious shrub or small to medium-sized tree up to 30(–40) m tall; bole usually slender, often low-branching, up to 60(–80) cm in diameter, often curved, fluted, eventually developing thin buttresses; bark surface rough, longitudinally fissured, flaking in long narrow strips, grey, inner bark fibrous, pale brown, rapidly becoming dirty grey upon exposure; crown narrow, with steeply ascending branches; young twigs densely whitish short-hairy. Leaves arranged spirally, crowded at the ends of twigs, simple; stipules absent; petiole 0.5–1(–1.5) cm long; blade oblanceolate to obovate or elliptical, 3–12(–15) cm × 1–3(–5.5) cm, usually cuneate at base, short-acuminate at apex, margins usually entire, sometimes remotely toothed, leathery, glabrous and shiny green above, densely short-hairy and silvery whitish or greyish below, pinnately veined with up to 16 pairs of lateral veins. Inflorescence a small, cylindrical head 2–6 mm long, 3–9-flowered, clustered on short side-branches or in axillary panicles; involucral bracts in several series, densely whitish short-hairy. Florets unisexual, 5-merous; corolla white, with cylindrical tube and slightly unequal, recurved lobes; male florets with exserted stamens having fused anthers, and rudimentary ovary; female flowers with inferior ovary and long slender style 2-branched at apex. Fruit a cylindrical achene 3–4 mm long, 5–8-ribbed, densely hairy and glandular, crowned by pappus of numerous pale brown bristles 4–6.5 mm long, 1-seeded.



Brachylaena huillensis – 1, tree habit; 2, flowering branch; 3, male flowering head; 4, female flowering head; 5, fruit without pappus. Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Brachylaena* comprises about 11 species and occurs in eastern and southern mainland Africa (6 species) and in Madagascar (5 species).

The distribution area of *Brachylaena discolor* DC. (synonym: *Brachylaena rotundata* S.Moore)

partly overlaps with that of *Brachylaena huillensis*. It is a shrub or small to medium-sized tree up to 20(–30) m tall with bole up to 45(–90) cm in diameter found in evergreen forest, deciduous bushland, secondary vegetation and dune forest in Botswana, Zimbabwe, Mozambique, South Africa and Swaziland, up to 1800 m altitude. Its wood is locally used for boat building, fence posts, axles and spokes of wheels, handles, bows and carving. Branches are used as fire-sticks. In traditional medicine leaf infusions are administered to treat diabetes and kidney complaints, as emetic and tonic, and against intestinal parasites. A root maceration is applied as an enema to treat gastric bleeding, whereas root infusions and decoctions are applied to treat syphilis, dysmenorrhoea and abdominal pain. *Brachylaena discolor* has been used for afforestation of dunes and is a decorative ornamental tree and hedge plant, and is additionally popular with bee keepers.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 1: growth ring boundaries distinct. Vessels: 5: wood diffuse-porous; 7: vessels in diagonal and/or radial pattern; 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; 40: mean tangential diameter of vessel lumina ≤ 50 μm; 50: ≥ 100 vessels per square milllimetre; 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: 76: axial parenchyma diffuse; 78: axial parenchyma scanty paratracheal; 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; 104: all ray cells procumbent; (106: body ray cells procumbent with one row of upright and/or square marginal cells); 116: ≥ 12 rays per mm. Storied structure: 118: all rays storied; 120: axial parenchyma and/or vessel elements storied.
(C. Essien, H. Beeckman & P. Baas)

Growth and development The growth of *Brachylaena huillensis* is slow, with an average diameter growth rate of 0.5–2.3 mm/year in natural stands in dry areas in Tanzania. In plantations in a region with an annual rainfall of 760 mm, trees reached up to 4.5 m tall with a bole diameter of 4.6 cm 5.5 years after planting, but in a region with an annual rainfall of 1780 mm they reached up to 9 m tall with a bole diameter of 8.5 cm 5 years after planting, with a very straight bole.
Usually the tree flowers and produces seeds profusely twice every year. Flowering heads appear between March and June and between October and January. Flowers open at the beginning of the rainy season. Bees and flies visit the male flower heads for the pollen and may serve as pollinators when they visit subsequently trees with female flower heads, which do not produce pollen but are visually similar. Fruit development after flowering is very rapid. The fruits with their pappus hairs are dispersed by wind. However, a study in Kenya showed that 98% of the fruits fell within 14 m of the mother tree and that nearly all seedlings are found within that distance.

Ecology *Brachylaena huillensis* can be found in diverse forest types, in dry evergreen and semi-deciduous forest, but also in scrub vegetation, from sea-level up to 2000 m altitude. The tree grows in a wide range of rainfall zones, with an average annual rainfall of 500–1600 mm. The mean annual temperature in the area of distribution ranges from 15°C to 32°C. *Brachylaena huillensis* prefers light, free-draining sandy soils, well-developed volcanic clayey loams, and red soils of coastal belts, but it is also found on rocky soils and stony hill sides, where it reaches only small dimensions.

Propagation and planting *Brachylaena huillensis* is normally propagated by seed. However, the fruits are difficult to collect because of their relatively small size. There are 330,000–500,000 seeds per kg. Mixing of fruits with sand is recommended before sowing to prevent spreading by wind. The germination rate is usually low, although under laboratory conditions 25–50% of the seeds may germinate. In natural forest germination rates are not more than 6%. Up to 80% of the massive fruit produce is subject to predispersal predation by insects and soil organisms may further decrease viability of the seeds on the ground. Complete loss of viability of seed occurs within 4 months in the forest. The fruits do not store well; viability is lost within 6 months in open storage at room temperature, although under laboratory conditions seed remained viable for over a year.
In a test seedlings remained healthy but showed poor growth under conditions of 2–14%

of full sunlight, and remained healthy and showed good growth under conditions of 45% of full sunlight. Under full light seedlings grew fast in the nursery but developed a poor stem form. Therefore, partial shading in the nursery is recommended.
In Tanzania stump planting was not successful, but plants raised in polythene tubes were planted into the field when 12 months old and 30–40 cm tall with a survival rate of 80% after 2 years.

Management In general, larger trees of *Brachylaena huillensis* occur scattered and in low densities in the forest because of heavy exploitation. In Dindili catchment forest reserve in Tanzania, the average density of *Brachylaena huillensis* was 15 stems of more than 4 cm diameter per ha, and the average density of seedlings 400 per ha.
Information regarding plantation development and silvicultural management is limited, as only small trial plantations have been established in Kenya and Tanzania. However, the trees are easy to raise in plantations and growth seems to be fair on good soils. They have self-pruning ability. Re-sprouting of coppice stumps is reported to be poor.

Diseases and pests Various insects feed on fruits, which is a major cause of the low viability of seeds.

Handling after harvest Logs do not float in water. The bole of old trees is often hollow. In storage logs are not subject to any degrade.

Genetic resources The population of *Brachylaena huillensis* has rapidly declined due to selective logging for its valuable timber for the local wood carving industries in Kenya and Tanzania. In 2001 most wood consumed by the wood carving industry in Kenya was in the log diameter class of 10–16 cm, indicating resource scarcity with a shift towards younger trees. In 2002 it was estimated that with the current illegal and unsustainable extraction of *Brachylaena huillensis* wood in Kenya the resource would be depleted in 2–3 decades. In Tanzania *Brachylaena huillensis* is still locally common, but the high demand from Kenya has led to massive illegal importation of logs from Tanzania. In southern Africa it is one of the favoured woods for poles for hut and house construction and this may have serious local effects on populations of the species, the more so as young trees can already serve this purpose. In South Africa populations partly occur in protected areas and are therefore more secure. *Brachylaena huillensis* is included in the IUCN Red list of threatened species, where it is still considered to be at lower risk although near threatened. However, updating of the status of the species is needed.

Prospects *Brachylaena huillensis* is a highly valued source of wood for the local carving industry and for local construction, but the slow growth is a serious limitation for sustainable exploitation of natural populations. It has been estimated that under natural conditions a tree will take at least 100 years to reach a bole diameter of 40 cm. Very little information is available on planted trees, but research is recommended because growth rates seem to be more acceptable under favourable conditions and with appropriate management.
The results of phytochemical investigations on the essential oil should stimulate further research as a basis for drug development and for use in the perfume industry.

Major references ATIBT, 1986; Beentje, 2000a; Beentje, 2000b; Bolza & Keating, 1972; Chikamai et al., undated; Choge, 2001; Kigomo, 1994; Maundu & Tengnäs (Editors), 2005; Mrema, 2006; World Agroforestry Centre, undated.

Other references Beentje, 1994; CAB International, 2005; Chudnoff, 1980; Coates Palgrave, 1983; Dale & Greenway, 1961; Dharani, 2002; Gaugris et al., 2007; Kigomo, Savill & Woodell, 1992; Kigomo, Woodell & Savill, 1994; Lovett et al., 2007; Mbuya et al., 1994; Msangi, 1991; Neuwinger, 2000; Oliva et al., 2003; Palmer & Pitman, 1972–1974; Pope, 1992; Takahashi, 1978; Viera, Himejima & Kubo, 1991; World Conservation Monitoring Centre, 1998; Zdero, Bohlmann & Wasshausen, 1991.

Sources of illustration Beentje, 2000a; Teel, 1984.

Authors N. Nyunaï

BRACHYLAENA RAMIFLORA (DC.) Humbert

Protologue Mém. Soc. Linn. Normandie 25: 54 (1923).

Family Asteraceae (Compositae)

Origin and geographic distribution *Brachylaena ramiflora* occurs in Comoros and in eastern and central Madagascar.

Uses The wood, known in Madagascar as 'hazotokana' and in Comoros as 'm'gou', is mainly used for poles in house construction, piles for bridges, exterior carpentry, railway sleepers, fence posts, axles of carts, mortars and handles. It is suitable for ship building,

Brachylaena ramiflora – wild

vehicle bodies, sporting goods and musical instruments. It can be used for flooring, carving and turnery, but its tendency to splitting and the high shrinkage rates make it less suitable for these purposes. In Comoros the wood is used for carpentry and furniture.

In traditional medicine, decoctions of leaves and sometimes bark are applied against malaria, stomach-ache, blennorrhoea, constipation and other intestinal complaints, arterial diseases, coughs and colds, as vermifuge, and in mixtures with other plants to treat diabetes. Leaf decoctions are considered to have stimulant and aphrodisiac properties. The wood is used in the treatment of epilepsy.

Production and international trade *Brachylaena ramiflora* wood is used locally in Comoros and Madagascar and rarely traded on the international timber market.

Properties The heartwood is golden-yellow to pale greenish brown, darkening upon exposure to yellowish brown, and distinctly demarcated from the 4–6 cm wide, whitish sapwood. The grain is straight to interlocked, texture fine and even.

The wood is heavy with a density of 890–1060 kg/m^3 at 12% moisture content. In small dimensions it air dries fairly rapidly and with little degrade. Boards of 2.5 cm thick take 3–4 months to air dry to 25% moisture content; boards of 4 cm thick take 10–11 months. Logs and quarter-sawn logs may split during drying. The rates of shrinkage are high, from green to oven dry 5.2–7.7% radial and 7.3–11.3% tangential. Once dry, the wood often shows considerable movement in service.

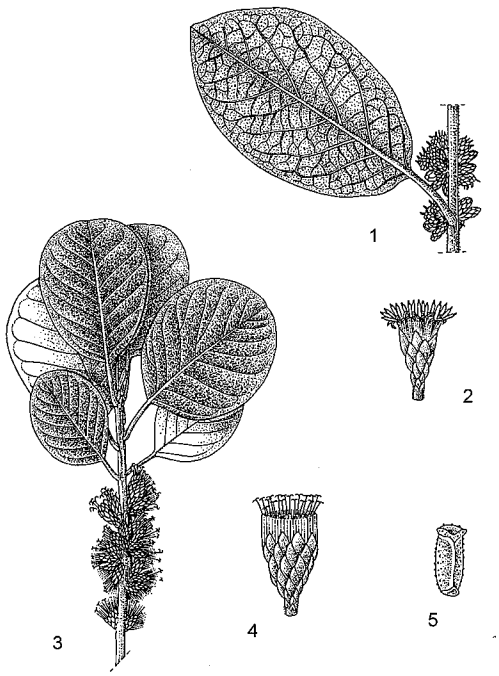
The wood is hard but somewhat brittle and fissile. At 12% moisture content, the modulus of rupture is 110–189(–245) N/mm^2, modulus of elasticity 14,500–18,630 N/mm^2, compression parallel to grain 70–95 N/mm^2, shear 5.5–10.5 N/mm^2, cleavage 13–20 N/mm and Chalais-Meudon side hardness 6.0–11.5.

The wood is difficult to saw and work; considerable power is needed, but the wood has only moderate blunting effect on cutting edges and saw teeth. A 10–15° cutting angle is recommended in planing operations. The wood takes a fine polish and smooth surface, and the use of a filler is unnecessary. Pre-boring is needed for screwing and nailing is difficult because the wood splits easily. It has appropriate waxing and varnishing properties, but is difficult to glue and paint. The wood is very durable with an expected outdoor service life of 25–50 years. It is highly resistant to all insect and fungal attacks. The heartwood is extremely resistant to impregnation with preservatives.

Leaf extracts showed pronounced in-vitro activity against *Plasmodium falciparum*. Onopordopicrine 3 has been isolated as active compound. This compound also showed cytotoxic, antibacterial and antifungal activities. An ethanol extract also showed anti-ulcer activity. In tests the extracts were not distinctly toxic.

Several triterpenoids and 2 triterpene esters have been isolated from small twigs. All these compounds showed weak cytotoxicity against human ovarian cancer cell lines.

Description Semi-deciduous, dioecious, small to medium-sized tree up to 20 m tall; bole branchless for up to 10 m, up to 60(–140) cm in diameter, without buttresses; bark surface deeply longitudinally fissured, corky, pale grey, inner bark thin, brown; young twigs densely greyish short-hairy. Leaves arranged spirally, simple and entire; stipules absent; petiole 0.5–3 cm long; blade elliptical to ovate or obovate, 3–20 cm × 2–7 cm, cuneate to rounded at base, short-acuminate to rounded or acute at apex, papery to slightly leathery, glabrous above, more or less whitish to greyish or yellowish short-hairy and glandular below, pinnately veined with 5–11 pairs of lateral veins. Inflorescence an obconical head 5–12 mm long, 14–28-flowered, usually clustered in axils of fallen leaves; involucral bracts in several series, glabrous to short-hairy, green. Florets unisexual, 5-merous; corolla whitish yellow to greenish yellow, with cylindrical tube; male florets with recurved corolla lobes up to 2.5 mm long, exserted stamens having fused whitish anthers, and rudimentary ovary; female flowers with



Brachylaena ramiflora – 1, part of branch with male flowering heads; 2, male flowering head; 3, branch with female flowering heads; 4, female flowering head; 5, fruit without pappus. Redrawn and adapted by Achmad Satiri Nurhaman

corolla lobes up to 0.5 mm long, inferior ovary and long slender style 2-branched at apex. Fruit a cylindrical achene 1.5–2.5 mm long, glandular, crowned by pappus of numerous bristles 3–8.5 mm long, 1-seeded.

Other botanical information *Brachylaena* comprises about 11 species and occurs in eastern and southern mainland Africa and in Madagascar. Madagascar has 5 species, all endemic except *Brachylaena ramiflora* that is also found in Comoros. The wood of some other *Brachylaena* spp. is used for similar purposes as that of *Brachylaena ramiflora*.

Brachylaena merana (Baker) Humbert is a small to medium-sized tree up to 25(–40) m tall with bole up to 60(–100) cm in diameter, occurring widely in Madagascar in rainforest as well as deciduous and riverine forest up to 2000 m altitude. The wood is valued for construction, carpentry and railway sleepers. It has been used for traditional tombs. Leaf decoctions are used in traditional medicine to treat pulmonary and stomach complaints, as a tonic, and to stimulate the appetite.

Brachylaena microphylla Humbert is a small tree up to 12 m tall with bole up to 35 cm in diameter, occurring in southern Madagascar in dry forest and bushland up to 1600 m altitude. The wood is sometimes used for construction. It has been exported to India as a substitute of sandalwood (from *Santalum album* L.) for use in ritual cremation ceremonies.

Brachylaena perrieri (Drake) Humbert is a small tree up to 10 m tall with bole up to 30 cm in diameter, occurring in western and central Madagascar in deciduous forest up to 1000 m altitude. The wood is used for fence posts. Leaf decoctions are used in traditional medicine to treat liver complaints, as a tonic, and to stimulate the appetite.

Brachylaena stellulifera Humbert is a small tree up to 15 m tall with bole up to 30 cm in diameter, occurring in western Madagascar in deciduous forest. It has no documented uses.

Three varieties have been distinguished in *Brachylaena ramiflora*: var. *ramiflora* which is widely distributed above 500 m altitude in Madagascar, var. *bernieri* (Baill.) Humbert which is characterized by slightly larger female flowers and occurs in humid forest below 200 m altitude in eastern Madagascar, and var. *comorensis* Humbert which is characterized by leaves narrowing into a comparatively long apex and is restricted to humid forest in Comoros.

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; (36: helical thickenings in vessel elements present); (37: helical thickenings throughout body of vessel element); 41: mean tangential diameter of vessel lumina 50–100 μm; (42: mean tangential diameter of vessel lumina 100–200 μm); 49: 40–100 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: 76: axial parenchyma diffuse; 78: axial parenchyma scanty paratracheal; 79: axial parenchyma vasicentric; (80: axial parenchyma aliform); (82: axial parenchyma winged-aliform); 83: axial paren-

chyma confluent; 85: axial parenchyma bands more than three cells wide; 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; (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; 120: axial parenchyma and/or vessel elements storied; 122: rays and/or axial elements irregularly storied. (E. Ebanyenle, P.E. Gasson & E.A. Wheeler)

Growth and development Leaves usually fall towards the end of the dry season or beginning of the rainy season, at the same time when new leaves develop. Flowering heads start developing at the end of the rainy season in May–June. Usually they open in September–October. Bees and flies probably visit the male flower heads for the pollen and may serve as pollinators when they visit trees with female flowers, which do not produce pollen but are visually similar. Fruit development after flowering is very rapid. The fruits with their pappus hairs are dispersed by wind.

Ecology *Brachylaena ramiflora* usually occurs in rainforest up to 2000 m altitude. It may persist as isolated individuals in secondary vegetation because its corky bark gives it some resistance to fire and because after cutting coppice shoots may develop.

Management In general, larger trees of *Brachylaena ramiflora* occur scattered in the forest. In the 1950s, an average of 2–3 exploitable trees per ha were recorded in forests in Madagascar.

Harvesting Traditionally, felling of trees to be used for construction purposes is done before the flowering season.

Yield Usually a tree produces only about 1 m^3 of usable wood.

Handling after harvest The wood is immersed in water for a period of about one year before it is traditionally used for cart axles.

Genetic resources There are no indications that *Brachylaena ramiflora* is threatened at present, although with the ongoing forest destruction in many regions in Madagascar and its selective exploitation it may become endangered in the near future. Evaluation of the present status of the species is needed.

Prospects *Brachylaena ramiflora* is a locally valued source of durable wood for construction. Under natural conditions, growth is probably slow as is the case in other *Brachylaena* spp., and this is a serious limitation for sustainable exploitation of natural populations. No information is available on planted trees, but research is recommended because growth rates may be more acceptable under favourable conditions and with appropriate management.
The preliminary results of pharmacological investigations are promising and warrant further research as a basis for drug development.

Major references Beentje, 2000b; Bolza & Keating, 1972; CTFT, 1955b; Guéneau, Bedel & Thiel, 1970–1975; Parant, Chichignoud & Rakotovao, 1985; Rakotovao et al., en préparation; Sallenave, 1955; Sallenave, 1971; Takahashi, 1978.

Other references Boiteau, 1986; Boiteau, Boiteau & Allorge-Boiteau, 1999; Chaturvedula et al., 2002; Debray, Jacquemin & Razafindrambao, 1971; Humbert, 1962; Neuwinger, 2000; Rafidiarison, 2002; Rakotoarizah, 2003; Rasoanaivo et al., 1999; Sallenave, 1964; Schatz, 2001.

Sources of illustration Beentje, 2000b; Humbert, 1962.

Authors S. Rakotonandrasana & V. Rasamison

BRACHYSTEGIA CYNOMETROIDES Harms

Protologue Bot. Jahrb. Syst. 26: 267 (1899).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Origin and geographic distribution *Brachystegia cynometroides* has a small area of distribution, in western Cameroon and Equatorial Guinea (Bioko), possibly also in the southwestern part of the Central African Republic and in northern Gabon.

Uses The wood of *Brachystegia cynometroi-*

Brachystegia cynometroides – wild

des, called 'naga' or 'okwen' in trade, is used for flooring, interior carpentry, joinery, panelling, stairs, wooden frames, furniture, cabinet work, veneer and plywood. It is suitable for construction, interior trim, ship building, vehicle bodies, boxes, crates and fibre board.

Production and international trade In Cameroon, where production of the wood of *Brachystegia cynometroides* is officially promoted, production in 1995 amounted to 1.9% of the timber produced, or about 51,300 m³. Most of the wood is used within the country; between 1998 and 1999, about 7500 m³ was exported from Cameroon to Europe and the United States. Statistics on trade are not available because the timber of *Brachystegia cynometroides* is often sold in mixed consignments together with the timber of other *Brachystegia* spp. and of several other genera such as *Aphanocalyx* and *Bikinia*.

Properties The heartwood of *Brachystegia cynometroides* is yellowish brown or reddish brown, often with a purplish or coppery hue; it is clearly demarcated from the white, very pale brown or yellowish, up to 15 cm thick sapwood. The grain is straight to interlocked, texture medium to coarse. The wood is often finely streaked on quarter-sawn surfaces.

The wood is medium-weight, with a density of (530–)600–730 kg/m³ at 12% moisture content, and moderately hard. It air dries fairly rapidly and well, but some sources report that its drying rate is slow to normal with a tendency of distortion and checking. The rates of shrinkage are moderate, from green to oven dry 4.2–5.4% radial and 6.5–7.9% tangential. Once dry, the wood is moderately stable in service.

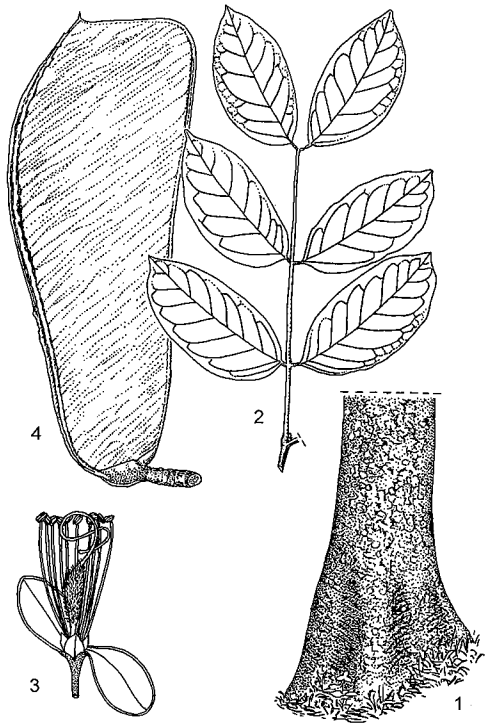
At 12% moisture content, the modulus of rupture is 98–144 N/mm², modulus of elasticity 8920–11,860 N/mm², compression parallel to grain 43–63 N/mm², shear 7–8.5 N/mm², cleavage 10–18 N/mm and Chalais-Meudon side hardness (1.7–)2.4–5.1.

The wood is fairly easy to saw and work with both hand and machine tools. Although the silica content is low (less than 0.05%), the wood may have a blunting effect on saws and cutting tools due to the presence of crystals. It is recommended to saw boles as soon as possible after felling, as green wood is much less abrasive and has less tendency to carbonize on sawing. For planing, a low cutting angle (15°) is required. The use of a filler is recommended to get a smooth finish. Nailing and screwing tend to cause splitting, and pre-boring is recommended. The wood glues well, although the occasional presence of wet pockets may cause difficulties. It takes paint and varnish well. The peeling and slicing properties are satisfactory, although the common presence of interlocked grain and the coarse texture may lead to rough or woolly surfaces. The turning and carving properties are variable. The wood is not durable to moderately durable, being liable to attack by fungi, termites, pinhole borers and marine borers. The heartwood is resistant to impregnation with preservatives, the sapwood is easily impregnated.

The wood contains 39.5–45% cellulose, 32–35% lignine, 15.5–18% pentosan, 0.7–1.2% ash and very little silica. The solubility is 1.7–2.5% in alcohol-benzene, 1.5–3.0% in hot water and 13.7–17.6% in a 1% NaOH solution.

Adulterations and substitutes The wood of *Brachystegia cynometroides* can be replaced by the woods of *Brachystegia eurycoma* Harms or *Brachystegia leonensis* Burtt Davy & Hutch., which have similar properties and are also traded as 'naga' or 'okwen'.

Description Deciduous, medium-sized to fairly large tree up to 35(–40) m tall; bole



Brachystegia cynometroides – 1, base of bole; 2, leaf; 3, flower; 4, fruit.
Redrawn and adapted by J.M. de Vries

branchless for up to 15 m, often bent, twisted or sinuous, but sometimes straight and cylindrical, up to 180 cm in diameter, with buttresses up to 4(–5) m high or with rounded thickenings at base; bark surface smooth to rough, peeling in scales leaving sinuous grooves especially towards base of the bole, orange-red or brownish, inner bark c. 1.5 cm thick, fibrous, reddish, turning brown on exposure, exuding a sticky, white gum; crown broadly spreading, open, with thick, twisted branches; twigs glabrous. Leaves alternate, paripinnately compound with (2–)3 pairs of leaflets; stipules persistent as hard scales; petiole swollen at the base, rachis 10–15 cm long; petiolules c. 5 mm long; leaflets opposite, obliquely oblong to elliptical, 6–8 cm × 3–4 cm, cuneate to obtuse at base, short-acuminate at apex, leathery, glabrous, pinnately veined with 6–9 pairs of lateral veins. Inflorescence a terminal or axillary, short panicle 3–4 cm long, with hairy branches. Flowers bisexual, regular, small, at base with 2 obovate bracteoles c. 5 mm × 3 mm; pedicel 2–3 mm long, hairy; sepals 5, 1–1.5 mm long, with hairy margins; petals absent; stamens 10, free, c. 7 mm long; ovary superior, ellipsoid, with short stipe, hairy, style slender, coiled. Fruit an oblanceolate to obovate, flattened pod 20–25 cm × 8–10 cm, at a right angle to the stipe, smooth but slightly wrinkled, dehiscent with 2 woody valves, 2–4-seeded. Seeds large, disk-shaped.

Other botanical information *Brachystegia* is a taxonomically difficult genus comprising about 30 species, distributed in mainland tropical Africa and South Africa, the majority of species occurring in southern tropical Africa, where they are characteristic of miombo woodland.

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); 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: 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); 104: all ray cells procumbent; 116: ≥ 12 rays per mm. Storied structure: 118: all rays storied; 121: fibres storied. Secretory elements and cambial variants: (131: intercellular canals of traumatic origin). Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E.E. Mwakalukwa, H. Beeckman & P. Baas)

Growth and development *Brachystegia cynometroides* flowers in April and fruits ripen in July. The roots are associated with ectomycorrhizae. N-fixing nodules have not been found.

Ecology *Brachystegia cynometroides* usually grows in groups in primary and old secondary, humid evergreen forest and riverine forest, up to 200 m altitude, in regions with an annual rainfall of 1500–3000 mm and mean temperatures of 23.5–25°C and 1–2 dry months. It is less common in semi-evergreen forest. It can be found on various types of ferralitic soils and on sedimentary sandy or sandy clay soils.

Management In forest in south-western Cameroon, trees with a bole diameter of more than 60 cm have been found at an average density of 0.13 trees/ha, and trees with a bole diameter of more than 15 cm at 0.33 trees/ha.

Harvesting The minimum bole diameter for felling in Cameroon is 60 cm.

Genetic resources In Cameroon *Brachystegia cynometroides* is classified as a timber resource of secondary importance, but it is promoted. Its limited export volume does not seem to cause a threat of genetic erosion, but *Brachystegia cynometroides* has a small area of distribution and therefore monitoring of the populations is recommended.

Prospects The wood of *Brachystegia cynometroides* will remain of mainly local importance for indoor construction and joinery. It was exported from Cameroon for a few years, but exports declined rapidly, and its prospects on the international timber market are therefore less certain. Information is needed on its growth rates, natural regeneration, appropriate management and potential yield.

Major references Aubréville, 1970; Bolza & Keating, 1972; CTFT, 1953b; Gérard et al.,

1998; Letouzey & Mouranche, 1952; Sallenave, 1964; Savard, Besson & Morize, 1954; Takahashi, 1978; Thirakul, 1983; Vivien & Faure, 1985.

Other references Bisby et al. (Editors), 2007; CIRAD Forestry Department, 2008; Karsenty et al., 2006; Letouzey, 1985b; ONADEF, 1991; Onguene & Kuyper, 2002; Verbelen, 1999.

Sources of illustration Aubréville, 1970; Letouzey & Mouranche, 1952; Vivien & Faure, 1985.

Authors V.A. Kémeuzé & M.G. Meikeu Kamdem

BRACHYSTEGIA EURYCOMA Harms

Protologue Bot. Jahrb. Syst. 49: 424 (1913).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Origin and geographic distribution *Brachystegia eurycoma* has a restricted area of distribution, occurring in southern Nigeria and western Cameroon, possibly also in Gabon.

Uses The wood of *Brachystegia eurycoma*, known as 'naga' or 'okwen' in trade, is used for construction, joinery and furniture. It is suitable for flooring, interior trim, interior carpentry, stairs, veneer and plywood.

Traditionally, the bark has been used to make a coarse cloth used as protection against rain and as a shield against arrows. It is used to make containers. The seeds are spicy and consumed as condiment, and are used to prepare a flour, named 'achi', used to thicken soups. Igbo people in Nigeria use the plant as anthelmintic.

Production and international trade The wood of *Brachystegia eurycoma* is mainly used and traded locally. It may occasionally be exported in mixed consignments.

Brachystegia eurycoma – wild

Properties The heartwood of *Brachystegia eurycoma* is pinkish brown with vague bands and rather distant fine streaks, clearly demarcated from the whitish sapwood. The grain is usually interlocked, texture medium.

There is no detailed information on physical and mechanical wood properties of *Brachystegia eurycoma*, but these are probably comparable to those of *Brachystegia cynometroides* Harms. The wood should be dried slowly and carefully to avoid defects; end splitting is common. It is hard to work with hand tools and has a blunting effect on saw teeth and cutting edges. To obtain a smooth surface, careful sanding and the use of a filler are required. The nailing and screwing properties are good, but preboring is needed to avoid splitting. Reports on the durability of the wood are contradictory; it is mostly considered non-durable, although wood extracts showed insecticidal and fungicidal activities. The heartwood is resistant to treatment with preservatives.

The seed flour used for thickening contains per 100 g: water 10–12 g, fat 13–14 g, protein 10–13 g, dietary fibre 1–2 g, carbohydrate 59–61 g and ash 1.5–4 g. As a thickening agent, 4–20 g of seed flour per litre water is used. Toasting the flour and addition of palm oil increases the viscosity of the solution, while salt has an opposite effect. Several commercial samples of 'achi' from Nigeria were found to contain aflatoxin B1-producing strains of the fungi *Aspergillus flavus*, *Aspergillus parasiticus* and *Aspergillus niger*. In a test in Nigeria, the seed mucilage was shown to be suitable as a tablet binder. The fatty acid composition of the seed oil is approximately: palmitic acid 26%, stearic acid 7%, lignoceric acid 13%, linoleic acid 6%, oleic acid 32% (total saturated fatty acids 59%, total unsaturated fatty acids 41%).

Ethanol extracts of the wood, and to a lesser extent aqueous extracts, have shown an insecticidal effect against the termite *Amitermes evuncifer* and a fungicidal effect against *Fomes heterobasidium*, *Polyporus coridus* and *Daedalea daedaleopsis*; aqueous extracts inhibited the growth and cellulolytic activity of *Bacillus subtilis*. Aqueous extracts of the bark, and to a lesser extent ethanol extracts, inhibited the growth of several fungi. The root has been tested for its effect on the snail *Bulinus globulus*, but showed no effect.

Pollen counts in honey samples have indicated

that *Brachystegia eurycoma* is an important bee plant. The yellow or reddish gum exuding from the bark hardens into a gutta-percha-like substance.

Botany Medium-sized to fairly large tree up to 35 m tall; bole often low-branched and irregular, up to 200(–250) cm in diameter, often with small buttresses; bark surface rough, grey to brown, flaking off in large patches, inner bark hard, fibrous, red, ripple-marked, darkening on exposure, exuding a reddish or yellowish gum; crown widely spreading and flattened, with spreading, twisted branches; twigs hairy but soon becoming glabrous. Leaves paripinnately compound with (4–)5(–6) pairs of leaflets; stipules early caducous; petiole 1.5–2.5 cm long, swollen at base, rachis 7–15 cm long; leaflets opposite, sessile, oblong-elliptical, up to 12 cm × 6 cm, basal leaflets smallest, upper ones largest, truncate to rounded and very asymmetrical at base, rounded or slightly notched at apex, thin-leathery, glabrous, pinnately veined with 6–8 pairs of lateral veins. Inflorescence a mostly terminal, up to 15 cm long panicle, short-branched, densely brown hairy, many-flowered. Flowers bisexual, slightly zygomorphic, small, at base with 2 oblong-obovate bracteoles c. 7 mm long; pedicel very short; sepals 5, c. 3 mm long, slightly unequal, with hairy margins; petals absent; stamens (8–)10, free, c. 9 mm long; ovary superior, ellipsoid, with short stipe, hairy, style slender, coiled. Fruit an oblong to oblanceolate or obovate, flattened pod, 12–22 cm × 3.5–6 cm, at a right angle to the stipe, smooth but slightly wrinkled, dehiscent with 2 woody valves, 4–6-seeded. Seeds disk-shaped, c. 2 cm in diameter, shiny brown.

Brachystegia eurycoma flowers in April–May; fruits ripen in September–January. The fruits open explosively, throwing out the seeds. A trial in Nigeria showed that seedlings of *Brachystegia eurycoma* grow best on a fertile mixture of top-soil and river sand with watering intervals of up to 3 days.

Brachystegia is a taxonomically difficult genus comprising about 30 species, distributed in mainland tropical Africa and South Africa, the majority of species occurring in southern tropical Africa, where they are characteristic of miombo woodland.

Ecology *Brachystegia eurycoma* is most common in riverine forest, up to 1150 m altitude. It is locally quite abundant.

Management In Cameroon the minimum bole diameter allowed for harvesting is 60 cm.

Genetic resources and breeding As *Brachystegia eurycoma* is fairly common, of high local value for its seed and little exploited as an export timber, it is probably not in danger of genetic erosion, except where its habitat is destructed. Measures to protect the tree as a source of edible seeds and to control its cutting for timber have been proposed.

Prospects The wood of *Brachystegia eurycoma* is likely to remain of local importance, but it will remain of little importance for export. The insecticidal and fungicidal activities of the wood deserve more attention. As the seeds are a source of thickener for soups, commercially traded in cities in Nigeria, they will increase in importance. The presence of several aflatoxin-producing *Aspergillus* species in commercial samples of 'achi' warrants further research attention.

Major references Agom & Ogar, 1994; Aubréville, 1970; Bhat & Karim, 2009; Keay, 1989; Keay, Hoyle & Duvigneaud, 1958.

Other references Adekunle, 2000; Ajayi et al., 2006; CIRAD Forestry Department, 2008; Femi-Ola & Odukoya, 2008; Ikegwu, Okechukwu & Ekumankana, 2010; Ikegwu et al., 2009; Ikojo, Olajide & Uwadinma, 2005; Ndukwu, 2009; Okwu, Achar & Sharma, 2010; Olubunmi & Oremeyi J., 2011.

Authors L.P.A. Oyen

BRACHYSTEGIA LAURENTII (De Wild.) Louis ex Hoyle

Protologue Fl. Congo Belge 3: 461 (1952).

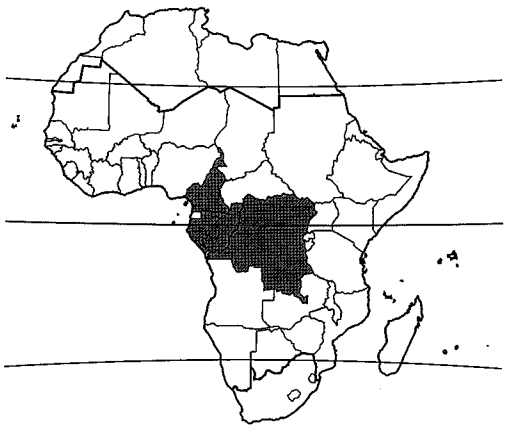
Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Brachystegia zenkeri* Harms (1910).

Origin and geographic distribution *Brachystegia laurentii* occurs from western Cameroon south to Gabon and east to DR Congo.

Uses The wood, known as 'bomanga' or 'léké', is locally used, mainly for construction and furniture. It is suitable for joinery, interior trim, panelling, ship building, vehicle bodies, toys, novelties, boxes, crates, vats, carvings, turnery, veneer and plywood. It is also used for charcoal production.

In DR Congo beaten stripped bark is used to make clothes, baskets, ropes, grain sacks and game nets. The bark is also used as a soap substitute. Among the Ngandu people in central DR Congo, powdered bark is blown into the nose to treat serious cough, especially in children. Bark decoctions are used to treat gonorrhoea. Soaked bark is rubbed onto scarifica-



Brachystegia laurentii – wild

tions around the snout of hunting dogs to increase their aggressiveness.

Production and international trade The wood of *Brachystegia laurentii* is mainly used and traded locally, but it may occasionally be included in mixed consignments of timber for export.

Properties The heartwood is pale brown to yellowish brown, occasionally with coppery streaks, and indistinctly demarcated from up to 20 cm thick, whitish or yellowish sapwood. The grain is straight or interlocked, texture medium.

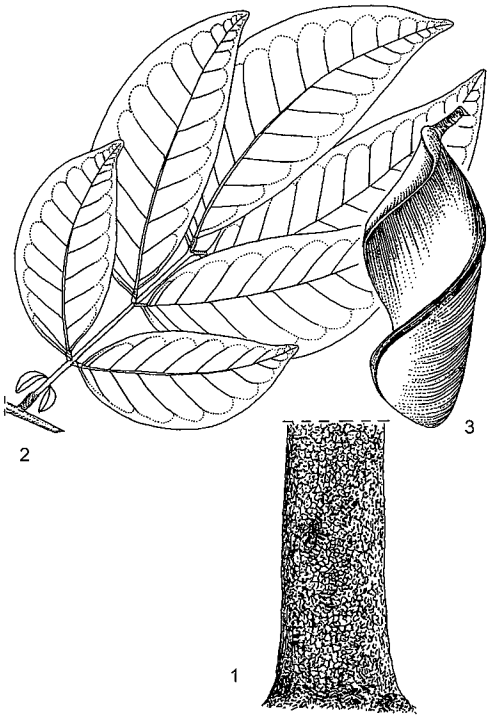
The wood is medium-weight, with a density of 520–610 kg/m^3 at 12% moisture content. It should be air dried with care as it has a tendency to twist and check. The rates of shrinkage are moderate, from green to oven dry 3.0–4.4% radial and 5.0–7.0% tangential. Once dry, the wood is moderately stable to stable in service.

At 12% moisture content, the modulus of rupture is (89–)111–143 N/mm^2, modulus of elasticity 9020–13,530 N/mm^2, compression parallel to grain 41–54 N/mm^2, shear 5.5–7.5 N/mm^2, cleavage 10.5–21.5 N/mm and Chalais-Meudon side hardness 2.1–3.3.

The wood is fairly easy to saw and work with both hand and machine tools. It polishes well to a good finish. The wood holds nails and screws well. It has good gluing and peeling characteristics. The bending properties are moderate. The wood has a low durability, being liable to termite and marine borer attacks. The heartwood is resistant to preservative treatment, but the sapwood is permeable to moderately resistant.

The wood contains 40–43% cellulose, 26.5–33.5% lignin, 15.5–16.5% pentosan, 0.5–1.2% ash and little silica. The solubility is 3.3–10.5% in alcohol-benzene, 0.8–5.1% in hot water and 15.5–17.6% in a 1% NaOH solution.

Description Deciduous or nearly evergreen, medium-sized to large tree up to 45 m tall; bole branchless for up to 25 m, straight and cylindrical, up to 150(–200) cm in diameter, without buttresses, sometimes slightly thickened and fluted at base; bark smooth, becoming rough and flaking off in irregular patches, silvery yellowish grey to dark grey, inner bark thick, hard, fibrous, orange-red, turning brown upon exposure; crown umbrella-shaped, dense, with ascending branches; twigs drooping, glabrous to slightly hairy, with numerous lenticels. Leaves alternate, paripinnately compound with 3–7 pairs of leaflets; stipules deltoid, early caducous; petiole 0.5–1 cm long, thickened at base, rachis (3–)8–15 cm long, angular, grooved; leaflets opposite, nearly sessile, obliquely oblong-lanceolate to obovate, 3–10(–15) cm × 1–5 cm, but basal pair of leaflets very small and often early caducous, cuneate to



Brachystegia laurentii – 1, base of bole; 2, leaf; 3, valve of dehisced fruit.
Redrawn and adapted by J.M. de Vries

more or less rounded at base, obtuse to slightly notched or short-acuminate at apex, papery to slightly leathery, glabrous, pinnately veined with up to 14 pairs of lateral veins. Inflorescence a terminal or axillary rounded panicle, strongly branched; peduncle thick, up to 2 cm long, densely hairy, many-flowered. Flowers bisexual, nearly regular, small, fragrant, at base with 2 ovate bracteoles c. 9 mm long; pedicel 1–2.5 mm long; sepals (3–)5, elliptical to ovate, 2–3(–4) mm long, nearly glabrous; petals 2–5, thread-like, 1–4 mm long; stamens 10, free, c. 1.5 cm long; ovary superior, ellipsoid, c. 4 mm long, with c. 4 mm long stipe, nearly glabrous, style slender, coiled. Fruit an oblong to oblanceolate or obovate, flattened pod 15–25(–30) cm × 5–10 cm, at a right angle to the stipe, smooth but slightly wrinkled, reddish brown to nearly black when ripe, dehiscent with 2 woody valves, 2–3-seeded. Seeds disk-shaped, c. 3.5 cm in diameter, dark brown.

Other botanical information *Brachystegia* is a taxonomically difficult genus comprising about 30 species, distributed in mainland tropical Africa and South Africa, the majority of species occurring in southern tropical Africa, where they are characteristic of miombo woodland.

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); 27: intervessel pits large (≥ 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; 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: 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: 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); 116: ≥ 12 rays per mm. Storied structure: (120: axial parenchyma and/or vessel elements storied); (121: fibres storied); 122: rays and/or axial elements irregularly storied. Secretory elements and cambial variants: (131: intercellular canals of traumatic origin). Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E.E. Mwakalukwa, P. Baas & H. Beeckman)

Growth and development *Brachystegia laurentii* usually sheds its leaves for a short period. Young leaves are bright red. When new leaves have appeared, the crown is characteristically brownish red from shining old leaves still present and falling. In DR Congo trees have been reported to flower in February–March. Fruits ripen about 4 months later. They open explosively, throwing out the seeds.

Ecology *Brachystegia laurentii* is commonly found in dense evergreen rainforest and semi-deciduous forest, where it often occurs along rivers. Where it occurs in the forest, it often grows gregariously, sometimes dominant. It is a shade bearer, represented in all size classes and often forming a large proportion of the highest storey. In DR Congo it is commonly found in association with *Gilbertiodendron dewevrei* (De Wild.) J.Léonard, *Pycnanthus angolensis* (Welw.) Warb. and *Fagara macrophylla* (Oliv.) Engl.

Propagation and planting Seedlings and saplings of *Brachystegia laurentii* are usually abundant near the mother tree.

Management In Cameroon *Brachystegia laurentii* is locally common and gregarious. In forest in south-western Cameroon, the average density of trees with a bole diameter of more than 60 cm is 0.3 tree/ha, with an average wood volume of 3.2 m^3/ha. In Gabon *Brachystegia laurentii* is less common, but locally it is dominant with up to 20 trees per ha with a bole diameter of more than 35 cm. The average wood volume in Gabon is 0.7 m^3/ha. In DR Congo *Brachystegia laurentii* usually grows either individually or in small clusters occupying not more than a few hectares, but also there it is locally dominant. It is one of the dominant species in the climax forest in the Yangambi Biosphere Reserve.

Harvesting The minimum diameter limit of the bole allowed for felling is 70 cm in Gabon and 60 cm in Cameroon.

Genetic resources *Brachystegia zenkeri* is included as vulnerable in the IUCN Red list of

threatened species as a result of habitat loss and scattered occurrence in Cameroon, but this name is considered a synonym of *Brachystegia laurentii*. It seems unlikely that *Brachystegia laurentii* suffers from genetic erosion because it is locally common and fairly widespread. However, populations in Cameroon and Gabon seem to have a limited and local scope and may easily become threatened because of habitat destruction and selective felling.

Prospects *Brachystegia laurentii* will continue to remain locally useful as a source of timber and fibre. With its straight and cylindrical bole reaching large dimensions, it is of interest for further commercialization, but its scattered occurrence limits the possibilities for commercial exploitation. Further research is needed on appropriate management systems in the natural forest to ensure sustainable exploitation.

Major references ATIBT, 1986; Aubréville, 1970; Bolza & Keating, 1972; CIRAD Forestry Department, 2008; de Saint-Aubin, 1963; Letouzey & Mouranche, 1952; Tailfer, 1989; Takahashi, 1978; Vivien & Faure, 1985; Wilczek et al., 1952.

Other references Aubréville, 1968; Burkill, 1995; Christy et al., 2003; Davy & Hutchinson, 1923; Fouarge, Quoilin & Roosen, 1970; Frankham, Ballou & Briscoe, 1996; Germain & Evrard, 1956; Keay, Hoyle & Duvigneaud, 1958; Normand & Paquis, 1976; Sallenave, 1955; Sallenave, 1964; Sallenave, 1971; Savard, Besson & Morize, 1954; World Conservation Monitoring Centre, 1998.

Sources of illustration Aubréville, 1968; de Saint-Aubin, 1963.

Authors E.A. Obeng

BRACHYSTEGIA LEONENSIS Burtt Davy & Hutch.

Protologue Bull. Misc. Inform. Kew 1923(4): 156 (1923).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Bush mahogany (En). Méblo (Fr).

Origin and geographic distribution *Brachystegia leonensis* occurs from Sierra Leone eastwards to western Côte d'Ivoire.

Brachystegia leonensis – wild

Uses The wood, traded as 'okwen' or 'naga', is used for construction, flooring and furniture. It is suitable for interior joinery, interior trim, ship building, vehicle bodies, boxes, crates, carvings, veneer and plywood. It is also used as fuelwood.

A decoction of the leaves is rubbed onto the gums to treat toothache.

Production and international trade The wood of *Brachystegia leonensis* is mainly used and traded locally, but may occasionally be traded internationally in mixed consignments.

Properties The heartwood is pale yellowish brown to copper brown, with purplish tinge and darker streaks; it is fairly distinctly demarcated from the yellowish or whitish, up to 15 cm wide sapwood. The grain is interlocked or wavy, sometimes straight, texture medium. Quarter-sawn surfaces sometimes show a striped or roe figure.

The wood is medium-weight, with a density of 490–560 kg/m^3 at 12% moisture content, and moderately hard. It air dries rather slowly, with a high risk of distortion, end splitting and checking. The rates of shrinkage are moderately high, from green to oven dry 4.7–4.9% radial and 7.5–7.6% tangential. Once dry, the wood is moderately stable to stable in service.

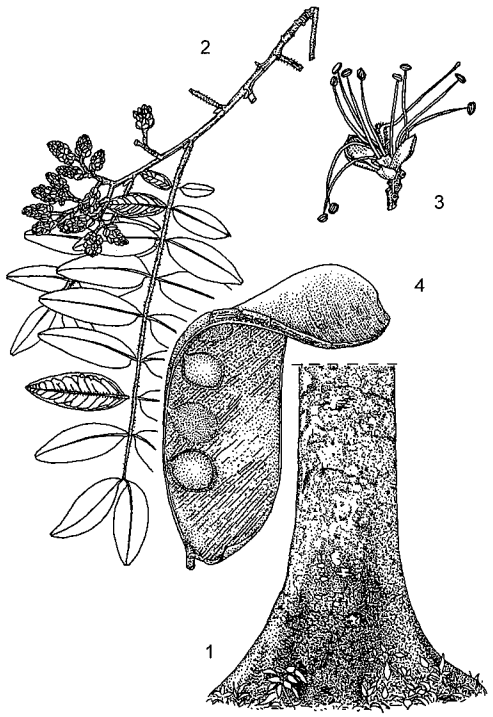
At 12% moisture content, the modulus of rupture is 116–138 N/mm^2, modulus of elasticity 8500–10,800 N/mm^2, compression parallel to grain 42–56 N/mm^2, shear 7.5–8 N/mm^2, cleavage 13.5 N/mm and Chalais-Meudon side hardness 2.2–2.8.

The wood is fairly easy to work with both hand and machine tools. It has low to moderate blunting effect on saw teeth and cutting edges. In planing and moulding, the wood has a tendency of tearing due to the interlocked grain, and a reduced cutting angle of 10–13° is recommended. Drilling and mortising properties

are satisfactory. A smooth surface is difficult to obtain, and therefore ample filler is needed for a good finish. The wood is liable to splitting upon nailing and pre-boring is therefore necessary; it holds nails and screws well. Gluing and veneering properties are good. The heartwood is moderately durable, being quite resistant to termite attack but susceptible to blue stain, pinhole borer and marine borer attacks. The sapwood is liable to *Lyctus*. The heartwood is resistant to preservative treatment, but the sapwood is permeable.

Adulterations and substitutes Several *Brachystegia* species have wood that is similar to that of *Brachystegia leonensis* and is also traded as 'naga', including *Brachystegia cynometroides* Harms, *Brachystegia eurycoma* Harms and *Brachystegia nigerica* Hoyle & A.P.D.Jones.

Description Evergreen, large tree up to 45 (–50) m tall; bole branchless for up to 30 m, straight and cylindrical, up to 200(–250) cm in diameter, thickened at base or with winged buttresses up to 2 m high; bark surface smooth, becoming rough and flaking off in irregular patches, grey to dark grey-brown, inner bark thick, hard, fibrous, reddish brown to dark red with whitish, yellowish or orange streaks, with some reddish exudate; crown with ascending branches; twigs drooping, slightly hairy. Leaves alternate, paripinnately compound with (3–)6–12(–13) pairs of leaflets, drooping; stipules narrowly oblong, caducous but base persistent; petiole 1–3 cm long, rachis 15–28 cm long, reddish hairy; leaflets opposite, nearly sessile, elliptical to lanceolate, 1.5–12 cm × 0.5–4.5 cm, rounded but strongly asymmetrical at base, obtuse to slightly notched or short-acuminate at apex, leathery, densely brownish hairy when young, but becoming nearly glabrous, with 2–3 nearly basal veins on one side of the leaflet and 4–6 pairs of lateral veins. Inflorescence a dense terminal or axillary panicle up to 20 cm long, densely brown short-hairy, many-flowered. Flowers bisexual, nearly regular, small, fragrant, greenish yellow, sessile, at base with 2 ovate bracteoles c. 10 mm long; sepals (4–)5(–6), broadly ovate, 2–2.5 mm long, nearly glabrous; petals absent; stamens 10, nearly free, c. 1.5 cm long; ovary superior, flattened ellipsoid, c. 4 mm long, with c. 3 mm long stipe, hairy on the edges, style slender. Fruit an oblong, flattened pod 12–30 cm × 4–8 cm, at a right angle to the stipe, smooth but slightly wrinkled, purplish brown, dehiscent with 2 woody valves, 2–6-seeded. Seeds disk-shaped, c. 2 cm in diameter, smooth, brown. Seedling with epigeal germination; hypocotyl 5–7.5 cm long, epicotyl 6–9 cm long, brown hairy; cotyledons round, c. 1.5 cm in diameter, pressed against the epicotyl; first 2 leaves opposite, with 2–3 pairs of leaflets, subsequent leaves alternate, gradually with more pairs of leaflets.



Brachystegia leonensis – 1, base of bole; 2, twig with flower buds; 3, flower; 4, valve of dehisced fruit with seeds.
Redrawn and adapted by J.M. de Vries

Other botanical information *Brachystegia* is a taxonomically difficult genus comprising about 30 species, distributed in mainland tropical Africa and South Africa, the majority of species occurring in southern tropical Africa, where they are characteristic of miombo woodland.

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; 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; 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: 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; 104: all ray cells procumbent; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Storied structure: 122: rays and/or axial elements irregularly storied. Secretory elements and cambial variants: (131: intercellular canals of traumatic origin). Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; 143: prismatic crystals in fibres.

(E.E. Mwakalukwa, H. Beeckman & P. Baas)

Growth and development The bole diameter increment in Sierra Leone was found to be variable; at a bole diameter around 20 cm the annual increment in diameter was 5 mm, around 30 cm it was 1.5 mm and around a bole diameter of 50 cm it was 9 mm. *Brachystegia leonensis* is among the largest trees in its area of distribution, second in size only to *Tieghemella heckelii* (A.Chev.) Roberty. Trees flower from January to April, young fruits become conspicuous in June–October and seed dispersal peaks in December–February. Old leaves are usually shed between September and mid November. Flushes of reddish brown new leaves appear around the same time.

Ecology *Brachystegia leonensis* is locally common in lowland humid evergreen forest, where it prefers well-drained localities. It is often associated with *Lophira alata* Banks ex C.F.Gaertn. and *Heritiera utilis* (Sprague) Sprague.

Propagation and planting Natural regeneration is generally fair close to mother trees; seedlings and saplings are often common in gaps in the forest where there has been disturbance of the soil. There are about 700 seeds per kg. The germination rate is fair if the seeds are sown soon after collection, and germination usually starts after 7–20 days. Seedlings grow rather slowly, reaching a height of 30 cm in 1 year.

Management In some forests in Sierra Leone, an average density of 0.8 trees with a bole diameter of more than 80 cm has been recorded per ha. *Brachystegia leonensis* can be managed by coppicing. Coppice shoots may grow to 4.5 m tall in 3 years.

Handling after harvest After felling, logs should be rapidly removed from the forest because the wood is liable to blue stain and borer attacks.

Genetic resources *Brachystegia leonensis* has a limited area of distribution and, although it is locally common, may be easily liable to genetic erosion with continuing deforestation in West Africa.

Prospects *Brachystegia leonensis* will continue to be valued as a locally useful timber tree, but its prospects as a commercial timber for international trade seem to be meagre because its wood has moderate finishing properties and moderate durability.

Major references ATIBT, 1986; Bolza & Keating, 1972; Burkill, 1995; CIRAD Forestry Department, 2008; CTFT, 1962; Kryn & Fobes, 1959; Sallenave, 1964; Savill & Fox, 1967; Takahashi, 1978; Voorhoeve, 1979.

Other references Aubréville, 1959b; de la Mensbruge, 1966; Hawthorne & Jongkind, 2006; Kunkel, 1965; Neuwinger, 2000; Normand, 1950a; Normand & Paquis, 1976; Poorter et al., 2004.

Sources of illustration Savill & Fox, 1967; Voorhoeve, 1979.

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

BRACHYSTEGIA MILDBRAEDII Harms

Protologue Notizbl. Bot. Gart. Berlin-Dahlem 8: 151 (1922).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Brachystegia nzang* Pellegr. (1937).

Origin and geographic distribution *Brachystegia mildbraedii* occurs in western Cameroon, Equatorial Guinea and Gabon.

Uses The wood of *Brachystegia mildbraedii*, known as 'bomanga' or 'ekop évène', is used indoors in construction and for furniture and cabinet work. It is suitable for joinery, interior trim, ship building, vehicle bodies, toys, novelties, boxes, crates, veneer and plywood. The bark is used to make grain sacks, game nets, snares, clothes and water baskets.

Brachystegia mildbraedii – wild

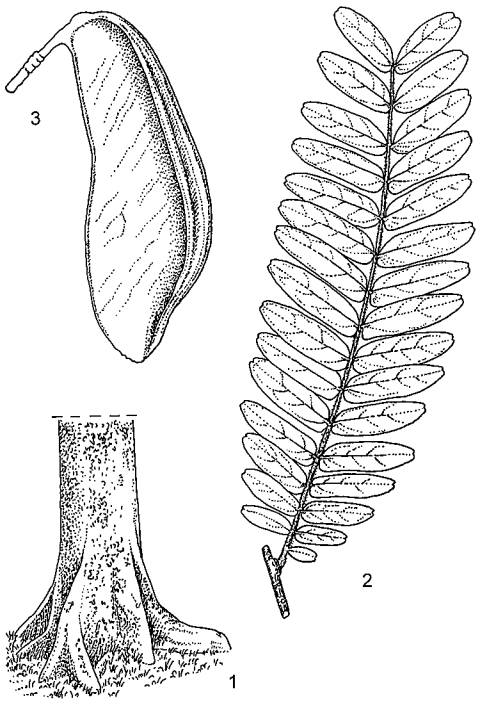
Production and international trade The wood of *Brachystegia mildbraedii* is locally important, but it is only traded internationally in mixed consignments.

Properties The heartwood is medium brown and not distinctly demarcated from the yellowish white, up to 15 cm wide sapwood. The grain is usually wavy or interlocked, texture coarse. The wood often shows a roe figure and is lustrous. It is medium-weight, with a density is 500–620 kg/m³ at 12% moisture content. The wood air dries with some difficulty, but kiln dries well if carefully and closely stacked. Kiln drying of 2.5 cm thick boards from green to 12% moisture content takes about 7 days. The rates of shrinkage are moderate, from green to oven dry 3.3–5.2% radial and 6.5–8.0% tangential. Once dry, the wood is moderately stable to stable in service.

At 12% moisture content, the modulus of rupture is 90–163 N/mm², modulus of elasticity 7940–10,790 N/mm², compression parallel to grain 39–59 N/mm², shear 5.5–9.0 N/mm², cleavage 10–18 N/mm and Chalais-Meudon side hardness 1.7–4.1.

The wood is moderately easy to work, with a moderate blunting effect on saw teeth and cutting edges. It has some tendency to pick up on planing; a cutting angle of 10° usually gives a good finish. The wood glues fairly well and finishes, stains and polishes fairly well if a filler is applied. The wood is not durable, being moderately susceptible to attacks by termites, powder-post beetles, marine borers and *Lyctus* borers. It is vulnerable to blue stain fungal attack. It is moderately permeable to preservatives.

Description Evergreen, medium-sized to large tree up to 40(–50) m tall; bole branchless for up to 20 m, straight and cylindrical, up to 150(–200) cm in diameter, slightly thickened and fluted at base or with small buttresses; bark smooth, becoming rough and flaking off in irregular patches, pinkish grey to dark grey, often with greenish patches, inner bark thick, hard, fibrous, dirty pink to orange-red, turning brown upon exposure; crown rounded, rather open, with ascending branches; twigs glabrous to slightly hairy, blackish, with scars of bud scales at base and with numerous lenticels. Leaves alternate, paripinnately compound with (5–)9–16(–20) pairs of leaflets; stipules early caducous; petiole 0.5–1 cm long, thickened at base, rachis 10–25 cm long, rusty hairy; leaflets opposite, sessile, obliquely oblong, 1.5–5(–10) cm × 0.5–1.5(–4) cm, rounded at base, slightly notched to short-acuminate at apex, papery to slightly leathery, nearly glabrous, pinnately veined with up to 14 pairs of lateral veins. Inflorescence a terminal or axillary, rounded, short panicle, strongly branched, densely hairy, many-flowered. Flowers bisexual, nearly regular, small, fragrant, at base with



Brachystegia mildbraedii – 1, base of bole; 2, leaf; 3, fruit.
Redrawn and adapted by J.M. de Vries

2 ovate bracteoles c. 6 mm long; pedicel 2–3 mm long; sepals (3–)5, slightly unequal, 1–2 mm long, nearly glabrous; petals absent; stamens 10, free, c. 1 cm long; ovary superior, ellipsoid, c. 3 mm long, with stipe, hairy, style slender. Fruit an oblong to obovoid, flattened pod 20–30 cm × 6–10 cm, at a right angle to the stipe, smooth but slightly wrinkled, reddish brown to dark brown or nearly black when ripe, dehiscent with 2 woody valves, 2–4-seeded. Seeds disk-shaped, c. 3 cm in diameter, dark brown.

Other botanical information *Brachystegia* is a taxonomically difficult genus comprising about 30 species, distributed in mainland tropical Africa and South Africa, the majority of species occurring in southern tropical Africa, where they are characteristic of miombo woodland.

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; 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; (81: axial parenchyma lozenge-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: 96: rays exclusively uniseriate; (97: ray width 1–3 cells); 104: all ray cells procumbent; 116: ≥ 12 rays per mm. Storied structure: 122: rays and/or axial elements irregularly storied. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E.A. Obeng, P. Baas & H. Beeckman)

Growth and development *Brachystegia mildbraedii* is evergreen, but sheds its leaves briefly in the dry season. The fruits open explosively, dispersing the seeds over short distances. As a result, seedlings and saplings are most common close to the parent tree.

Ecology *Brachystegia mildbraedii* occurs in evergreen forest, often on slopes, up to 1000 m altitude. It grows on shallow soils derived from shale or quartzite, which are poor in nutrients.

Management *Brachystegia mildbraedii* occurs scattered in the forest or in small groups. In forest in south-western Cameroon, the average density of trees with a bole diameter of more than 60 cm is 0.3 tree/ha, with an average wood volume of 3.2 m³/ha, but *Brachystegia mildbraedii* is not distinguished from *Brachystegia laurentii* (De Wild.) Louis ex Hoyle, which probably provides the largest share in these figures.

Harvesting In Gabon the minimum bole diameter allowed for harvesting is 70 cm.

Handling after harvest Freshly felled logs should be treated with preservatives or processed soon after felling to avoid blue stain attack.

Genetic resources It is unlikely that *Brachystegia mildbraedii* is in immediate risk of genetic erosion because it is locally common and not much traded internationally. However, some care is needed because it has a limited area of distribution and may become endangered in regions subject to forest degradation and selective felling.

Prospects *Brachystegia mildbraedii* will continue to provide a useful timber of local importance, but it should be managed properly to ensure its sustainable use. It is unlikely that it will become important on the international market due to its scattered occurrence.

Major references ATIBT, 1986; Aubréville, 1970; Bolza & Keating, 1972; CIRAD Forestry Department, 2008; de Saint-Aubin, 1963; Letouzey & Mouranche, 1952; Sallenave, 1964; Tailfer, 1989; Vivien & Faure, 1985; Wilks & Issembé, 2000.

Other references Aubréville, 1968; Davy & Hutchinson, 1923; Normand & Paquis, 1976; Raponda-Walker & Sillans, 1961; Takahashi, 1978.

Sources of illustration Letouzey & Mouranche, 1952; Wilks & Issembé, 2000.

Authors J.K. Mensah

BRACHYSTEGIA NIGERICA Hoyle & A.P.D.Jones

Protologue Kew Bull. 1947(1): 68 (1947).
Family Caesalpiniaceae (Leguminosae - Cae-

salpinioideae)

Origin and geographic distribution *Brachystegia nigerica* is endemic to southern Nigeria.

Uses The wood, traded together with some other *Brachystegia* species as 'okwen' or 'naga', is used for low-quality furniture and tool handles. It is suitable for light construction, flooring, joinery, interior trim, ship building, vehicle bodies, boxes, crates, food containers, toys, novelties, veneer and plywood.

Flour made from the seeds is used as thickening and flavouring agent in soup preparation. In traditional medicine, leaf and bark extracts are used in the treatment of stomach disorders, fever, urinary infections and gonorrhoea.

Production and international trade The wood of *Brachystegia nigerica* is mainly used and traded locally. It is probably occasionally exported in mixed consignments.

Properties The heartwood is pale brown to dark brown and distinctly demarcated from the whitish to pale yellowish brown, up to 15 cm wide sapwood. The grain is often wavy or interlocked, texture moderately coarse to coarse. Quarter-sawn surfaces often show a stripe or roe figure.

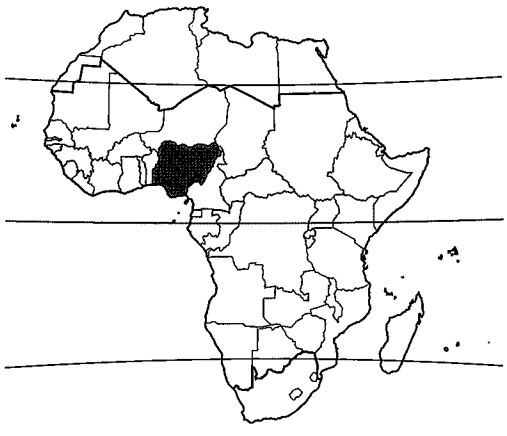
The wood is medium-weight, with a density of 675–705 kg/m^3 at 12% moisture content, and moderately hard. It air dries slowly but fairly well. Kiln drying should be done slowly and carefully because there is a risk of deep surface checks. End splitting can be minimized by applying a bituminous coating to cross-cut ends of boards. Small splits tend to enlarge as drying progresses. Collapse is common in tension wood. The wood has a tendency to bow, cup and spring. The rates of shrinkage are moderate.

At 12% moisture content, the modulus of rupture is 75–105 N/mm^2, modulus of elasticity 8800–11,300 N/mm^2, compression parallel to grain 38–57 N/mm^2, shear 10.5–18.5 N/mm^2, cleavage 18 N/mm and Janka side hardness 5420–6360 N.

The wood works fairly well with machine tools, but with serious blunting effect on saw teeth and cutting edges and a risk of overheating during sawing. It is difficult to work with hand tools. During planing, there is a tendency of tearing when interlocked grain is present; a reduced cutting angle of 10–13° should be used for best results. The wood is liable to splitting upon nailing, and pre-boring is recommended. The wood is moderately durable, being susceptible to blue stain and insect attacks.

Seed of *Brachystegia nigerica* yields about 7.3% of a fixed oil on dry weight basis. Per 100 g, the oil contained 84 g of mixed fatty acids; the iodine number is 10.82 and the saponification equivalent 342.5. The essential oil from the leaves is reported to contain α-pinene (17.7%), β-selinene (12.5%) and α-gurjunene (8.8%).

Botany Evergreen medium-sized to large tree up to 40(–45) m tall; bole branchless for up to 15 m, straight and cylindrical, up to 120 cm in diameter, with or without buttresses; bark surface smooth in young trees, becoming rough and scaly, flaking off in large scales, brown with reddish patches, inner bark fibrous, hard, pinkish, turning brown on exposure; crown spreading, dense; twigs glabrous. Leaves alternate, paripinnately compound with (3–)5–9 pairs of leaflets; stipules 1–2 cm long, caducous; petiole c. 0.5 cm long, swollen at the base, grooved above, rachis 3.5–11 cm long, narrowly winged; leaflets opposite, obliquely elliptical to obovate or oblong, 0.5–7.5 cm × 0.3–3.5 cm, becoming larger towards the apex of rachis, nearly glabrous, pinnately veined with up to 14 pairs of lateral veins. Inflorescence a terminal panicle up to 3.5 cm long, short-hairy, densely flowered. Flowers bisexual, nearly regular, small, fragrant, at base with 2 ovate bracteoles c. 6 mm long; pedicel 3–5 mm long; sepals (3–)5, slightly unequal, 2–2.5 mm long, nearly glabrous; petals absent; stamens 10, nearly free, c. 1 cm long; ovary superior, ellipsoid, c. 3 mm long, with c. 3 mm long stipe, hairy, style slender, c. 1 cm long. Fruit an oblong to obovoid, flattened pod 9–15(–17) cm × 3.5–5 cm, at a right angle to the stipe, smooth but slightly wrinkled, dark purplish brown or nearly black when ripe, dehiscent with 2 woody valves, usually 4-seeded. Seeds disk-shaped, c. 2 cm in diameter, dark brown.



Brachystegia nigerica – wild

Brachystegia nigerica, especially mature trees, may be recognized by its small leaflets diminishing in size from the apex downwards. In young trees, the grooved and narrowly winged petiole distinguishes it from the other *Brachystegia* species in its range. Trees usually flower in December. Fruits ripen in October–December, but have also been recorded in June. They open explosively, dispersing the seeds over short distances.

Brachystegia is a taxonomically difficult genus comprising about 30 species, distributed in mainland tropical Africa and South Africa, the majority of species occurring in southern tropical Africa, where they are characteristic of miombo woodland.

Brachystegia kennedyi Hoyle is a medium-sized to large tree up to 45(–50) m tall with bole up to 220 cm in diameter and often large buttresses. It occurs, sometimes gregariously, in evergreen forest in Nigeria and western Cameroon, and differs from *Brachystegia nigerica* mainly in its leaves which have generally larger leaflets with apical leaflets slightly smaller than middle ones. The brownish wood, also traded as 'okwen' or 'naga', is moderately tough and durable, and suitable for construction work and joinery, having fairly good machining properties.

Ecology *Brachystegia nigerica* occurs in lowland rainforest, especially in wetter parts along watercourses, where it may grow gregariously. It is also reported from deciduous woodland and hill slopes.

Management *Brachystegia nigerica* can be managed by coppicing. Logs may have brittle heart, requiring caution during harvesting. It is necessary to treat freshly felled logs with preservatives or to process them immediately to prevent blue stain attack. Freshly harvested logs do not float in water and cannot be transported by river.

Genetic resources and breeding *Brachystegia nigerica* has a limited distribution area and occurs in small populations. It is not common and is likely to suffer from genetic erosion, requiring conservation measures. It is classified as vulnerable in the IUCN Red List of threatened species.

Prospects *Brachystegia nigerica* will only remain useful tree for domestic use of the edible seeds and in traditional medicine. Its prospects as a timber tree seem small, even for the local market, due to its limited occurrence. The focus of research should be towards its conservation and sustainable management.

Major references Bolza & Keating, 1972; Burkill, 1995; Keay, 1989; Obasi & Ndelle, 1991; Takahashi, 1978.

Other references Davy & Hutchinson, 1923; Federal Department of Forest Research, 1966a; Federal Department of Forest Research, 1966b; Keay, Hoyle & Duvigneaud, 1958; Ogunwande et al., 2008; World Conservation Monitoring Centre, 1998.

Authors E.A. Obeng

BRACHYSTEGIA SPICIFORMIS Benth.

Protologue Trans. Linn. Soc. London 25: 312 (1866).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 24$

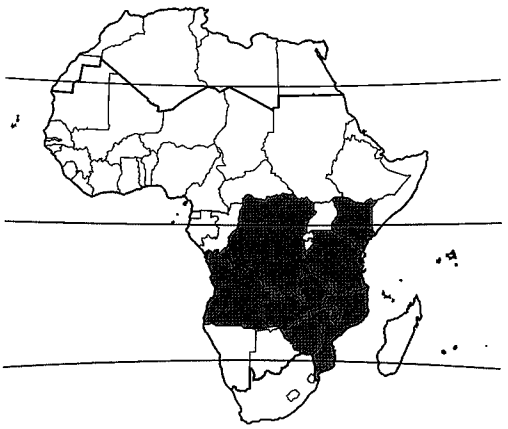
Synonyms *Brachystegia lujae* De Wild. (1920).

Vernacular names Bean-pod tree (En). Messasa (Po). Myombo, mriti, mrihi (Sw).

Origin and geographic distribution *Brachystegia spiciformis* is distributed from southern and eastern DR Congo, south-eastern Kenya, Tanzania and Angola southward to Zimbabwe, Mozambique and northernmost South Africa.

Uses The wood of *Brachystegia spiciformis* is used for construction, door frames, canoes, cheap furniture, railway sleepers (if treated), utensils and beehives. It is suitable for flooring, joinery, interior trim, mine props, vehicle bodies, boxes, crates, food containers, veneer, plywood and pulp for paper. It is equally important as a source of firewood and charcoal, being among the preferred species for charcoal making throughout southern Africa.

The bark is used to make beehives, the inner



Brachystegia spiciformis – wild

bark to make rope for roof ties, sacks, cloth and grain bins. In Tanzania thread is made from the roots. The bark is astringent, containing about 13% tannin, and an extract of it is used traditionally as a final dressing in tanning hides. It imparts a reddish colour to the finished product. In traditional medicine, root infusions provide treatment for dysentery and diarrhoea, and a decoction is applied as an eyewash to treat conjunctivitis. The bark is chewed as a treatment of snake bites.

The tree is a source of nectar for bees and the leaves are used as fodder. The trees are famous for the attractive pink, wine red, copper and bronze colours of their new foliage and are suitable for amenity planting; their crowns provide fine shade.

Production and international trade The wood and charcoal of *Brachystegia spiciformis* is mainly used and traded locally, and is only traded internationally in mixed consignments.

Properties The heartwood is variable in colour, from pale brown to reddish brown, darkening on exposure, sometimes striped, and clearly demarcated from the pale cream to white, 5–12 cm thick sapwood. The grain is interlocked, texture coarse.

The wood is fairly heavy, with a density of 680–915 kg/m^3 at 12% moisture content. It air and kiln dries slowly with some tendency to warping, surface checking and splitting at ends and knots, but more serious drying defects have also been reported. It takes about 13 weeks to air dry 2.5 cm thick boards from 60% to 13% moisture content and about 4 weeks for kiln drying. The rates of shrinkage from green to oven dry are 2.9–4.1% radial and 4.3–5.8% tangential. Once dry, the wood is moderately stable in service.

At 12% moisture content, the modulus of rupture is 88–125 N/mm^2, modulus of elasticity 11,100–14,400 N/mm^2, compression parallel to grain 60–69 N/mm^2, shear 11–16 N/mm^2, cleavage 15–16 N/mm, Janka side hardness 6620–8140 N and Janka end hardness 6850–7920 N.

Because of its hardness and interlocked grain, the wood is difficult to saw and work with both hand and machine tools, with a moderate to severe blunting effect on saw teeth and cutting edges. The interlocked grain makes it liable to tear on planing, and a reduced cutting angle of 10°, a slow feeding speed and the use of a filler are recommended to obtain a smooth surface. Moulding properties are poor. Mortising is difficult with hand tools but easy with a chain mortiser; drilling is easy, but breaking may occur at unsupported ends. The wood sands to a good finish and polishes well. It has a strong tendency to split on nailing, making pre-boring necessary. The bending properties are poor.

The wood not durable and is liable to attack by termites, pinhole borers and marine borers; especially the sapwood is susceptible to staining fungi. The heartwood is difficult to impregnate with preservatives even by pressure, the sapwood can be satisfactorily impregnated when a prolonged pressure treatment is used. The wood is not well suited for paper making because it is difficult to chip and the yield of pulp by the sulphate process is low, whereas the yield of bleached pulp is very low.

The wood contains 50–57% cellulose, 27.5–31% lignin, 16.5–18% pentosan and 0.9–1.3% ash. The solubility is 2.2–5.1% in alcohol-benzene, 2.2–4.0% in hot water and 14–18% in a 1% NaOH solution.

In traditional charcoal making in Tanzania, the average yield of marketable charcoal from *Brachystegia spiciformis* wood with 40–50% moisture content was about 90 kg per m^3. The foliage is of intermediate value as forage. The rumen degradability is 0.4–0.5. Young leaves contain per 100 g dry matter approximately: digestible dry matter 52 g, crude protein 18 g and energy 760 kJ; for old leaves: digestible dry matter 60 g, crude protein 11 g and energy 870 kJ.

Botany Deciduous or semi-evergreen, small to fairly large tree up to 35(–40) m tall; bole branchless for up to 15 m, straight and cylindrical or poorly formed, up to 120 cm in diameter, without buttresses but sometimes fluted at base; bark surface smooth, grey to greyish brown, often flaking off in thick scales, in older trees becoming shallowly fissured, inner bark reddish; crown rounded but becoming flattened in older trees, with spreading branches; twigs glabrous or slightly hairy. Leaves alternate, paripinnately compound with 2–8 pairs of leaflets; stipules 1–4 cm long, usually caducous; petiole 1–5 cm long, thickened at base, rachis (3–)5–15(–18) cm long, grooved and slightly winged; leaflets opposite, ovate to elliptical, oblong or lanceolate, 1.5–20 cm × 0.5–8 cm, basal pair of leaflets smallest, obliquely rounded, truncate or cordate at base, acute to rounded or notched at apex, glabrous or slightly hairy, pinnately veined but with 3–5 basal veins. Inflorescence a terminal or axillary panicle up to 8 cm long, glabrous to short-hairy. Flowers bisexual, nearly regular, small, fra-

grant, at base with 2 obovate to rounded bracteoles 0.5–1 cm long; pedicel 2–8 mm long; sepals 0–4, slightly unequal, 0.5–3 mm long, nearly glabrous; petals absent; stamens 10, fused at base, 1–2 cm long; ovary superior, ellipsoid, 2–5 mm long, with stipe up to 6 mm long, hairy, style slender, up to 1.5(–2) cm long, coiled. Fruit an oblong to obovoid, flattened pod 8–15(–20) cm × 3–5 cm, at a right angle to the stipe, smooth but slightly wrinkled, slightly winged along one suture, dark brown to purplish brown, dehiscent with 2 woody valves, up to 6-seeded. Seeds oblong to ovoid, 1.5–2.5 cm long, dark brown.

Brachystegia is a taxonomically difficult genus comprising about 30 species, distributed in mainland tropical Africa and South Africa, the majority of species occurring in southern tropical Africa, where they are characteristic of miombo woodland.

Brachystegia spiciformis is extremely variable in leaf and inflorescence characters. It is slow growing, and may become a fairly large tree in wetter savanna and woodland, but remains a small stunted tree in dry areas. The taproot can reach a depth of more than 5 m and laterally the root system can extend over more than 25 m. Flowering and fruiting do not always occur every year and depend on the climatic conditions. In southern Africa, flowering usually occurs in August–November. The flowers are much visited by bees, which probably pollinate them. After pollination, fruit development takes 7–8 months. At the end of the dry season seeds are scattered when dry fruits split open explosively.

Ecology *Brachystegia spiciformis* occurs in coastal and upland deciduous woodland and open forest, up to 2000(–2350) m altitude. It is characteristic of miombo woodland, where it is often dominant in higher rainfall areas. It can be found on hill slopes and river banks, but also on intensely drained and very poor and shallow soils. The annual rainfall in the area of distribution ranges from 500 mm to 1200 mm. *Brachystegia spiciformis* is frost and fire tender.

Management At the end of the dry season seeds are scattered when dry pods split open explosively. The weight of 1000 seeds is 375–670 g. Under favourable conditions, germination takes 3–4 weeks with a germination rate of about 80%. No seed treatment is needed, but germination is better when seeds are nicked. Seed can be stored for one year if kept free from insects. Under natural conditions, root suckers play a minor role and recruitment under large trees is almost exclusively due to seedlings.

In previously cultivated rangeland in Zimbabwe, regeneration of *Brachystegia spiciformis* was mainly from coppices and less vigorous than that of *Julbernardia globiflora* (Benth.) Troupin, a co-dominant tree in the original miombo vegetation. Trees produced less coppice shoots when cut at 5 cm above the ground than when cut at a higher level. Under regular cultivation, *Brachystegia spiciformis* is likely to become less common. Its growth is strongly affected by heavy browsing by goats, but grazing cattle have a less pronounced effect. Although many insects have been found feeding on *Brachystegia spiciformis* and trees may occasionally be defoliated, no serious pests or diseases have been described.

Care should be taken in harvesting old boles because heart rot may be present and ring shakes frequently arise immediately after felling, sometimes for the whole length of the log. To avoid blue stain and insect attacks logs should be treated with preservatives or converted soon after felling.

Genetic resources and breeding *Brachystegia spiciformis* is widespread and in many localities dominant. Its genetic diversity is considered to be at low risk, although it is locally heavily exploited for timber, charcoal and fuelwood.

Prospects *Brachystegia spiciformis* is likely to remain a general-purpose timber of local importance, although it is difficult to work and not durable. More attention has to be given to its role as a source of fuel and charcoal in view of its economic importance and conservation needs.

Major references Brummitt et al., 2007a; Coates Palgrave, 2002; Lovett et al., 2007; Mbuya et al., 1994; Orwa et al., 2009.

Other references Campbell (Editor), 1996; Chinuwo et al., 2010; Dale & Greenway, 1961; Ernst, 1998; Grundy, Campbell & Frost, 1994; Herd, 2007; Luoga, Witkowski & Balkwill, 2000; Nshubemuki & Mbwambo, 2007; Saidi & Tshipala-Ramatshimbila, 2006; Topps, 1997.

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

BRACHYSTEGIA TAMARINDOIDES Benth.

Protologue Trans. Linn. Soc. London 25: 312 (1866).

Family Caesalpiniaceae (Leguminosae - Cae-

salpinioideae)

Vernacular names Mountain acacia, redwood (En).

Origin and geographic distribution *Brachystegia tamarindoides* occurs from eastern DR Congo and Tanzania southwards to Angola, Zimbabwe and Mozambique.

Uses The wood is locally used in house building, e.g. for flooring joist and lintels, in wagon construction, and for mine props. It is suitable for joinery, interior trim, ship building, vehicle bodies, furniture, railway sleepers (if treated), toys, novelties, turnery, veneer and plywood. It is considered an excellent source of firewood; it is in demand by farmers for curing tobacco. The wood is also important for charcoal production.

The inner bark is a source of fibre used for ropes, sacks, cloths, mats, bags, hats, bins and handicrafts. The bark is chewed to treat constipation and as anthelmintic. The foliage is browsed by livestock such as cattle and goats.

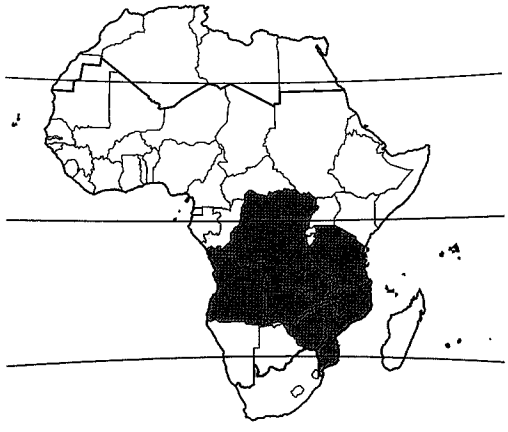
Production and international trade The wood of *Brachystegia tamarindoides* is locally used and has no importance on the international timber market.

Properties The heartwood is greyish brown to reddish brown or dark brown and is distinctly demarcated from the yellowish white, up to 10 cm wide sapwood. The grain is interlocked, texture moderately coarse to coarse. Quartersawn surfaces show a nice figure.

The wood is medium-weight to fairly heavy, with a density of 770–880 kg/m³ at 12% moisture content. It air dries slowly; boards of 2.5 cm thick take about 9 weeks to dry from green to air dry, with moderately severe distortion and sometimes surface checking and end splitting. The rates of shrinkage during drying are medium, from green to 12% moisture content 2.1% radial and 2.8% tangential. At 12% moisture content, the modulus of rupture is about 88 N/mm², modulus of elasticity 10,500 N/mm², compression parallel to grain 67 N/mm², shear 15 N/mm² and Janka side hardness 6450 N.

Sawing may give some difficulties because the wood has a tendency to char and splinter. Surfaces may be rough due to the interlocked grain; in planing, a reduced cutting angle to 10° is recommended. The wood has a tendency to split upon nailing, and therefore pre-boring is advised. It mortises and drills well if it is supported. The heartwood is moderately durable, being susceptible to insect attack. The sapwood is liable to attacks by blue-stain fungi and *Lyctus* borers. The heartwood is resistant to impregnation with preservatives, the sapwood moderately resistant.

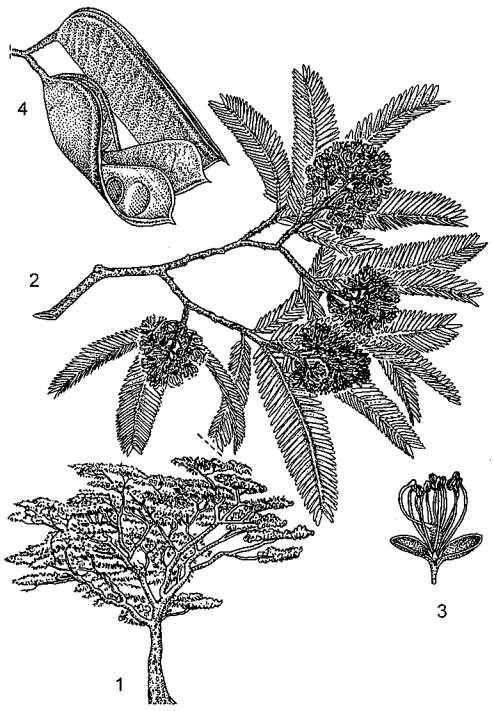
The amount of tannin in the bark varies greatly, from 8% to 25%.



Brachystegia tamarindoides – wild

Description Deciduous, small to medium-sized tree up to 30(–35) m tall; bole generally straight and cylindrical, up to 80(–120) cm in diameter; bark surface smooth, silvery grey to dark grey, flaking off leaving round yellowish patches, inner bark yellowish to pinkish, becoming brown upon exposure; crown rather open, flattened, with spreading branches; twigs short-hairy to glabrous. Leaves alternate, paripinnately compound with 6–72 pairs of leaflets; stipules 0.5–3 cm long, usually caducous; petiole 0.2–1.5 cm long, thickened at base, rachis 5–12 cm long, grooved and slightly winged; leaflets opposite, ovate to elliptical, oblong or linear, 0.5–6 cm × 0.2–2 cm, obliquely rounded or cordate at base, acute to rounded or notched at apex, glabrous or short-hairy, pinnately veined. Inflorescence a terminal or axillary panicle up to 8 cm long, short-hairy. Flowers bisexual, nearly regular, small, fragrant, at base with 2 ovate bracteoles 4–8 mm long; pedicel 1.5–3 mm long; sepals (4–)5, slightly unequal, 2–2.5 mm long, nearly glabrous; petals absent or 1 and then c. 1.5 mm long; stamens 10, nearly free, c. 1 cm long; ovary superior, ellipsoid, 3–4 mm long, with stipe up to 3 mm long, hairy, style slender, up to 1 cm long, coiled. Fruit an oblong to obovoid, flattened pod 5–10 cm × 1.5–3 cm, at a right angle to the stipe, smooth but slightly wrinkled, dark brown to purplish brown, dehiscent with 2 woody valves, up to 7-seeded. Seeds oblong to ovoid, 1.5–2 cm long, dark brown.

Other botanical information *Brachystegia*



Brachystegia tamarindoides – 1, tree habit; 2, flowering twig; 3, flower; 4, fruits.
Redrawn and adapted by J.M. de Vries

is a taxonomically difficult genus comprising about 30 species, distributed in mainland tropical Africa and South Africa, the majority of species occurring in southern tropical Africa, where they are characteristic of miombo woodland.

Three subspecies have been distinguished in *Brachystegia tamarindoides*: subsp. *tamarindoides* restricted to Angola, subsp. *microphylla* (Harms) Chikuni widespread throughout the distribution area of the species, and subsp. *torrei* (Hoyle) Chikuni occurring in Malawi, Zimbabwe and Mozambique. The latter two subspecies are sometimes distinguished as separate species, i.e. *Brachystegia microphylla* Harms and *Brachystegia torrei* Hoyle, respectively, whereas *Brachystegia glaucescens* Hutch. & Burtt Davy is sometimes also kept separate from subsp. *microphylla* on species level.

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; 70: fibres very thick-walled. Axial parenchyma: 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; 104: all ray cells procumbent; 116: ≥ 12 rays per mm. Storied structure: 122: rays and/or axial elements irregularly storied. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; (143: prismatic crystals in fibres).

(E.E. Mwakalukwa, H. Beeckman & P. Baas)

Growth and development Two years after germination, seedlings had a mean height of only 25 cm. In plantations in Burundi, trees reached a height of 7–8 m 11 years after planting. Trees are leafless in the dry season, usually in August–September. They flower in September–October and fruits ripen in April–September. When ripe, the fruits split open explosively, dispersing the seeds over some distance. The roots are associated with ectomycorrhizal fungi.

Ecology *Brachystegia tamarindoides* is most common in deciduous woodland on rocky hills and escarpments, at 800–2000 m altitude. It occurs on granite soils and leached reddish soils, often in localities with thin but humus-rich soils. It is quite drought tolerant

Propagation and planting In Zimbabwe the germination rate of seeds was only 30%, and the survival rate of seedlings after one year also 30%. Pre-treatment of the seeds by immersion in boiling water accelerates germination and improves the germination rate.

Management *Brachystegia tamarindoides* is locally dominant or co-dominant with other *Brachystegia* spp.

Diseases and pests The foliage is often attacked by caterpillars of the saturniid moth *Imbrasia epimethea*; these caterpillars are edible.

Harvesting People typically collect branch-

es and stems with a diameter of 3–8 cm as firewood for household fires. For use in construction and charcoal production, thicker stems and branches are collected. Big and tender shoots of young trees are often cut to extract fibre. Harvesting for all these purposes is done throughout the year.

Handling after harvest After felling, logs should not be left for longer periods in the field because the wood is susceptible to insect attacks; they should be processed rapidly or treated with preservatives. Extracted fibre is often boiled together with ash for colouring, followed by drying. Subsequently the fibre is pressed to soften it and then spun into strands or strings.

Genetic resources *Brachystegia tamarindoides* is not considered to be endangered because it is widespread and locally abundant or even dominant. However, wood exploitation for construction and charcoal production, logging for agricultural fields and uncontrolled forest fires have locally led to serious degradation of the miombo woodland in which *Brachystegia tamarindoides* plays an important role. In some regions, damage caused by elephants has contributed to loss of woodland with a high proportion of *Brachystegia tamarindoides*.

Prospects Together with some other *Brachystegia* spp. from the miombo woodland, *Brachystegia tamarindoides* is important for local people as a source of timber, firewood, charcoal and fibre. Planting programmes have locally been initiated to counterbalance high levels of exploitation and forest degradation. More research is needed on growth rates, propagation, silvicultural methods and harvesting techniques to arrive at appropriate recommendations for sustainable forest management.

Major references Bolza & Keating, 1972; Brenan, 1967; Brummitt et al., 2007a; Bryce, 1966; Bryce, 1967; Coates Palgrave, 2002; Coates Palgrave, 1957; Gerhardt & Nemarundwe, 2006; Takahashi, 1978; Wilczek et al., 1952.

Other references Allen & Allen, 1981; Bongo & Bourdillon, 2000; Campbell (Editor), 1996; Hyde & Wursten, 2011; Tafangenyasha, 2001; Wilczek et al., 1952; Williamson, 1955.

Sources of illustration Brenan, 1967; Coates Palgrave, 2002.

Authors L. Jimu

BRANDZEIA FILICIFOLIA Baill.

Protologue Adansonia 9: 217 (1869).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Bathiaea rubriflora* Drake (1903).

Origin and geographic distribution *Brandzeia filicifolia* is endemic to northern and western Madagascar, where it occurs from Antsiranana south to Morondava.

Uses The wood is used for planks in house construction.

Properties The wood is whitish and hard.

Botany Deciduous small to medium-sized tree up to 25 m tall; bole up to 60 cm and sometimes more in diameter; bark surface smooth and pale grey, with numerous lenticels, inner bark thick, fibrous, reddish; twigs slightly fleshy, glabrous, silvery grey-brown, with numerous lenticels. Leaves alternate, pinnately compound with (5–)7–9 leaflets; stipules triangular, small; petiole 1–3 cm long, rachis slightly zigzag, 4.5–10 cm long; petiolules 3–4 mm long; leaflets alternate, elliptical to ovate or oblong, 3.5–7(–8) cm × 1.5–3.5(–4) cm, slightly unequal, glabrous, pinnately veined. Inflorescence a panicle, often many together into dense and complex clusters, branches up to 3.5 cm long, many-flowered. Flowers bisexual, regular, bright pink-red, sessile; hypanthium obconical, 7–9 mm long, resembling a pedicel; sepals 4, free, broadly triangular-elliptical, 3.5–4 mm long, concave, with many large gland dots; petals 5, free, oblong-elliptical, 6.5–7 mm long, clawed at base; stamens 10, free, 13–20 mm long; disk prominent, grooved, yellow-green; ovary superior, 2–2.5 mm long, with stipe c. 3 mm long, glabrous, style slender, c.

Brandzeia filicifolia – wild

11 mm long. Fruit a samara-like pod 7–8 cm long, with 5–8 mm long stipe, glabrous, pale brown, with a single apical seed and a large basal wing, with ridge over the seed-containing portion, indehiscent, with persistent sepals at base. Seed oblong-ovate, flat, 1.5–2 cm long, reticulately veined, blackish brown.

Trees flower when they are leafless and they are then very conspicuous because of the profusion of flowers. It has been observed that the flowers are visited by small sunbirds, which may play a role in pollination. New leaves usually start developing when the fruits have ripened. The fruits, which strongly resemble those of maples (*Acer*) except that the seed is at the apex and the wing at the base, are dispersed by wind; the wing makes that the fruit spins rapidly and falls slowly.

Brandzeia comprises a single species. Its affinity is still uncertain, but *Neoapaloxylon*, a genus of 3 species occurring in dry regions of western and southern Madagascar, has similar fruits. *Neoapaloxylon* differs in leaflets and sepals having small red-brown glandular dots, the absence of petals and the absence of a ridge over the seed-containing portion of the fruit.

Ecology *Brandzeia filicifolia* occurs in deciduous woodland, up to 300 m altitude. It is often found on limestone soils, but has also been recorded from sandy, basalt and gneiss soils.

Management Fruits can be collected from the ground in November–December; they should be sown as soon as possible.

Genetic resources and breeding Although *Brandzeia filicifolia* is fairly widely distributed in Madagascar, it seems to be common only locally, especially in the limestone massifs of Ankarana and Namoroka.

Prospects Very little is known about *Brandzeia filicifolia*, of which the bole becomes large enough to be interesting for the production of wood that has apparently a fair quality. Research is needed on nearly all aspects before its prospects can be judged. However, it is probably not common enough to promote increased usage.

Major references du Puy et al., 2002; Schatz, 2001.

Other references Lewis et al., 2005; Randrianasolo et al., 1996.

Authors R.H.M.J. Lemmens

BREONADIA SALICINA (Vahl) Hepper & J.R.I.Wood

Protologue Kew Bull. 36(4): 860 (1982).

Family Rubiaceae

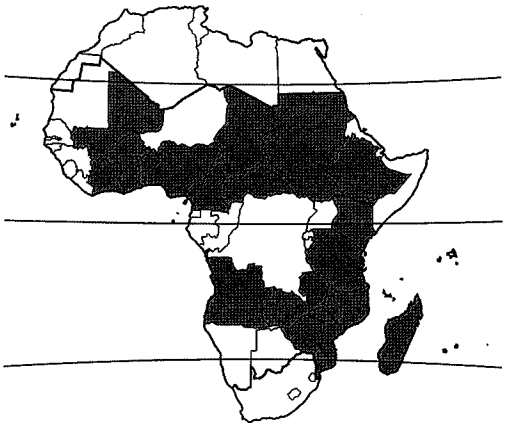
Synonyms *Adina microcephala* (Delile) Hiern (1877), *Breonadia microcephala* (Delile) Ridsdale (1975).

Vernacular names Water shea nut, African teak, wild oleander (En). Mgwina (Sw).

Origin and geographic distribution *Breonadia salicina* is widely distributed in tropical Africa, from Côte d'Ivoire and Mali eastward to Ethiopia, and southward to Angola, Zimbabwe, Mozambique and Madagascar. It also occurs in South Africa, Swaziland and Yemen. It is sometimes planted.

Uses The wood is suitable for heavy construction (including bridges), heavy flooring, joinery, mine props, boat building, vehicle bodies, furniture, sporting goods, toys, novelties, agricultural implements, railway sleepers, marine piles, carvings, pattern making and turnery. It is made into bows in Nigeria, for caskets in Madagascar, while in Malawi and Madagascar dugout canoes are made from the boles. In southern Tanzania the wood is extensively used as fuelwood.

The twigs are used for cleaning the teeth in West Africa. *Breonadia salicina* is often planted as an ornamental tree and sometimes also for erosion control and in windbreaks. The flowers serve as bee forage. In Madagascar the bark is added in the preparation of local alcoholic drinks ('toaka gasy') to help fermentation. *Breonadia salicina* is widely used in traditional African medicine. Root decoctions are drunk as a purgative in Tanzania and against tachycar-



Breonadia salicina – wild and planted

dia in South Africa. An infusion of the pounded stem is given to breast-fed children in Ethiopia for the treatment of diarrhoea and vomiting. In Tanzania bark infusions are used for preventing influenza and for the treatment of stomach problems, and a decoction or infusion of the bark is used as a wash to clean wounds. Dried powdered bark is applied as a wound dressing. In Malawi the bark is chewed for the treatment of diarrhoea and stomach-ache, and a bark infusion is drunk for the treatment of pneumonia. In Madagascar a decoction of the inner bark is used as a mouthwash in case of cavities and abscesses. A leaf decoction is used in Nigeria as a bath for the treatment of yellow fever. In Malawi a leaf infusion is drunk to treat diarrhoea and stomach-ache. In Madagascar a leaf decoction is drunk for the treatment of malaria. In Ethiopia the seed is put into fire and the patient exposed to the smoke to treat joint pain. In veterinary medicine in Nigeria, the bark is used against diarrhoea. In Nigeria the root and bark are ingredients of arrow poisons on the basis of *Strophanthus sarmentosus* DC.

Properties The heartwood may vary from yellowish to pale brown, pinkish brown, dark brown, dark grey or reddish, with brown or black markings; it is indistinctly or distinctly demarcated from the 2.5–5 cm wide sapwood. The grain is straight or wavy, texture fine and even. Freshly sawn wood has an oily feel and a characteristic smell, reminiscent of linseed oil. The wood is heavy, with a density of 830–960 kg/m^3 at 12% moisture content, strong and hard. It air dries well if dried slowly, but surface checking may occur. The rates of shrinkage are moderate, from green to oven dry 3.3–4.0% radial and 6.0–6.7% tangential. Reports on stability of the wood in service vary. At 12% moisture content, the modulus of rupture is 81–114 N/mm^2, modulus of elasticity 13,400–14,500 N/mm^2, compression parallel to grain 59–61 N/mm^2, compression perpendicular to grain 14 N/mm^2, shear 11.5–12 N/mm^2, Janka side hardness 8370–9790 N, Janka end hardness 7740–8770 N and Chalais-Meudon side hardness 6–9.
The wood is difficult to saw when green, but it saws fairly easily when dry. It works well with machine tools, but hand tools are subject to slip over due to oily surfaces. The wood is somewhat difficult to plane, but finishes and polishes well. It does not glue satisfactorily, but holds nails and screws well. It has good turning properties, but it is brittle in mortising. It has excellent weathering and wearing properties. The durability of the wood is high; it is resistant to fungi, termites and marine borers. The sapwood is resistant to *Lyctus* borers.
In studies in Swaziland, a 1:1 dichloromethane-methanol extract of the bark showed in-vitro antimalarial activity against *Plasmodium falciparum*, but no antibacterial activity against *Escherichia coli*. The extract did not show toxic effects on human red blood cells and kidney epithelial cells. In studies in South Africa, acetone, hexane, dichloromethane and methanol extracts of the bark showed antifungal activity against various fungi of plants or animals, but the extracts contained toxic compounds, limiting their usability. *Breonadia salicina* is reported to contain the alkaloid mitraphylline.

Description Evergreen, small to large tree up to 40 m tall; bole up to 150 cm in diameter, usually with slender branches near the base; bark surface longitudinally fissured, scaly, grey to grey-brown, inner bark fibrous, reddish, exuding a sticky sap; crown spreading, dense; twigs glabrous. Leaves usually arranged in whorls of (2–)3–5 at the ends of twigs, simple

Breonadia salicina – 1, flowering twig; 2, flower; 3, fruit.
Source: Flore analytique du Bénin

and entire; stipules interpetiolar, triangular, 4–6 mm long, bifid, fused at base, caducous; petiole 1–2.5 cm long; blade lanceolate to narrowly elliptical, 7–33 cm × 2–9 cm, cuneate at base, acute to slightly acuminate at apex, leathery, glabrous, pinnately veined with 16–25 pairs of lateral veins. Inflorescence an axillary, solitary, globose head 1.5–2.5 cm in diameter; peduncle up to 9.5 cm long, short-hairy, with 2–4 ovate bracts 0.5–1 cm long just above the middle. Flowers bisexual, regular, 5-merous, small, fragrant, sessile, with numerous 3–5 mm long bracteoles between the flowers; calyx with 1–2 mm long tube and oblong to linear or triangular lobes 1–2.5(–4.5) mm long; corolla 4–9 mm long, white, pinkish or yellowish, hairy outside, tube 3–6.5 mm long, lobes 1–2.5 mm long; stamens inserted in the corolla throat; ovary inferior, 2-celled, style 1–1.5 cm long, exserted, white, stigma ellipsoid or head-shaped, c. 0.5 mm long, green. Fruit an ellipsoid to obovoid capsule up to 5 mm long, densely clustered in a globose infructescence, hairy, dehiscent with 2 valves, few-seeded. Seeds obovoid, narrowly compressed, 2–3 mm long.

Other botanical information *Breonadia* comprises a single species. It was formerly included in *Adina*, which is now restricted to Asia.

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; 24: intervessel pits minute (≤ 4 μm); 29: vestured pits; 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; 48: 20–40 vessels per square millimetre. Tracheids and fibres: 62: fibres with distinctly bordered pits; 63: fibre pits common in both radial and tangential walls; 66: non-septate fibres present; 69: fibres thin- to thick-walled; 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. Rays: 97: ray width 1–3 cells; 100: rays with multiseriate portion(s) as wide as uniseriate portions; 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; 116: ≥ 12 rays per mm.
(F.D. Kamala, P. Baas & H. Beeckman)

Growth and development *Breonadia salicina* grows fairly fast, at least 1 m per year in South Africa. In Benin trees flower in February–August, and fruits ripen in June–September. In southern Africa flowering is in November–March and fruiting in June–July.

Ecology *Breonadia salicina* occurs from sea-level up to 1550 m altitude, usually in savanna regions but nearly always near rivers and streams, often in gallery forest, occasionally in rocky locations. In Madagascar it is found in dry deciduous forest as well as humid evergreen forest in areas with an average annual rainfall of 1000–2000 mm and 4–6 dry months, but always along rivers.

Propagation and planting *Breonadia salicina* can be propagated from seed, but the germination rate is recorded to be low. More often, cuttings and wildings are used for planting. Cuttings are normally placed in mud. Seedlings are planted out from the nursery when they are at least 1 m tall.

Management *Breonadia salicina* is prone to weed competition. Trees have been reported to coppice well. In Mozambique the minimum diameter allowed for felling is 50 cm.

Genetic resources *Breonadia salicina* is widespread and locally common within its range. It is therefore unlikely to suffer from genetic erosion. In Malawi and South Africa, however, it is a protected species.

Prospects *Breonadia salicina* is a multipurpose tree valued for its strong and durable timber and its medicinal uses. In view of its multipurpose character and fairly fast growth, its integration in agroforestry systems is recommended.

Major references Arbonnier, 2004; Bekele-Tesemma, 2007; Bolza & Keating, 1972; Bridson & Verdcourt, 2003; Burkill, 1997; Coates Palgrave, 2002; Keay, 1989; Neuwinger, 1998a; Neuwinger, 2000; Takahashi, 1978.

Other references Akoègninou, van der Burg & van der Maesen (Editors), 2006; Blaser et al., 1993; Bryce, 1967; Chhabra, Mahunnah & Mshiu, 1991; Guéneau, Bedel & Thiel, 1970–1975; Hepper & Keay, 1963; Hines & Eckman, 1993; Johnson & Johnson, 2002; Kaufmann & Elvin Lewis, 1995; Lovett et al., 2007; Lutze, 2001; Mahlo, 2009; Maliwichi, 2000; Maliwichi-Nyirenda & Maliwichi, 2010; Offiah et al.,

2011; Palmer & Pitman, 1972–1974; Sibandze & van Zyl, 2009; Sibandze, van Zyl & van Vuuren, 2010; Teferi Flatie, Teferi Gedif & Tsige Gebre-Mariam, 2009; van Wyk & Gericke, 2000.

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

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

BREONIA PERRIERI Homolle

Protologue Bull. Soc. Bot. France 84: 461 (1938).

Family Rubiaceae

Origin and geographic distribution *Breonia perrieri* is endemic to Madagascar, where it is distributed in the western parts of the island.

Uses The wood of *Breonia perrieri* is locally used for construction, carpentry and furniture, and for making boats, bridges and handicrafts. It is also suitable for flooring, carvings, turnery, wheels and railway sleepers. The pulp of the infructescence is edible.

Properties The heartwood is pale yellow to brownish beige or pinkish beige, and not clearly differentiated from the yellowish brown sapwood. The wood is heavy, with a density of 800–940 kg/m³ at 12% moisture content, and moderately hard to hard. Drying is quite difficult and should be done slowly and carefully. The rates of shrinkage are moderately high to high, from green to oven dry 3.7–6.0% radial and 6.0–12.6% tangential. The wood is not stable in service, making it unsuitable for flooring. At 12% moisture content, the modulus of rupture is 137–198 N/mm², modulus of elasticity 8630–12,950 N/mm², compression parallel to grain 60–77 N/mm², cleavage 23.5 N/mm and Chalais-Meudon side hardness 5.1–8.1. The wood saws, planes, finishes and paints well, but nailing is difficult; pre-boring is necessary. It is moderately resistant to resistant to attacks by termites and fairly resistant to attacks by fungi. The heartwood is resistant to impregnation with preservatives, but the sapwood impregnates well.

Breonia perrieri – *wild*

Botany Deciduous, small tree up to 15(–25) m tall; bole straight and cylindrical, up to 70 cm in diameter, grooved at the base, sometimes buttressed; bark surface longitudinally fissured, grey. Leaves decussately opposite, simple and entire; stipules boat-shaped, 8–14 mm long, caducous; petiole 3.5–6 cm long, terete, glabrous or hairy towards apex; blade broadly obovate to rounded, 9–15 cm × 6–13 cm, base cordate, apex rounded to acuminate, leathery, short-hairy or glabrous, pinnately veined with c. 9 pairs of lateral veins, but with a few basal veins. Inflorescence a solitary, axillary, globose head 2.5–3 cm in diameter; peduncle 2.5–3.5 cm long, with node near apex. Flowers bisexual, regular, (4–)5-merous, sessile; calyx tube c. 2.5 mm long, glabrous outside, lobes oblong, c. 1 mm long, short-hairy; corolla glabrous, yellow-tinged, tube 4–5 mm long, lobes oblong, c. 1.5 mm long; stamens inserted at the throat of the corolla tube, anthers c. 1 mm long, filaments c. 1 mm long; ovary inferior, 2-celled, style c. 10 mm long. Fruit a berry, many together fused in an infructescence c. 2 cm in diameter, up to 4-seeded. Seeds ellipsoid, strongly flattened, with rudimentary wings at base, reticulate, white-tinged.

Breonia perrieri flowers in November–January and bears fruits in January–March. The tree loses its leaves in the dry season and new leaves appear after the start of the rainy season.

Breonia comprises about 20 species and is endemic to Madagascar. Species limits have changed over the years, which has led to much confusion and erroneous attribution of uses to species. *Breonia madagascariensis* A.Rich. (synonym: *Sarcocephalus madagascariensis* (A.Rich.) Baill.), for instance, has sometimes been mentioned to be used as a source of timber, but this species has only been collected a few times.

The wood of *Breonia decaryana* Homolle (synonyms: *Breonia keliravina* Homolle, *Neobreonia decaryana* (Homolle) Ridsdale), a medium-sized tree up to 30 m tall distributed in eastern Madagascar, is used for the same purposes as that

of *Breonia perrieri*. It is heavy, with a density of 830–1090 kg/m³ at 12% moisture content.
Breonia boivinii Havil. is a shrub or small tree up to 15 m tall, distributed in northern Madagascar. The hard wood is used in construction, and the bark is used as a laxative.
Breonia chinensis (Lam.) Capuron is a shrub or small to medium-sized tree up to 25 m tall, distributed from northern to south-eastern Madagascar. Its wood is used for construction, planks and dugout canoes, and as fuelwood. The bark is used in the fermentation of the local alcoholic beverage 'betsabetsa'. The infructescence is edible. In traditional medicine, a decoction of the leaves or bark is used for the treatment of diarrhoea. *Breonia cuspidata* (Baker) Havil. (synonym: *Nauclea cuspidata* Baker) is a rare tree occurring in north-western Madagascar. Its wood has been used for joinery and carpentry.
The wood of *Breonia fragifera* Capuron ex Razafim., a shrub or small tree up to 15(–25) m tall distributed in northern and eastern Madagascar, *Breonia macrocarpa* Homolle, a small to medium-sized tree up to 20 m tall distributed in north-eastern Madagascar, and *Breonia stipulata* Havil., a shrub or small to medium-sized tree up to 25 m tall distributed in northern and western Madagascar, is used in construction.

Ecology *Breonia perrieri* occurs in dry deciduous forest.

Management The 1000-seed weight is about 2 g. At a temperature of 25°C and 8 hours light per day, the germination rate was 94%.

Genetic resources and breeding It is unclear whether *Breonia perrieri* is threatened with genetic erosion, but it has a fairly wide distribution in Madagascar.

Prospects The wood of *Breonia perrieri* and other *Breonia* species is hard and durable and easy to work, but its instability in service limits its range of potential uses. Because of the lack of information on the availability of its timber, the prospects of *Breonia perrieri* are difficult to assess.

Major references Guéneau, Bedel & Thiel, 1970–1975; Madagascar Catalogue, 2011; Missouri Botanical Garden, undated; Razafimandimbison, 2002; Sallenave, 1971.

Other references Andriamilison, 1993; Boiteau, Boiteau & Allorge-Boiteau, 1999; Cailliez & Guéneau, 1972; Grenfell, 1999; Parant, Chichignoud & Rakotovao, 1985; Rafidison, 1999; Rohner & Sorg, 1986; Royal Botanic Gardens Kew, 2008; Takahashi, 1978; Verdcourt, Leroy & Tirvengadum, 1989.

Authors M. Brink

BRIDELIA GRANDIS Pierre ex Hutch.

Protologue Dyer, Fl. trop. Afr. 6(1): 1042 (1913).

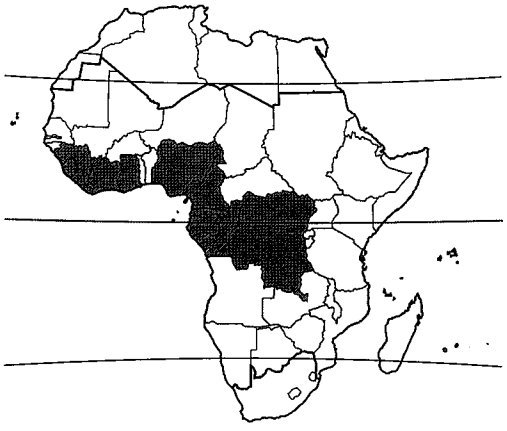
Family Euphorbiaceae (APG: Phyllanthaceae)

Synonyms *Bridelia aubrevillei* Pellegr. (1931).

Origin and geographic distribution *Bridelia grandis* is distributed from Guinea and Sierra Leone eastward to DR Congo.

Uses In Sierra Leone the wood of *Bridelia grandis* is used for light construction and furniture. In Côte d'Ivoire it is one of the preferred woods for canoes. In Gabon branches are used for the construction of roofs. The wood is suitable for light flooring, joinery, interior trim, mine props, vehicle bodies, railway sleepers, toys, novelties, ladders, handles, boxes, crates, pattern making, turnery, veneer and plywood. It is widely used as firewood.
In Côte d'Ivoire bark decoctions or macerations are taken as a purgative, diuretic, febrifuge, anodyne and aphrodisiac. The bark is also used in a wash or a vapour bath to relieve rheumatic pains. In Cameroon pygmy people use the bark in dental care. In Liberia palm wine to which bark has been added is drunk by women to stimulate lactation.

Production and international trade The timber is traded under the name 'asas' or 'assas' but quantities are small and statistics are not available. Considerable amounts of bark are traded on local markets for medicinal purposes, but also for this trade statistics are not



Bridelia grandis – wild

available.

Properties The heartwood is grey-brown or brown, often mottled and lustrous, and not well demarcated from the up to 6 cm wide sapwood. The grain is interlocked, texture very fine. The wood has some resemblance to that of walnut (*Juglans* spp).

The wood is medium-weight, with a density of 590–670 kg/m³ at 12% moisture content, fairly hard and strong. The rates of shrinkage during drying are moderate, from green to oven dry about 3.1% radial and 7.6% tangential. The wood air dries slowly but satisfactorily without much degrade. After drying, it is stable in service. At 12% moisture content, the modulus of rupture is 105–127 N/mm², modulus of elasticity 10,600 N/mm², compression parallel to grain 53–57 N/mm², cleavage 18.5–20.5 N/mm and Chalais-Meudon side hardness 2.5–2.7.

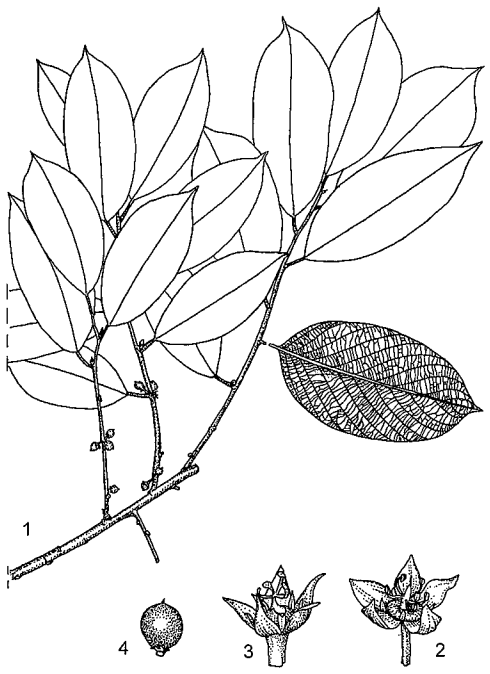
The wood saws and planes well and if a reduced cutting angle is used it can be finished to an excellent surface. It holds nails and screws satisfactorily, and glues well, and it is easy to peel and slice. The heartwood is moderately durable, having some resistance to termite attack; the sapwood is susceptible to *Lyctus* attack. The wood is an excellent firewood and produces good charcoal.

The wood contains about 44% cellulose, 28.5% lignin, 15% pentosan and 0.8% ash. The solubility is 7.3% in alcohol-benzene, 2.7% in hot water and 14.9% in a 1% NaOH solution.

The bark has antibacterial activity against *Streptococcus* spp., as well as antitrypanosomal and antiplasmodial activities. The medicinal properties have been attributed to the presence of tannins and saponosides.

Adulterations and substitutes The timber of *Bridelia grandis* shares its trade name with that of *Bridelia micrantha* Baill. and the timber of both species is mixed in trade.

Description Evergreen, monoecious, small to medium-sized tree up to 30 m tall; bole branchless for up to 15 m, usually straight and cylindrical, up to 90 cm in diameter, in lower part usually with stout aerial roots up to 60 cm long extending into ridges up to 1.2 m high along the bole; bark surface with deep longitudinal fissures, brown-black, inner bark fibrous, red, strongly scented; crown rounded, fairly open, heavily branched; branches often with long, straight spines; twigs rusty-brown soft-hairy, becoming glabrous. Leaves alternate, distichous, simple and entire; stipules 6–10 mm long, caducous; petiole 4–8 mm long; blade elliptical to obovate, 6–14 cm × 2–6 cm, base



Bridelia grandis – 1, fruiting twig; 2, male flower; 3, female flower; 4, fruit.
Redrawn and adapted by J.M. de Vries

rounded to broadly cuneate, apex acuminate, glabrous to slightly hairy above, with soft and spreading hairs below, pinnately veined with 8–10(–13) pairs of lateral veins. Inflorescence a small axillary fascicle. Flowers unisexual, regular, 5(–6)-merous; sepals triangular, 1–1.5 mm long, with few scattered hairs; petals small, c. 0.5 mm long; disk ring-shaped; male flowers with pedicel c. 1.5 mm long, stamens with filaments fused in a column below, free and spreading above, ovary rudimentary; female flowers nearly sessile with superior, 2-celled ovary, styles 2, fused at base, 2-branched. Fruit a nearly globose, fleshy drupe c. 7 mm in diameter, dark purple to black when ripe, 1-seeded. Seed c. 5 mm long, brownish. Seedling with epigeal germination; hypocotyl 3–4 cm long, epicotyl c. 1 cm long, reddish hairy; cotyledons leafy, transversely oblong, 8–10 mm × 11–15 mm; first leaves alternate.

Other botanical information *Bridelia* occurs in the Old World tropics, and comprises about 75 species. About 15 species occur in mainland tropical Africa and 2 species are endemic to the Indian Ocean islands.

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; 32: vessel-ray pits with much reduced borders to apparently simple: pits horizontal (scalariform, gash-like) to vertical (palisade); 34: vessel-ray pits unilaterally compound and coarse (over 10 µm); 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; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 78: axial parenchyma scanty paratracheal; 93: eight (5–8) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 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; 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; (110: sheath cells present); 115: 4–12 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; 140: prismatic crystals in chambered upright and/or square ray cells; 142: prismatic crystals in chambered axial parenchyma cells; 143: prismatic crystals in fibres.
(C. Essien, P.E. Gasson & E.A. Wheeler)

Growth and development The tree grows rapidly. Seedlings reached 12 cm tall 3 months after sowing and 50 cm after 6 months. In Guinea they reached on average 2.9 m tall 2 years after planting in full sun, but only 1.1 m in light shade. In open sites trees reached a height of 12 m and a bole diameter of 15 cm 7 years after planting. In Côte d'Ivoire trees with a bole diameter of 80 cm have been recorded in secondary forest of 40 years old. In Liberia and Côte d'Ivoire *Bridelia grandis* usually flowers from April till June and fruits can be found from August to November. In Guinea trees fruit in December–January. The flowers have a pleasant smell. The fruits are probably dispersed by birds.

Ecology *Bridelia grandis* is a typical pioneer species; hence seedlings and saplings are more abundant in recently logged forest than in undisturbed forest. *Bridelia grandis* prefers moist conditions, and occurs especially in swampy localities.

Propagation and planting Propagation with seed is easy. There are about 25,000 seeds per kg. Seeds start germinating 1–3 weeks after sowing and the germination rate is high, over 90%. Seedlings tolerate some shade. Seedlings are ready for planting in the field when they are 30 cm tall, which is about 4 months after planting them in nursery pots. It is recommended to plant at a spacing of 3 m × 3 m.

Diseases and pests Elephants eat the leaves of *Bridelia grandis* and may cause damage in plantations.

Harvesting In the Central African Republic and Gabon, the minimum bole diameter allowed for felling is 70 cm.

Genetic resources There are no indications that *Bridelia grandis* is threatened by genetic erosion, although it has been recorded as not very common in Liberia. As a pioneer that is commonly found in disturbed and secondary forest, it is not likely to become endangered.

Prospects There is little information on growth rates and appropriate silvicultural management of *Bridelia grandis*, but it might be an interesting timber tree with potentially economic importance because it seems to be able to grow rapidly and to propagate easily. Increased pharmacological interest also seems justified.

Major references Bolza & Keating, 1972; Burkill, 1994; de Koning, 1983; Raponda-Walker & Sillans, 1961; Sallenave, 1955; Savard, Besson & Morize, 1954; Takahashi, 1978; Voorhoeve, 1965.

Other references Adjanohoun & Aké Assi, 1979; Atindehou et al., 2002; Atindehou et al., 2004; Brusotti et al., 2010; de la Mensbruge, 1966; Gassita et al. (Editors), 1982; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Ngueyem et al., 2008; Ngueyem et al., 2009; Njamen et al., 2011; Normand, 1955; Ong, 1998b.

Sources of illustration Voorhoeve, 1965.

Authors G.D. Djagbletey

BRIDELIA MICRANTHA (Hochst.) Baill.

Protologue Adansonia 3: 164 (1862).

Family Euphorbiaceae (APG: Phyllanthaceae)

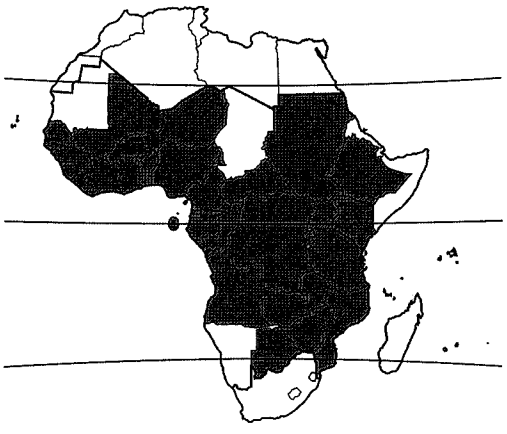
Synonyms *Bridelia stenocarpa* Müll.Arg. (1864).

Vernacular names Mitzeerie, Coast goldleaf, Yoruba ironwood, Benin ironwood (En). Mwiza (Sw).

Origin and geographic distribution *Bridelia micrantha* is widely spread throughout mainland tropical Africa with the exception of a number of countries with very low annual rainfall. It has been introduced in Réunion, probably because of its medicinal properties, and has become naturalized there.

Uses The wood is widely used for construction, poles, furniture, mortars, spoons and tool handles. It is suitable for flooring, joinery, interior trim, mine props, ship building, vehicle bodies, toys, novelties, boxes, crates, carvings, pattern making, draining boards, turnery, veneer and plywood. The wood is also used as firewood and for charcoal.

The leaves are fed to cattle. They are a favourite food of the wild silkworm (*Anaphe* spp.), and silk and edible caterpillars are collected from wild stands as well as from semi-domesticated plants. The fruits are sweetish and edible, and in East Africa the Maasai people use the fruits to flavour milk. In West Africa the bark is added to palm wine to improve the taste. *Bridelia micrantha* is planted in agroforestry systems to provide shade and mulch, and it is sometimes used for hedges. In South Africa it has been planted to restore and stabilize irrigation canals on sugarcane farms. It is planted as an ornamental and especially recommended where waterlogging is a problem. In the Sahel region, a decoction of the leaves and young branches is used as a black dye for pottery, and in Tanzania a red dye is extracted from the bark. Bark, leaves and roots have medicinal applications throughout the range of *Bridelia micrantha*. The bark is widely used in the treatment of wounds, and as a purgative, abortifacient and aphrodisiac, whereas in Congo bark decoctions are taken to treat cough and sore throat. In South Africa the bark is used as a remedy for headache, sore joints, sore eyes, stomach-ache, diarrhoea, tapeworms, venereal diseases and fever.The leaves are used as a laxative and chewed against headache. In Tanzania the roots are used to treat symptoms of non-insulin dependent diabetes mellitus such as excessive thirst and urine production, and sweating. In Côte d'Ivoire leaf and root extracts are applied as anthelmintic and to treat malaria and trypanosomiasis. In DR Congo the inner bark is used in the preparation of arrow poison.



Bridelia micrantha – wild

Production and international trade The timber is traded under the name 'asas' or 'assas' but quantities are small and statistics are not available. Considerable amounts of bark are traded on local markets for medicinal purposes, but also for this trade statistics are not available.

Properties The heartwood is pale to dark brown and clearly to poorly demarcated from the greyish or yellowish white sapwood. The grain is straight to interlocked, texture fine and uneven.

The wood is medium-weight, with a density of 500–610(–705) kg/m^3 at 12% moisture content. It requires careful drying to avoid distortion and checking. The rates of shrinkage are moderate, from green to oven dry 3.8–4.0% radial and 6.1–6.5% tangential. Once dry, the wood is moderately stable in service. At 12% moisture content, the modulus of rupture is 119–135 N/mm^2, modulus of elasticity 10,380–12,250 N/mm^2, compression parallel to grain 39–48 N/mm^2, cleavage 19–20.5 N/mm, Janka side hardness 5200 N, Janka end hardness 6490 N and Chalais-Meudon side hardness 1.7–3.8.

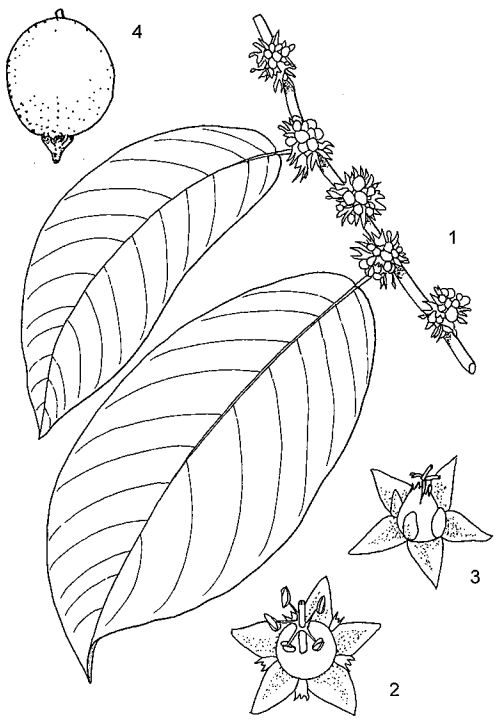
The wood saws fairly easy, planes well and takes a good polish. It holds nails and screws well, glues well, and makes good joints. The wood is durable even when exposed to the soil or water, being quite resistant to fungi and all kinds of insect attacks including termites, but the sapwood is susceptible to *Lyctus* attack. It is an excellent firewood and produces a good-quality charcoal.

The wood contains about 43% cellulose, 28% lignin, 14% pentosan, 1.1% ash and little silica. The solubility is 6.6% in alcohol-benzene, 2.1% in hot water and 14.1% in a 1% NaOH solution. Tannins isolated from the bark showed antibacterial activity, and aqueous bark extracts showed anti-inflammatory effect. Methanolic and aqueous extracts of roots and stem bark of *Bridelia micrantha* were shown to have strong activity against HIV-1 reverse transcriptase and integrase. Methanolic bark extracts showed in-vitro inhibition of a wide range of gram-positive and gram-negative bacteria. Extracts of the roots had the same effect but only at higher concentrations. Compounds isolated and possibly responsible for the antibacterial activity are friedelin, taraxerone, epifriedelinol, taraxerol and the tannins gallic acid, ellagic acid and caffeic acid.

Adulterations and substitutes The wood resembles that of *Lovoa trichilioides* Harms. The timber of *Bridelia micrantha* shares its trade name with that of *Bridelia grandis* Pierre ex Hutch. and the timber of both species is mixed in trade.

Description Evergreen or deciduous, monoecious, small to medium-sized tree up to 20(–27) m tall; bole short, often twisted, up to 50(–100) cm in diameter, sometimes with scattered blunt spines; bark surface with fine fissures, dark grey; crown spreading, fairly open; branches often with blunt spines; twigs sparingly soft-hairy or glabrous. Leaves alternate, distichous, simple and entire; stipules linear-lanceolate, 4–7 mm long, caducous; petiole 5–13 mm long; blade elliptical to oblong-elliptical, 3–28 cm × 2–12 cm, base rounded to cuneate, apex short-acuminate, glabrous to slightly hairy above, sparingly soft-hairy below, pinnately veined with 5–20 pairs of lateral veins. Inflorescence a small axillary fascicle. Flowers unisexual, regular, 5(–6)-merous; sepals triangular, c. 2 mm long; petals small, 0.5–1 mm long; disk shallowly 5-lobed; male flowers with pedicel c. 1 mm long, stamens with filaments fused in a column below, free and spreading above, ovary rudimentary; female flowers nearly sessile with superior, 2–3-celled ovary, styles 2, fused at base, 2-branched. Fruit a nearly globose, fleshy drupe c. 7 mm in diameter, black when ripe, 1-seeded. Seeds c. 5 mm long, brownish. Seedling with epigeal germination; hypocotyl 3–4 cm long, epicotyl 0.5–1 cm long, slightly hairy; cotyledons leafy, transversely oblong, c. 1 cm × 2 cm; first leaves alternate.

Other botanical information *Bridelia* occurs in the Old World tropics, and comprises about 75 species. About 15 species occur in mainland tropical Africa and 2 species are endemic to the Indian Ocean islands.



Bridelia micrantha – 1, flowering twig; 2, male flower; 3, female flower; 4, fruit.
Source: Flore analytique du Bénin

Bridelia ndellensis Beille is a small tree up to 15(–20) m tall with bole up to 30 cm in diameter, distributed from southern Nigeria eastward to Sudan and Uganda. Its wood is whitish and hard, and used in DR Congo for house building. In Sudan the fruits are eaten. In DR Congo a bark maceration is taken as a remedy for cough and diarrhoea.

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; (19: reticulate, foraminate, and/or other types of multiple 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); 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); (34: vessel-ray pits unilaterally compound and coarse (over 10 µm)); 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; 65: septate fibres present; 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; (98: larger rays commonly 4- to 10-seriate); 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; (110: sheath cells present); 115: 4–12 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; 140: prismatic crystals in chambered upright and/or square ray cells; 141: prismatic crystals in non-chambered axial parenchyma cells; 142: prismatic crystals in chambered axial parenchyma cells.

(N.P. Mollel, P.E. Gasson & E.A. Wheeler)

Growth and development Under favourable conditions when planted in deep and moist soils, growth of seedlings is fast, up to 2 m per year. *Bridelia micrantha* already produces considerable shade and may start flowering 3 years after sowing. Flowering takes place during the dry season. Reportedly, trees do not fruit every year. Fruits are dispersed by numerous animals, including civet, rodents and probably birds. Roots may produce suckers when they are injured.

Ecology *Bridelia micrantha* is found in a variety of habitats, from savanna and woodland to seasonally flooded grassland, riverine forest, swamp forest and the margins of mangrove swamps, from sea-level in West Africa to 1750(–2500) m altitude in East Africa. It is a pioneer that tolerates a wide diversity of soils. It withstands moderate frost.

Propagation and planting Sowing fresh seed is the easiest way to propagate *Bridelia micrantha*. The oily seeds lose their viability quickly and storing seed for longer periods is difficult. Wildlings are also collected for planting. In Uganda cuttings have been successfully used to establish plantations. For good early growth, weeding is necessary after planting.

Management *Bridelia micrantha* can be pollarded, pruned and coppiced, and a 30 year coppicing rotation has been proposed. In small farms in Tanzania, it is commonly intercropped and pollarded in short rotations to reduce shade from the crowns. In Nigeria and Uganda pure stands have been established for the production of silkworms.

Genetic resources In Ethiopia *Bridelia micrantha* has become scarce as a result of overexploitation for its termite-resistant wood. In Kenya the intensive use has had the same effect and probably populations are under pressure in many other regions. To have continued access to sizeable timber, protective measures and domestication are needed.

Prospects There will be continued demand for the wood of *Bridelia micrantha* for applications where durability is demanded. The isolation and the structural elucidation of the active constituents of *Bridelia micrantha* will provide useful leads in the development of antibiotics with β-lactamase inhibitory activity. Resistance of bacteria to this type of antibiotics is rare. For the production of silk the prospects are good. Research into domestication and management practices is important for all applications.

Major references Arbonnier, 2004; Bekele-Tesemma, 2007; Bolza & Keating, 1972; Burkill, 1994; de Koning, 1983; Léonard, 1962; Neuwinger, 2000; Radcliffe-Smith, 1996; Raponda-Walker & Sillans, 1961; Takahashi, 1978.

Other references Bessong et al., 2005; Chiotha, Seyani & Fabiano, 1991; Dalziel, 1937; de la Mensbruge, 1966; Gangoué-Piéboji et al., 2006; Gangoué-Piéboji et al., 2007; Gillah et al., 2004; Guéneau, Bedel & Thiel, 1970–1975; Johnson & Johnson, 2002; Mbahin et al., 2008; Mbahin et al., 2010; Moshi & Mbwambo, 2002; Mushambanyi, 2000; Ngueyem et al., 2009; Noad & Birnie, 1989; Sallenave, 1955; Samie et al., 2005; SEPASAL, 2011; Teel, 1984; Watt & Breyer-Brandwijk, 1962.

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

Authors C.H. Bosch

BRIDELIA TULASNEANA Baill.

Protologue Adansonia 2: 40 (1861).

Family Euphorbiaceae (APG: Phyllanthaceae)

Origin and geographic distribution *Bridelia tulasneana* is endemic to Madagascar, where it is widely distributed in the eastern parts of the island.

Uses The timber is locally used for house construction, boat building, coffins, weatherboards and shingles. It has been used for railway sleepers. It is suitable for joinery, interior trim, boxes, veneer, plywood and particle board. The local name 'arina' is given to a few tree species that yield superior charcoal, and apparently the wood is in demand for charcoal production.

Properties The heartwood is beige marked with dark brown spots, and not well demarcated from the sapwood that is only slightly paler in colour. The wood becomes greyish upon exposure.

The wood is medium-weight, with a density of 550–580(–890) kg/m^3 at 12% moisture content. It air dries slowly and it is difficult to avoid distortion during drying. The rates of shrinkage during drying are moderate, from green to oven dry 1.8–3.2% radial and 7.0–8.3% tangential. Once dry, the wood is moderately stable to unstable in service. At 12% moisture content, the modulus of rupture is 96–137 N/mm^2, modulus of elasticity 7750–11,200 N/mm^2, compression parallel to grain 46 N/mm^2, cleavage 18 N/mm and Chalais-Meudon side hardness 1.2–2.8(–5.0).

The wood saws and planes well, but it is brittle and moderately fissile. It holds nails and screws well, glues moderately well and paints easily. The heartwood is fairly durable, being moderately sensitive to fungal attack but quite resistant to termites and wood-boring beetles. The heartwood is resistant to impregnation with preservatives.

The lignan deoxypodophyllotoxin has been isolated from the bark. This compound has cytostatic properties, but cannot be used in chemotherapy because of serious side-effects.

Bridelia tulasneana – *wild*

Botany Evergreen, monoecious small to medium-sized tree up to 20 m tall; bole usually straight, up to 100 cm in diameter but generally less, often with buttresses; bark surface with rather deep longitudinal fissures, pale brown to black; branches and twigs with c. 1 cm long spines; twigs covered with lenticels, red soft-hairy when young. Leaves alternate, distichous, simple and entire; stipules early falling; petiole 8–12 mm long; blade ovate or obovate, 8–14 cm × 2–9 cm, base rounded, apex short-acuminate, glabrous above, brown soft-hairy below, pinnately veined with 15–18 pairs of lateral veins. Inflorescence a small axillary fascicle, 10–20-flowered. Flowers unisexual, regular, 5-merous, glabrous; sepals fused into a short tube at the base; petals smaller than the sepals; male flowers with flat or concave disk, stamens with filaments fused in a column below, free and spreading above, ovary rudimentary; female flowers nearly sessile with superior, 2(–3)-celled ovary, styles 2, fused at base, 2-branched. Fruit a fleshy drupe c. 8 mm × 5 mm, dark purple when ripe, 1(–2)-seeded. Seeds ovoid, furrowed towards the tip, glabrous. Seedling with epigeal germination.

Bridelia tulasneana flowers from October to January and fruits ripen around September.

Bridelia occurs in the Old World tropics, and comprises about 75 species. About 15 species occur in mainland tropical Africa and 2 species are endemic to the Indian Ocean islands.

Ecology *Bridelia tulasneana* occurs in humid evergreen forest.

Genetic resources and breeding *Bridelia tulasneana* is widespread and locally common in eastern Madagascar. However, the on-going deforestation may threaten its populations in the near future.

Prospects Too little is known about *Bridelia tulasneana* to assess its prospects as a timber tree of commercial importance, but it deserves more research on silviculture and propagation.

Major references Capuron, 1966a; Guéneau, Bedel & Thiel, 1970–1975; Leandri, 1958; Parant, Chichignoud & Rakotovao, 1985; Takahashi, 1978.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Brown et al., 2009; Cailliez & Guéneau, 1972; Guéneau, 1967; Guéneau & Guéneau, 1969; Raymond, 1995; Sallenave, 1971; Schatz, 2001; Williams, 2002; Winberg, 2009.

Authors C.H. Bosch & D. Louppe

BULLOCKIA MOMBAZENSIS (Baill.) Razafim., Lantz & B.Bremer

Protologue Ann. Missouri Bot. Gard. 96(1): 175 (2009).

Family Rubiaceae

Synonyms *Canthium mombazense* Baill. (1878).

Vernacular names Mfupapu, kifuwahe (Sw).

Origin and geographic distribution *Bullockia mombazensis* is distributed in Somalia, Kenya, Tanzania and Mozambique.

Uses The stems are often used as poles in house construction. The fruit is very sweet and edible.

Botany Evergreen, usually dioecious shrub or small tree up to 7.5 m tall; outer bark smooth or fissured, pale grey; twigs glabrous or occasionally short-hairy. Leaves opposite, simple and entire; stipules ovate, 4–16 mm long, acuminate at apex; petiole 2–20 mm long; blade broadly oblong-elliptical to nearly round, 2–13 cm × 1–7.5 cm, base obtuse to rounded, often oblique, apex obtuse to rounded, leathery, glabrous or sometimes hairy beneath, pinnately veined with 4 main pairs of lateral veins. Male inflorescence a sessile umbel, 3–20-flowered; female flowers solitary. Flowers functionally unisexual, regular, 5–6-merous; pedicel 3–10 mm long; calyx with tube up to 2.5 mm long and lobes up to 3 mm long; corolla whitish or yellowish green, tube c. 1.5 mm long, with a ring of deflected hairs at throat inside, lobes triangular-ovate, 1–1.5 mm long; stamens inserted in corolla throat alternating with lobes, anthers nearly sessile; ovary inferior, 2-celled, style slightly longer than corolla tube, with distinct pollen carrier at apex; functionally male flowers with short calyx tube and rudimentary ovary, functionally female flowers with longer calyx tube and sterile stamens. Fruit an obovoid drupe 7–12 mm × 7–9 mm, laterally compressed, dark brown-red, crowned by persistent calyx lobes, with 2 stones; stones obovoid, c. 7 mm × 3.5 mm, flattened, smooth except for shallow crest around apex, 1-seeded. *Bullockia mombazensis* is usually dioecious, but occasionally polygamous. In the Shimba Hills (south-eastern Kenya) fruits of *Bullockia mombazensis* are found in (June–)July–August (–October). They are eaten by animals such as civets, elephants and baboons, which contribute to seed dispersal.

Bullockia mombazensis – *wild*

Bullockia comprises 8 species, of which 6 in East and southern Africa and 2 in Madagascar. It was formerly included in *Canthium* as a subgenus.

Bullockia dyscriton (Bullock) Razafim., Lantz & B.Bremer (synonym: *Canthium dyscriton* Bullock) is a shrub up to 3 m tall, distributed in Kenya and Tanzania. Its wood is used for making arrow heads.

Ecology *Bullockia mombazensis* occurs in coastal bushland, wooded grassland and evergreen forest, from sea-level up to 1200 m altitude.

Management In experiments in Kenya seed germination was slow, with first emergence of seedlings 74 days after sowing. The stems are locally collected; they are sometimes traded.

Genetic resources and breeding *Bullockia mombazensis* has a limited distribution, but is common and locally abundant in its distribution area, and seems not threatened with genetic erosion.

Prospects *Bullockia mombazensis* is a useful local source of poles for house construction. Information on its wood properties is lacking, but in view of its small size its importance is unlikely to increase.

Major references Bridson & Verdcourt, 2003; Engel, 2000; Pakia, 2000; Razafimandimbison et al., 2009; Verdcourt & Bridson, 1991.

Other references Beentje, 1994; Bridson, 1987; Bridson, Thulin & Degreef, 2006; Bur-

gess & Clarke, 2000; Medley & Kalibo, 2007.

Authors M. Brink

BURKEA AFRICANA Hook.

Protologue Icon. pl. 6: t. 593–594 (1843).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

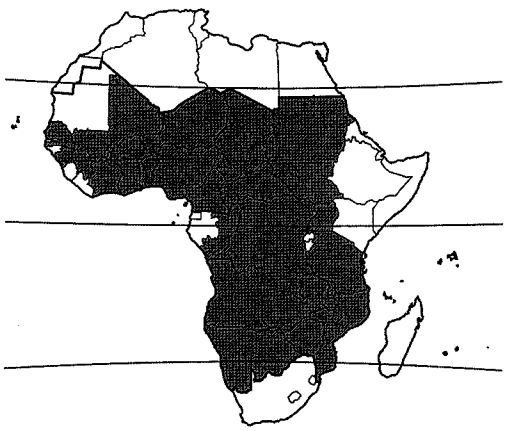
Chromosome number $2n = 28$

Vernacular names Burkea, wild syringa, wild seringa, red syringa, sand syringa (En).

Origin and geographic distribution *Burkea africana* is widespread, occurring from Senegal east to Sudan and Uganda, and south to Namibia, Botswana, Mozambique and northern South Africa.

Uses The wood is used for poles (e.g. for heavy construction and fences), parquet flooring, furniture, railway sleepers, utensils such as mortars, tool handles, drums and other musical instruments such as xylophones and balafons. It has been claimed by wagon makers that *Burkea africana* wood is the best for making hubs because it does not shrink or split. It is suitable for joinery, interior trim, ship building, mine props, sporting goods, toys, novelties, draining boards, carving and turnery. The wood is also used as firewood and for charcoal production, and has been used commonly for iron smelting because of the hot flame and little ash produced.

The bark, roots and leaves are commonly used in traditional medicine. Bark decoctions or infusions are used to treat fever, cough, catarrh, pneumonia, menorrhoea, headache, inflammation of tongue and gums, poisoning and skin diseases. Powdered bark is applied to ulcers and wounds, and to treat scabies. Root decoctions or infusions are used to treat stomach-ache, abscesses, oedema, epilepsy, bloody diarrhoea, gonorrhoea, syphilis and toothache. In Burkina Faso roots have been used as antidote against arrow poison. Leaves are used in the treatment of fever, headache, epilepsy, ascites and conjunctivitis. Twigs are used as chewing sticks. Pounded bark is used as a fish poison.



Burkea africana – wild

Young flowers are eaten in sauces. In Burkina Faso leaves are used as condiment. The bark and pods have been used for tanning leather. The bark is used as a dye to make the roots of *Combretum zeyheri* Sond. grey to blackish; these roots are woven into baskets in Namibia. The gum from the bark is edible; it is locally considered an aphrodisiac. *Burkea africana* is planted as a roadside tree and ornamental. It is host to caterpillars of Saturnid moths (*Cirina forda* and *Rohaniella pygmaea*), which are collected by people as food; after boiling and frying, these are considered a delicacy. The flowers produce nectar collected by honey bees.

Production and international trade The wood of *Burkea africana* is mainly used locally and traded in limited volume internationally. Production and trade statistics are not available. Bark and roots are commonly sold on local markets for medicinal purposes.

Properties The heartwood is brown with grey and green tinges, turning reddish brown or dark brown upon exposure. It is usually distinctly demarcated from the yellowish or pinkish white, c. 2.5 cm wide sapwood. The grain is interlocked or wavy, texture fine to moderately fine and even. The wood is lustrous and displays a nice stripe figure.

The wood is heavy, with a density of 735–1020 kg/m^3 at 12% moisture content. It air dries moderately fast, with little tendency to corrugate, split or distort, but kiln drying should be done with great care. It takes about 3 weeks to kiln dry boards of 2.5 cm thick. The rates of shrinkage are moderate, from green to oven dry 2.9–5.6% radial and 4.2–9.2% tangential. Once dry, the wood is stable in service.

At 12% moisture content, the modulus of rupture is 84–143 N/mm^2, modulus of elasticity 12,940 N/mm^2, compression parallel to grain 48–85 N/mm^2, compression perpendicular to grain 12 N/mm^2, shear 14.5–15 N/mm^2, Janka side hardness 6490 N and Janka end hardness 7605 N.

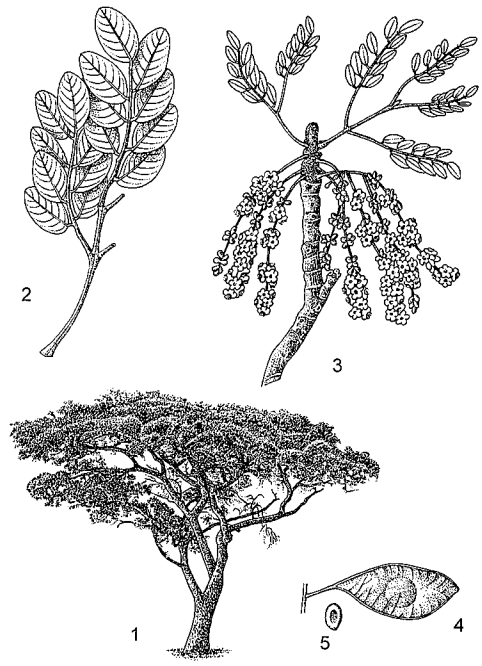
Although the wood is hard, it is not difficult to saw, but it is difficult to work with hand tools.

The wood is susceptible to tearing in planing operations due to the presence of interlocked grain. It takes a nice polish upon finishing. Pre-boring in nailing is recommended because the wood is liable to splitting. The gluing properties are good. The wood turns well. It is durable, but the sapwood is susceptible to *Lyctus* attack. Extracts of the heartwood showed fungicidal and termiticidal properties, and this in combination with the strongly hydrophobic character of the wood and the high dimensional stability explains the good natural durability. The heartwood is extremely resistant to treatment with preservatives, the sapwood is more permeable.

Bark and leaves are reportedly toxic to livestock. The bark contains tannin and produces a semi-translucent yellowish to reddish gum. A hydroethanol extract of the bark showed pronounced antioxidant and radical scavenging activity, with proanthocyanidins as the most likely active constituents. Twigs showed antimicrobial activity against a wide variety of bacteria and fungi; this supports the use as chewing-stick for dental care.

Adulterations and substitutes The wood of *Erythrophleum* spp. and of *Afzelia quanzensis* Welw. resembles that of *Burkea africana* and is used for similar purposes.

Description Deciduous small to medium-sized tree up to 20 m tall; bole branchless for up to 7 m, up to 80 cm in diameter; bark surface scaly and fissured, grey to dark greyish brown, inner bark fibrous, pink to dull red or purplish brown; crown open, often flat, with spreading branches; twigs thick, with conspicuous leaf scars, reddish brown hairy when young. Leaves alternate, clustered near the ends of twigs, bipinnately compound with (1–) 2–5(–7) pairs of pinnae; stipules minute, soon falling; petiole and rachis together 7–32 cm long; petiolules 2–5 mm long; leaflets alternate, 5–15(–18) per pinna, usually elliptical, 1.5–7.5 cm × 0.5–4 cm, slightly asymmetrical at base, obtuse to slightly notched at apex, silvery short-hairy but becoming glabrous. Inflorescence an elongate spike 5–30 cm long, crowded near the ends of twigs, pendulous, many-flowered. Flowers bisexual, regular, 5-merous, sweet-scented, sessile; calyx with short tube and rounded lobes c. 1.5 mm long; petals free, obovate-oblong, 4–5 mm long, glabrous, white to cream-coloured; stamens 10, free, c. 5 mm long; ovary superior, ovoid, densely hairy, 1-celled, style short, stigma funnel-shaped. Fruit an elliptical, strongly flattened pod 3–8 cm × 2–3 cm, distinctly stiped, pale brown to reddish brown, indehiscent, 1-seeded. Seed ellipsoid, flattened, 9–12 mm × 7–8 mm, brown, with a cavity at both sides.



Burkea africana – 1, tree habit; 2, leaf; 3, flowering twig with young leaves; 4, fruit; 5, seed. Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Burkea* comprises a single species. It seems related to the African genera *Erythrophleum*, *Pachyelasma* and *Stachyothyrsus*. When not flowering or fruiting, *Burkea africana* is often confused with *Erythrophleum africanum* (Welw. ex Benth.) Harms and *Albizia antunesiana* Harms, but it differs from both by its reddish brown velvety hairy young growing tips of twigs.

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 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; 81: axial parenchyma lozenge-aliform; 82: axial parenchyma winged-aliform; 83: axial parenchyma confluent; 85: axial parenchyma bands more than three cells wide; 86: axial parenchyma in narrow bands or lines up to three cells wide; (89: axial parenchyma in marginal or in seemingly marginal bands); 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; (143: prismatic crystals in fibres).
(E.A. Obeng, P. Baas & H. Beeckman)

Growth and development Rooting of *Burkea africana* trees is often superficial, and the roots can extend for many metres from the bole. Young trees reach sexual maturity when the bole diameter is about 12.5 cm. The inflorescences usually appear before the leaves, often at the end of the dry season. In southern Africa trees often flower in October–November and in West Africa in January–April. The flowers are pollinated by insects such as bees. It has been reported that trees fruit only once every two years. Fruits may remain for a long time on the tree, and are often still present after leaf fall.

Ecology *Burkea africana* occurs in deciduous woodland and wooded savanna, at 50–1750 m altitude. The annual rainfall in its area of distribution is 1000–1200 mm. It is usually found on light, well drained soils, often on loose, sandy or gravelly red soils, but sometimes also on rocky hills or on loam-clay soils. In South Africa *Burkea africana* is often associated with *Terminalia sericea* Burch. ex DC. and *Ochna pulchra* Hook.f., and in Namibia with *Colophospermum mopane* (Benth.) J.Léonard, *Combretum imberbe* Wawra and *Pterocarpus angolensis* DC. Trees with a bole diameter above 12.5 cm are fire resistant, being sufficiently protected by their bark.

Propagation and planting *Burkea africana* has a reputation for being difficult to cultivate. Seeds may germinate in 10 days, but may also take 6 months to germinate, and the germination rate is often low. Experiments in Burkina Faso showed that mechanical scarification or exposure to sulphuric acid for 15–20 minutes resulted in a significantly higher germination rate of seeds. Seeds can be stored for a long time in a dry place, but they are susceptible to insect attacks. It has been reported that seedlings often die off in the seed tray or when transplanted. However, experiments showed that if the seedlings are transplanted into a well-drained, sandy soil with superphosphate, the rates of survival can be quite high. Seedlings should be given 70–80% shade and water once every week. Red sandy soil gives the best results. Cuttings produce leaves and shoots that often soon die off.

Management In many regions *Burkea africana* is common, locally abundant, but it usually occurs scattered and not gregarious. However, in southern Africa it can be dominant. Natural regeneration often occurs after fire. It has been noted that regeneration was good in natural stands in Namibia, both by seedlings and coppicing. The number of saplings per ha averaged 350.

Diseases and pests A large proportion of the seeds is damaged by bruchid beetles. Porcupines have been recorded to damage trees seriously by scarring them, making them susceptible to fire damage. The foliage is consumed by caterpillars of several butterfly and moth species; *Cirina forda* has been classified as a pest.

Yield A tree inventory in Namibia showed an average number of mature trees of 80 per ha and a mean wood volume of 16.5 m^3/ha. However, the average yield of logs of good quality, i.e. 2 m long, straight and without defects, was only 0.05 m^3/ha.

Handling after harvest The centre of the bole is often defective. After harvesting for medicinal purposes, the bark is washed and air dried. When kept in airtight containers, it can be stored for 3–6 months. Bark decoctions are used immediately or stored in bottles for usage within one week.

Genetic resources *Burkea africana* is not under threat of genetic erosion because it is widespread and common over large areas. However, in many regions natural stands have declined as a result of clearing for agriculture, changes in climatic conditions and soil salinity, excessive burning and locally also growing elephant populations. Systematic germplasm collection and specific preservation programmes do not exist, but there are small collections in botanical gardens, private gardens and re-

search institutes in Namibia, Zimbabwe and South Africa.

Prospects The bole is usually of small size and this limits the use of the wood to smaller pieces of furniture and parquet blocks for flooring. If accessions developing large and straight boles would be available, *Burkea africana* might be interesting for cultivation as a timber tree because it yields high-quality timber. Research on silvicultural aspects would be required, as well as on propagation techniques and growth rates.

Burkea africana is a true multi-purpose tree, not only important for its timber but also as a source of medicine, firewood, dye and edible caterpillars, whereas its popularity as an ornamental tree is rising. As an important and widely used medicinal plant, it deserves more research on its active compounds, some of which have already shown interesting pharmacological activities.

Protection measures and domestication should be considered with a view to attain sustainable exploitation of this important African tree, which is being depleted at a quite high rate.

Major references Arbonnier, 2004; Bolza & Keating, 1972; Brummitt et al., 2007a; Burkill, 1995; Dry, 1993; Mathisen et al., 2002; Neya et al., 2004; Palmer & Pitman, 1972–1974; Takahashi, 1978; Wilson & Witkowski, 2003.

Other references Adjanohoun & Aké Assi, 1979; Adjanohoun et al., 1989; Aubréville, 1950; Bossard, 1993; Brenan, 1967; Burke, 2006; Coates Palgrave, 1983; Gelfand et al., 1985; Irvine, 1961; Kpakote et al., 1998; Leger, 1997; Lewis et al., 2005; Leyens & Lobin, 2009; Neuwinger, 2000; Steenkamp, 2003; van Wyk & Gericke, 2000; van Wyk & van Wyk, 1997; Watt & Breyer-Brandwijk, 1962; Williamson, 1955; Zida et al., 2005.

Sources of illustration Brenan, 1967; Coates Palgrave, 1957; Palmer & Pitman, 1972–1974.

Authors A. Maroyi

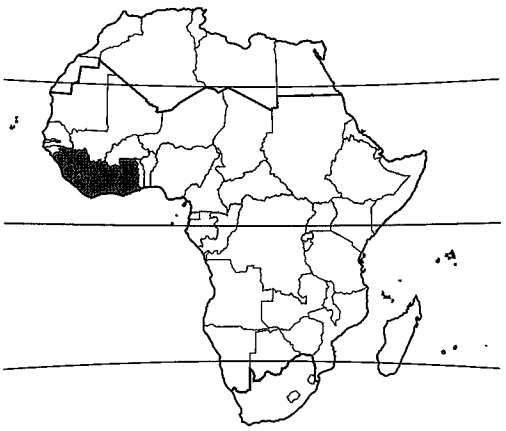
BUSSEA OCCIDENTALIS Hutch. & Dalziel

Protologue Bull. Misc. Inform. Kew 1928(10): 400 (1928).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 22$

Origin and geographic distribution *Bussea occidentalis* occurs from Guinea eastwards to Ghana.



Bussea occidentalis – wild

Uses The wood of *Bussea occidentalis*, known in trade as 'samanta' together with *Calpocalyx* spp. and *Xylia* spp., is recommended for heavy construction, industrial flooring, tools, turnery and ornaments. In Liberia it is especially valued for axe handles. Wedges made of *Bussea occidentalis* wood and used for felling trees proved superior to those made from the wood of other species.

The seeds are eaten after roasting; they are much appreciated in Guinea. In Liberia stem bark is added to palm wine and taken as diuretic. The bark is also used as a medicine for treating sleeping sickness, yellow fever, jaundice and heart troubles. The seeds are also used to treat heart troubles. Bark mixed with maize is used to poison monkeys in Côte d'Ivoire; the same mixture may kill cattle as well. The bark has been used in mixtures to prepare arrow poison. The bark and leaves are used in Côte d'Ivoire as a fish poison. The ash from pods serves as vegetable salt and for making soap.

Production and international trade The timber of *Bussea occidentalis* is rarely traded on the international market and usually only used locally.

Properties The heartwood is brown to olive brown or dark brown, darkening upon exposure, and distinctly demarcated from the greyish white to pale brown, c. 5 cm wide sapwood. The grain is interlocked, texture moderately coarse.

The wood is heavy, with a density of 870–1090 kg/m^3 at 12% moisture content, and very hard. It air dries comparatively rapidly for such a heavy wood; boards of 2.5 cm thick dry to 20%

moisture content in about 2 months. End checks may develop during drying. The rates of shrinkage are moderate, from green to oven dry 4.3–6.0% radial and 7.7–9.8% tangential. At 12% moisture content, the modulus of rupture is 156–171 N/mm², modulus of elasticity 19,600–20,480 N/mm², compression parallel to grain 72 N/mm² and Janka side hardness 14,500 N.

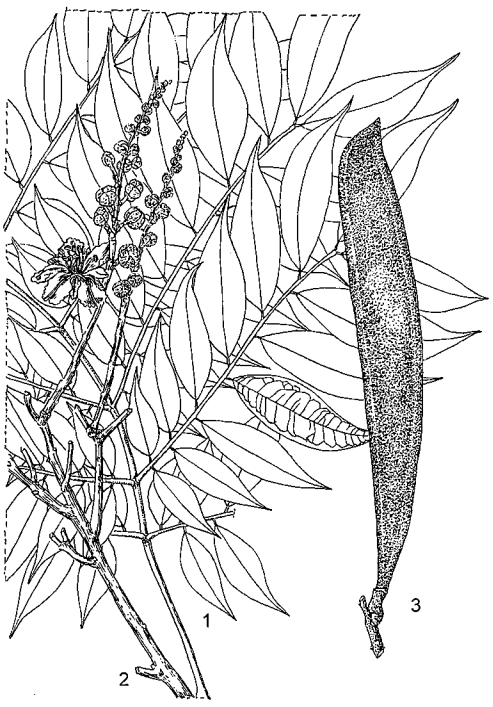
The wood is difficult to work with hand tools because of its hardness, but is not difficult to machine. It is rather difficult to plane because of the presence of interlocked grain. However, it takes a good finish. It tends to split upon nailing and pre-boring is needed. The wood glues well and gives good results in turnery. The heartwood is durable, being resistant to termites and borers, but the sapwood is susceptible to *Lyctus* attack. The wood is resistant to impregnation with preservatives.

The seed coat contains a haemolytic compound and a fish poison. Roasting makes the seeds safe for human consumption. The toxicity of the leaves is attributed to saponins, and the leaves also contain traces of alkaloids. Bark and roots contain tannins.

The amino acid azetidine-2-carboxylic acid has been found in high concentration in the seed, and 3-hydroxyproline and γ-methylglutamic acid are also present. Bark extracts of *Bussea occidentalis* showed promising in-vitro trypanocidal activity against *Trypanosoma brucei rhodesiense* with IC_{50} values below 10 µg/ml. The extract was found to show a modest selectivity index, in contrast to commercially available trypanocides with a more distinct selective toxicity. High cytotoxicity for a human fibroblast cell line (WI-38) has also been reported for a methanol extract of the bark.

Adulterations and substitutes In the timber trade *Bussea occidentalis* is sometimes confused with *Peltophorum africanum* Sond., which has quite similar wood but a completely different distribution area, from DR Congo southwards throughout a large part of southern Africa. The wood is also similar to that of *Erythrophleum suaveolens* (Guill. & Perr.) Brenan, which becomes slightly less dark after exposure.

Description Evergreen, medium-sized to fairly large tree up to 35(–45) m tall; bole straight and cylindrical to crooked or knotted, up to 75 cm in diameter, often fluted at base, sometimes with small buttresses up to 1 m high; bark surface smooth but with numerous lenticels, slightly scaly in old trees, pale grey to greenish grey, inner bark gritty, pale orange-brown, with copious watery exudate; crown often rounded and small, dense, sometimes with spreading branches; young twigs densely brown short-hairy. Leaves alternate, bipinnately compound; stipules needle-shaped, 4–8 mm long, curved inwards, early caducous; petiole c. 10 cm long, jointed at base, rachis ribbed, rusty brown short-hairy; pinnae 4–6 pairs, opposite; petiolules 2–4 mm long; leaflets 12–22 per pinna, alternate, oblong-elliptical to ovate-elliptical, 4–10 cm × 1.5–4 cm, base asymmetrically cuneate, long-acuminate at apex, glabrous. Inflorescence an axillary or terminal panicle consisting of dense racemes, up to 30 cm long, densely brown short-hairy. Flowers bisexual, slightly zygomorphic, 5-merous, bright yellow, sessile; sepals free, 7–15 mm × 6–8 mm, outside red-brown hairy; petals shortly clawed, one c. 2 cm × 1 cm, other 4 obovate, c. 2.5 cm × 1.5 cm; stamens 10, free, c. 1 cm long; ovary superior, c. 0.5 cm long, sessile, 1-celled, style slender, c. 7 mm long. Fruit a woody, narrowly obovate, flattened pod 15–30 cm × c. 3 cm, red-brown short-hairy, dehiscing



Bussea occidentalis – 1, leaf; 2, flowering branch; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

with 2 valves splitting from top and recurving, 1–2-seeded. Seeds elliptical to rounded, flattened, c. 3.5(–5) cm × 2 cm, yellowish brown. Seedling with epigeal germination; hypocotyl 5–9 cm long, epicotyl 5–18 cm long; cotyledons sessile, 2–4 cm long, thick and fleshy, rounded at apex; first leaves opposite, paripinnate with 2–3 pairs of leaflets.

Other botanical information *Bussea* comprises 7 species, 5 of which occur in continental tropical Africa and 2 are endemic to Madagascar. *Bussea massaiensis* (Taub.) Harms is a shrub or small tree up to 12 m tall, occurring in Tanzania and northern Zambia. Its wood is hard and termite resistant and is used in Tanzania for construction, tool handles, pestles and carvings. The seeds are roasted and eaten as a snack or powdered and added to soup, vegetables or meat. Leaves and seeds are fed to goats and sheep. *Bussea massaiensis* is useful as ornamental and shade tree.

Bussea perrieri R.Vig. and *Bussea sakalava* Du Puy & R.Rabev. are small to medium-sized trees up to 25 m tall. They are both distributed in dry deciduous forest in Madagascar, where their hard wood is used for construction. The wood of *Bussea sakalava* is additionally used as firewood, whereas a bark infusion of *Bussea perrieri* is taken to combat fatigue.

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); 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; 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: (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); 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; 115: 4–12 rays per mm. Storied structure: 122: rays and/or axial elements irregularly storied. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells; (143: prismatic crystals in fibres).

(E.A. Obeng, P. Baas & H. Beeckman)

Growth and development Young trees reached a mean height of 6.5 m and an average bole diameter of 8.5 cm when 7 years old, but the mortality was quite high, about 40%, apparently due to termite attack. In plantations trees may already start fruiting 4 years after planting. Trees flower throughout the rainy period, from May to October, and fruits are ripe in December–January. The fruits open explosively, dispersing the seeds over short distances. The seeds are eaten by colobus monkeys. No nodulation of the roots of *Bussea occidentalis* has been observed, but association with vesicular-arbuscular mycorrhizae has been recorded.

Ecology *Bussea occidentalis* can be found in all types of forest in its area of distribution, including gallery and secondary forest. It is most frequent in areas with an annual rainfall of 1500–2000 mm. It is locally dominant in the lower and middle storey of the forest and prefers well-drained soils.

Propagation and planting Natural regeneration is recorded as poor; numerous seeds germinate but few survive, probably due to poor light conditions and insect attacks. Survival of seedlings is best in small gaps in the forest canopy; the seedlings seem to prefer some shade.

There are about 250 seeds per kg. Seedlings can be easily produced from seeds, which germinate within 1–2 weeks at a germination rate close to 70%. They are easy to grow in the nursery, reaching about 30 cm tall 4 months after sowing, and can be transplanted into the field in full sun. Two-year old stumps transplant well.

Management In Liberia the total standing stock of *Bussea occidentalis* trees of more than 50 cm in bole diameter has been estimated at less than 500,000 m^3. In Ghana it has been found that where canopy openings were made to encourage natural regeneration, the dense crown of *Bussea occidentalis* tends to become spreading and to suppress young trees. Careful management is required to obtain straight boles.

Diseases and pests In nurseries seedlings of *Bussea occidentalis* are sometimes attacked by shoot borers, but damage is not serious and the seedlings usually recover.

Harvesting There is no prescribed minimum bole diameter for felling, but the recommendation in Ghana is 50 cm.

Handling after harvest Freshly felled logs sink in water and therefore can not be transported by river.

Genetic resources Although the range of *Bussea occidentalis* is limited, there are no clear indications that it is threatened at present. There are no known germplasm collections.

Prospects The prospects as a timber tree of more economic importance are not bright unless specific applications of the hard wood are developed, for instance for durable parquetry. Availability of larger boles is limited, which hampers exploitation. Planting for seed production might be interesting, but more research on phytochemistry and nutritional value of the seeds is needed. Although promising, the trypanocidal properties of *Bussea occidentalis* have not been fully explored yet.

Major references Burkill, 1995; Dudek, Förster & Klissenbauer, 1981; Freiburghaus et al., 1996; Hawthorne & Jongkind, 2006; Holmgren et al., 2004; Kryn & Fobes, 1959; Oteng-Amoako (Editor), 2006; Takahashi, 1978; Taylor, 1960; Voorhoeve, 1979.

Other references Atindehou et al., 2002; Atindehou et al., 2004; Aubréville, 1959b; Bakarr & Janos, 1996; Brummitt et al., 2007a; Busson, 1965; de Koning, 1983; de la Mensbruge, 1966; Diabate et al., 2005; du Puy et al., 2002; Evans & Bell, 1978; Hawthorne, 1995; Hawthorne & Gyakari, 2006; Koné et al., 2008; Lisowski, 2009; Mangenot & Mangenot, 1958; Neuwinger, 1998a; Pan et al., 2010; Ruffo, Birnie & Tengnäs, 2002; Schatz, 2001.

Sources of illustration Voorhoeve, 1979.

Authors G.D. Djagbletey & C.H. Bosch

CARPOLOBIA ALBA G.Don

Protologue Gen. hist. 1: 370 (1831).

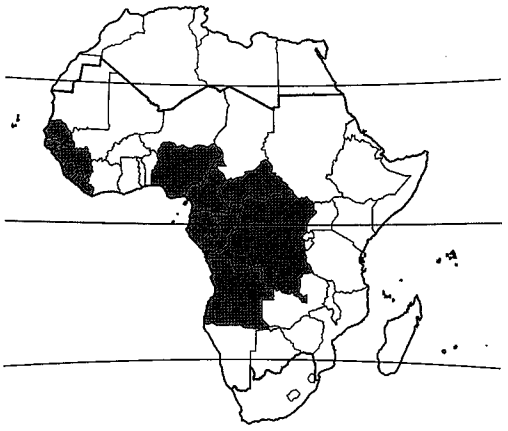
Family Polygalaceae

Chromosome number $2n = 22$

Synonyms *Carpolobia glabrescens* Hutch. & Dalziel (1927).

Vernacular names Poor man's candle (En).

Origin and geographic distribution *Carpolobia alba* occurs from Senegal to Liberia and from eastern Nigeria to the Central African Republic, DR Congo and northern Angola.



Carpolobia alba – wild

Uses The wood is used for making house posts, walking-sticks, cudgels, tool handles, spoons, combs, toys, games and traps. Because of its flexibility and resonance, it is used for musical instruments and cattle-sticks. It is useful for carving and turnery. The stems are used as torches as they burn even when fresh. Twigs are used as chew-sticks.

In southern Nigeria bark decoctions are used internally and externally to treat rheumatism. A maceration of the leaves and twigs is taken against stomach complaints. Leaf sap is dropped into the eye against cataract. The root is considered invigorating, aphrodisiac and vermifuge; it may be chewed or taken in decoction and is also taken in combinations with other medicines. Together with the fruit it enters in medicines to increase vitality. Mixed with other plants, the roots are used against miscarriage and poisoning, and to protect against spirits and spells. The sweet pulp of the fruit is eaten, while the fruit is also eaten green.

Production and international trade The wood of *Carpolobia alba* is only used and traded locally.

Properties The heartwood is yellowish brown and rather indistinctly demarcated from the sapwood. The wood has a fine and even texture. It is hard and takes a fine polish. It is resistant to termites. The wood is oily to the touch and burns even when wet.

The roots contain complex triterpene glycosides, which possibly have antiplasmodial properties.

Botany Shrub or small tree up to 5 m tall; bark surface smooth; twigs short-hairy, soon becoming glabrous. Leaves alternate, simple and entire; stipules absent or reduced to glan-

dular spots; petiole 1.5–3 mm long; blade elliptical, 1.5–12.5(–15) cm × 1–5(–6.5) cm, base rounded or cuneate, apex usually acuminate, papery, short-hairy below or nearly glabrous, pinnately veined with (3–)4–7(–9) pairs of lateral veins. Inflorescence an axillary raceme up to 3 cm long, short-hairy, (1–)2–5(–7)-flowered. Flowers bisexual, zygomorphic, 5-merous; pedicel 3–7 mm long; sepals unequal, ovate to elliptical, 3–8 mm × 2–6 mm, margins hairy; petals unequal, 1–2 cm long, 2 upper ones oblong, 2 lateral ones narrowly obovate and lower one hooded, white, cream or yellowish, purplish red to bright pink on tips; stamens 1–1.5 cm long, fused for more than half their length into a sheath fused again to upper petals; ovary superior, ellipsoid, slightly 3-lobed, tapering into curved style c. 1 cm long. Fruit a globose to obovoid berry up to 2.5 cm × 2 cm, slightly 3-lobed, glabrous, yellow to orange when ripe, pointed, 1–3-seeded. Seeds ellipsoid to ovoid, flattened, 0.5–1 cm long, densely rusty-brown hairy.

Carpolobia comprises 5 species, all in mainland tropical Africa but one also in Madagascar.

Carpolobia lutea G.Don is a shrub or small tree up to 5 m tall, occurring in the forest understory from Guinea to Nigeria. It is used for similar purposes as *Carpolobia alba*, with which it has been much confused. In addition, its root is used against pain and to ease childbirth.

Carpolobia goetzei Gürke, called 'mtindapo' in Swahili, is a shrub or small tree up to 5 m tall, occurring in rather dry forest and savanna woodland from eastern DR Congo and southern Sudan to Mozambique and northern Madagascar. Its wood is probably used for similar purposes as that of *Carpolobia alba*, and in East Africa its roots are used for similar medicinal purposes. In Mozambique the wood is used as firewood. Its fruits are eaten.

Ecology *Carpolobia alba* occurs in the understory of evergreen forest, semi-deciduous forest and gallery forest, up to 400 m altitude.

Genetic resources and breeding *Carpolobia alba* is widespread and locally common; there are no indications that it is in danger of genetic erosion.

Prospects The wood is likely to remain locally of some importance for carving and implements where hardness and a smooth surface are valued, as well as for house posts where durability is important. Its wood properties and pharmacological properties deserve research attention.

Major references Aké Assi et al., 1985; Breteler & Smissaert-Houwing, 1977; Burkill, 1997; Neuwinger, 2000; Normand, 1955.

Other references Afolayan & Yakubu, 2009; Aubréville, 1959a; Breteler, 2010a; Chhabra, Mahunnah & Mshiu, 1991; Coates Palgrave, 2002; Gassita et al. (Editors), 1982; Mitaine-Offer et al., 2002; Mitaine-Offer et al., 2005; Ogunsile & Quintana, 2010; Paiva, 2007.

Authors L.P.A. Oyen

CASEARIA BATTISCOMBEI R.E.Fr.

Protologue Notizbl. Bot. Gart. Berlin-Dahlem 9: 326 (1925).

Family Flacourtiaceae (APG: Salicaceae)

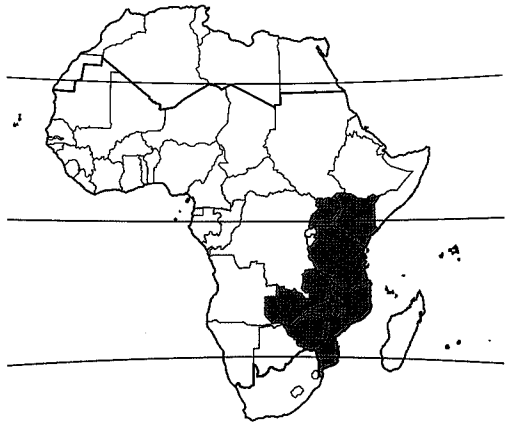
Vernacular names Forest sword-leaf (En).

Origin and geographic distribution *Casearia battiscombei* occurs from Kenya and Uganda southward to Zimbabwe and Mozambique.

Uses The wood (known in Kenya as 'casearia' or 'muirungi' and in Tanzania as 'white matua') is commonly used for joinery, interior trim and furniture. It is suitable for vehicle bodies, boxes, crates, turnery, veneer and plywood, and as pulpwood for paper production. It is also used as firewood and for charcoal production. In Mozambique the roots are used to treat malaria.

Production and international trade The wood of *Casearia battiscombei* has no importance in the international trade. It is mainly used locally.

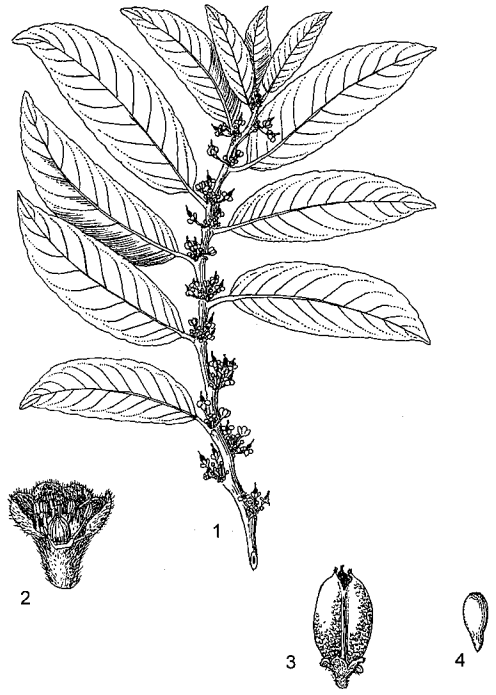
Properties The heartwood is restricted to a narrow dark brown core, sapwood very wide, whitish to pale yellow-brown, sometimes with reddish streaks. The grain is straight, texture fine and even. Freshly sawn wood has an un-



Casearia battiscombei – *wild*

pleasant smell which disappears upon drying.
The wood is medium-weight, with a density of 515–750 kg/m³ at 12% moisture content, soft and brittle. It air dries moderately fast, with a slight tendency to distortion and warping. The wood is very susceptible to blue staining, and therefore rapid drying of freshly sawn wood is advised. For kiln drying, low temperatures are recommended. The rates of shrinkage are moderate, from green to 12% moisture content 1.9% radial and 4.9% tangential.
At 12% moisture content, the modulus of rupture is 81 N/mm², modulus of elasticity 10,290 N/mm², compression parallel to grain 46 N/mm², shear 12.5 N/mm² and Janka side hardness 3205 N.
The wood saws and works well with both hand and machine tools. Planing is satisfactory with back-sawn material, but quarter-sawn material is liable to tearing. The wood polishes well and takes a satisfacory finish. It holds nails well. Boring is less favourable and should be done with support to avoid splitting. The bending properties are rather poor. The wood is not durable, being susceptible to termite, *Lyctus* and marine borer attacks. The sapwood is permeable and can be easily treated with preservatives using either open-tank or pressure-vacuum systems. Wood dust may cause irritation of mucous membranes in wood workers.

Description Small to fairly large tree up to 40 m tall; bole cylindrical, straight, branchless for up to 21 m, up to 50(–110) cm in diameter, often slightly buttressed; bark surface smooth, becoming scaly and rough in older trees, pale greyish to brownish, inner bark orange-brown; crown rounded, with spreading or slightly drooping branches arranged in tiers; young twigs short-hairy, soon becoming glabrous. Leaves alternate, simple; stipules triangular, up to 2 mm long, caducous; petiole 0.5–1(–1.5) cm long; blade oblong to elliptical, 8–22 cm × 3–6(–7) cm, asymmetrically cuneate to rounded at base, obtuse to acuminate at apex, margin entire to wavy, sometimes slightly and irregularly toothed, glabrous but with pellucid dots, pinnately veined with 10–20 pairs of lateral veins. Inflorescence an axillary fascicle, many-flowered. Flowers bisexual, regular, yellowish green; pedicel 3–4 mm long, up to 1 cm in fruit; receptacle funnel-shaped, c. 2 mm long; sepals 5, broadly elliptical to round, c. 2 mm long, short-hairy to nearly glabrous; petals absent; stamens 6–10, c. 1 mm long, alternating with hairy staminodes c. 0.5 mm long; ovary superior, ovoid, glabrous, 1-celled, with very short style and head-shaped stigma. Fruit an ellipsoid to ovoid capsule 1–2 cm × 0.5–1 cm, slightly angular, pointed at apex, glabrous, yellowish to orange when ripe, dehiscing from above with 2–4 valves, few-seeded. Seeds ellipsoid to obovoid, c. 0.5 cm long, smooth and pale, almost completely enclosed in a fleshy whitish aril becoming reddish upon exposure.



Casearia battiscombei – 1, flowering branch; 2, flower with one sepal and stamen removed; 3, fruit; 4, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Casearia* comprises about 180 species and occurs in all tropical and subtropical regions. In tropical Africa approximately 15 species can be found, most of them in mainland Africa and a few in Madagascar and the Mascarene islands.
Casearia engleri Gilg is a medium-sized tree up to 20 m tall, endemic to the West Usambara Mountains in Tanzania, where it plays a role in agro-ecosystems. Its wood, which seems to be quite similar to that of *Casearia battiscombei*, is used for poles and as firewood. *Casearia engleri* is listed as vulnerable in the IUCN Red List.
Casearia gladiiformis Mast. is a large shrub or small tree up to 15(–20) m tall, occurring from

Kenya south to South Africa. Its wood, which is similar to that of *Casearia battiscombei*, is suitable for joinery and furniture. Bark ash is used as snuff, and in Tanzania a root decoction is taken to enhance conception.

Casearia nigrescens Tul. is a large shrub or small tree up to 15(–20) m tall, endemic to Madagascar, where it is widespread. It is variable and has been considered to represent several distinct species. Its soft but elastic wood is used for joinery and musical instruments. Leaf and bark decoctions are considered to relieve pain and are an ingredient of mixtures taken by women as a tonic. Leaf and bark extracts were found to be cytotoxic in a human ovarian cancer cell line; the clerodane diterpene casearlucin L was isolated as most active compound.

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; 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; 65: septate fibres present; 69: fibres thin- to thick-walled; (70: fibres very thick-walled). Axial parenchyma: 75: axial parenchyma absent or extremely rare. Rays: 97: ray width 1–3 cells; 102: ray height > 1 mm; 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; 137: prismatic crystals in upright and/or square ray cells; (144: druses present); (145: druses in ray parenchyma cells); (148: druses in chambered cells).

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

Growth and development In southern Africa *Casearia battiscombei* flowers in October and fruits ripen about 3 months later. The seed arils are probably eaten by animals, which may serve as seed dispersers.

Ecology *Casearia battiscombei* is most common in high rainfall areas in highlands, where it is found in moist forest and forest margins, at 1000–2500 m altitude.

Propagation and planting The 1000-seed weight is about 21 g.

Management In general the density of *Casearia battiscombei* trees in the forest is quite variable; it is locally still abundant, e.g. in South Nandi Forest in Kenya where more than 5 boles of more than 20 cm in diameter occur per ha, and near Arusha in Tanzania, but it is dwindling in other areas due to excessive logging.

Harvesting Trees are harvested by the selective logging system. Caution should be taken during harvesting operations because logs may be brittle. Large logs may have heart rot, whereas star shakes are common.

Handling after harvest Freshly felled logs should be rapidly removed from the forest and processed because the wood is very susceptible to blue-stain attack.

Genetic resources *Casearia battiscombei* is locally common within its fairly large geographical range and its exploitation is moderate, and it is therefore unlikely to be threatened by genetic erosion at present. However, in several regions it has been recorded as rare (especially in southern Africa, e.g. in Zimbabwe) or dwindling in forests where it was formerly abundant (especially in East Africa). Monitoring of populations is therefore recommended.

Prospects *Casearia battiscombei* is a useful source of wood for purposes where durability is not required. Although very little is known about growth rates and suitable silvicultural and management practices, it is one of the emerging preferred species within its geographical range and it could have a high potential. Research is warranted to give recommendations for sustainable management in the natural forest.

Major references Bolza & Keating, 1972; Bryce, 1967; Chikamai et al., undated; Chudnoff, 1980; Coates Palgrave, 1983; Maundu & Tengnäs (Editors), 2005; Takahashi, 1978; Wimbush, 1957.

Other references Arumadri, 2001; Beentje, 1994; Boiteau, Boiteau & Allorge-Boiteau, 1999; Breteler, 2008a; Fowler, 2006; Guza, 2004; Hyde & Wursten, 2010a; Kitula, 2007; Liu et al., 2008c; Lovett & Clarke, 1998; Lovett & Pócs, 1993; Lovett et al., 2007; Munishi et al., 2008; Rutamu, 1999; Sleumer, 1971; Sleumer, 1975; Wild, 1960.

Sources of illustration Wild, 1960.

Authors E.A. Obeng

CASSIA HIPPOPHALLUS Capuron

Protologue Adansonia, sér. 2, 8(1): 22 (1968).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Origin and geographic distribution *Cassia hippophallus* is endemic to northern and western Madagascar, from Antsiranana south to the Bemaraha Plateau.

Uses The wood is used locally for construction.

Properties It has been reported that leaflets and fruit pulp have laxative properties.

Botany Deciduous shrub or small tree up to 15(–20) m tall; bole up to 50 cm in diameter; bark surface pale grey, rough, inner bark thick; twigs grey, with lenticels, initially densely yellowish short-hairy. Leaves arranged spirally, paripinnately compound with 13–20(–25) pairs of leaflets; stipules minute, caducous; petiole 2–4 cm long, rachis up to 30 cm long; petiolules 2–3 mm long; leaflets usually opposite, oblong to elliptical, slightly asymmetrical, 2–5 cm × 0.5–2 cm, short-hairy on both surfaces. Inflorescence an axillary or terminal raceme up to 30 cm long, combined into large panicles, short-hairy; bracts up to 13 mm long. Flowers bisexual, nearly regular, 5-merous; pedicel 2.5–4 cm long; sepals free, ovate to elliptical, 7–9 mm long, yellow; petals free, oblong-elliptical, 1.5–2 cm long, bright yellow, the upper petal slightly smaller than the other ones; stamens 10, very unequal, 3 lower ones c. 2.5 cm long, filaments inflated near the middle, 4 central ones up to 1 cm long, and 3 rudimentary up to 6 mm long; ovary superior, narrow and curved, c. 2 cm long, hairy, with stipe c. 5 mm long, style 4–5 mm long. Fruit a cylindrical, pendulous pod 8–20 cm × 2.5–3 cm, with a thick stipe, woody, wrinkled, dark brown, with a soft pulp inside, indehiscent, many-seeded. Seeds obovoid, compressed, up to 1 cm long, glossy brown.

The fruits persist for a long time on the ground after they have fallen from the tree.

Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* and *Senna*. In Madagascar only 2 *Cassia* spp. have been found.

Ecology *Cassia hippophallus* occurs in deciduous woodland and open scrubland, up to 500(–1150) m altitude. It is often found in margins of woodland, where it is subject to regular fires. It has been recorded on sandy, clayey and limestone soils.

Genetic resources and breeding Considering its preferred habitat, *Cassia hippophallus* does not seem to be easily threatened by genetic erosion.

Prospects The wood of *Cassia hippophallus* is probably only occasionally and locally used, and it is not likely that it will become more important in the future because of the comparatively small size of the bole. In view of the often interesting medicinal properties of other *Cassia* spp., research on phytochemistry and pharmacological properties may be worthwhile. *Cassia hippophallus* may have value as ornamental shrub or tree.

Major references Capuron, 1968; du Puy et al., 2002.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Lewis et al., 2005.

Authors R.H.M.J. Lemmens

Cassia hippophallus – wild

CAVACOA QUINTASII (Pax & K.Hoffm.) J.Léonard

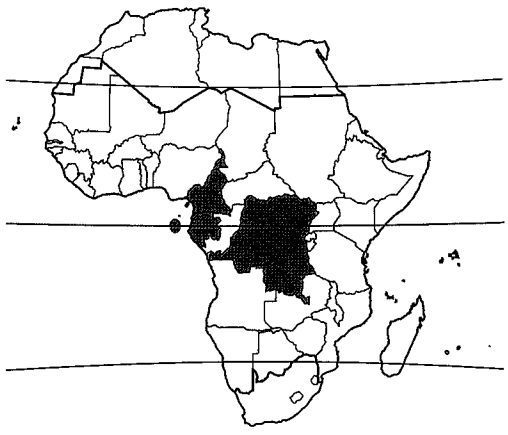
Protologue Bull. Jard. Bot. Etat 25(4): 322 (1955).

Family Euphorbiaceae

Synonyms *Grossera quintasii* Pax & K.Hoffm. (1912).

Origin and geographic distribution *Cavacoa quintasii* occurs in São Tomé and Principe, and from Cameroon to DR Congo.

Uses In DR Congo, the Efe and Balese people use branches of the tree to make fences around their compounds. Young Balese girls adorn themselves by putting the leaves around the waist and hips, especially for dances of the initiation rites. Scrapings from the root are smoked as a substitute for tobacco.



Cavacoa quintasii – wild

Properties The wood is pale orange-brown, has a fine texture and is very hard.

Botany Dioecious small to medium-sized tree up to 20 m tall; bole branchless for up to 8 m, deeply fluted and slightly twisted, up to 50 cm in diameter; bark surface yellowish brown, often with white marks; twigs greenish, glabrous, with whitish scars of stipules. Leaves alternate, simple and entire; stipules falling early; petiole 1–8 cm long; blade elliptical, sometimes obovate, up to 28 cm × 11.5 cm, cuneate at base, acuminate at apex, glabrous, with small translucent dots, pinnately veined with 8–15 pairs of lateral veins. Inflorescence a terminal raceme up to 10 cm long, short-hairy to glabrous; bracts broadly ovate, up to 5 mm × 8 mm, forming a cone-like structure in young inflorescences, soon falling. Flowers unisexual, regular, (4–)5-merous; male flowers with 1–2 cm long, yellowish pedicel jointed near base, calyx splitting into 2 broadly ovate lobes c. 5 mm long, whitish, petals free, elliptical to oblong, 6–9 mm long, yellowish, stamens many, disk glands whitish; female flowers with stout, 5–8 mm long pedicel, sepals free, ovate to oblong, 4–7 mm long, thin, yellowish green, soon falling, petals free, elliptical, 7–12 mm long, yellow, disk cupule-shaped, ovary superior, 3-lobed, styles 3, 3–4 mm long, 2-branched. Fruit a 3-lobed capsule 1–1.5 cm × 1.5–2 cm, glabrous, green becoming blackish, each lobe dehiscing with 2 valves and 1-seeded. Seeds 7–8 mm × 5–8 mm, brownish, slightly mottled. Seedling with epigeal germination; hypocotyl 2.5–9 cm long; cotyledons round to oblong, 2–4.5 cm long, leafy; first leaves alternate.

Cavacoa comprises 3 species and is confined to Africa. It is closely related to *Grossera*. *Cavacoa aurea* (Cavaco) J.Léonard is used in southern Africa as a medicinal plant.

Ecology *Cavacoa quintasii* occurs in the understorey of rainforest, usually on soils derived from schist and mica-schist.

Genetic resources and breeding *Cavacoa quintasii* is locally common to abundant, and there are no indications of genetic erosion.

Prospects *Cavacoa quintasii* is likely to remain of local use only because of its comparatively small and often poorly shaped bole. The tree flowers richly, spreading a pleasant fragrance, and has ornamental value.

Major references Léonard, 1962; Léonard, 1963; Normand & Paquis, 1976; Terashima, Ichikawa & Sawada, 1988; van Welzen & Stuppy, 1999.

Other references Schmelzer, 2008; Westra & Koek-Noorman, 2004.

Authors L.P.A. Oyen

CELTIS ADOLFI-FRIDERICI Engl.

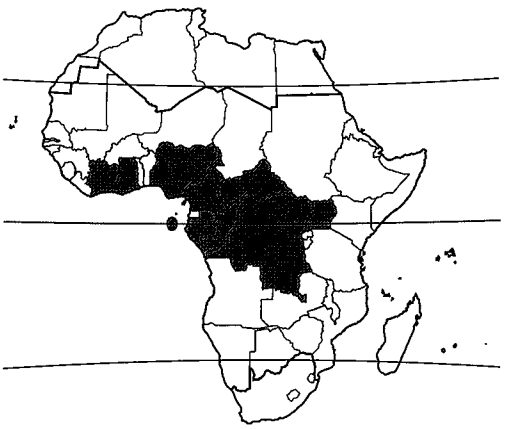
Protologue Bot. Jahrb. Syst. 43: 308 (1909).

Family Celtidaceae (APG: Cannabaceae)

Vernacular names African ita, ita (En).

Origin and geographic distribution *Celtis adolfi-friderici* is widespread, occurring from Côte d'Ivoire east to western Uganda and south to Gabon and DR Congo.

Uses The wood, traded together with other *Celtis* spp. as 'African celtis', is used for light construction, flooring, joinery, interior trim, frames, staircases, furniture, ladders, sporting goods, agricultural implements, handles, pestles, crates, boxes, match splints, hardboard



Celtis adolfi-friderici – wild

and particle board. It is suitable for mine props, ship building, railway sleepers, veneer and plywood. It is also used as firewood.
In traditional medicine, bark decoctions are taken to treat general malaise, severe cough, fever and headache, and as an emetic. A leaf decoction is used for treating sore eyes. In DR Congo bark pulp is applied on scarifications in the chest to relieve costal and side pains, and fruits have been used to treat tuberculosis. The bark is used as emetic and in magical preparations. The seeds are edible, and edible caterpillars are collected from the leaves and edible beetle larvae from dead trunks.

Production and international trade The wood of *Celtis adolfi-friderici* is mainly used locally and only occasionally traded on the international market in mixtures with other *Celtis* spp. Trade statistics are not available.

Properties The heartwood is white to pale yellow when freshly cut, later turning to grey-white; it is not distinctly demarcated from the sapwood. The grain is usually straight, sometimes interlocked, texture moderately fine. The wood is usually lustrous.

Celtis adolfi-friderici – 1, part of flowering twig; 2, part of inflorescence with many male flowers and one female flower; 3, leaf and fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

The wood is medium-weight, with a density of about 700 kg/m³ at 12% moisture content, and fairly hard. Kiln drying requires care to avoid splitting and distortion. The rates of shrinkage are moderate, from green to oven dry 4.8% radial and 7.8% tangential.
At 12% moisture content, the modulus of rupture is 150 N/mm², modulus of elasticity 11,760 N/mm², compression parallel to grain 65 N/mm², shear 8 N/mm², cleavage 21 N/mm and Chalais-Meudon side hardness 7.2.
The wood works well with both hand and machine tools and has moderate blunting effect on cutting tools. Straight-grained stock planes well, but a cutting angle of 15° is recommended to avoid tearing in wood with interlocked grain. The wood finishes and polishes very well. It is difficult to nail and screw; pre-boring is recommended to prevent splitting. The wood glues well. The veneering properties are variable. The wood has a low durability with an expected service life of 1–8 years for external usage. It is susceptible to attacks of blue-stain fungi and insects, including termites and *Lyctus* borers. The heartwood is moderately resistant to preservative treatment, but the sapwood is permeable. Wood dust may cause allergic reactions and skin irritation in wood workers.
Some traces of alkaloids have been reported in the bark and leaves of *Celtis adolfi-friderici*.

Description Semi-deciduous, medium-sized to fairly large tree up to 35(–50) m tall; bole branchless for up to 20(–30) m, usually straight and cylindrical, up to 100 cm in diameter, usually with wide-spreading buttresses up to 2(–5) m high; bark surface rough, brownish grey to dark grey, usually marked with horizontal ridges near the base of the bole, inner bark thick, granular, creamy with dark brown blotches; crown rounded, dark green, with branches drooping towards tips; twigs whitish short-hairy, soon becoming glabrous. Leaves alternate, simple and entire; stipules lanceolate, 3–6 mm long, hairy, caducous; petiole 0.5–2 cm long, grooved above; blade elliptical to ovate or obovate, 8–16(–20) cm × 5–10 cm, cuneate to rounded and very asymmetrical at base, with short-acuminate apex, leathery, glabrous except for some tufts of hairs in axils of veins below, slightly rough on lower surface, prominently 3-veined from the base and additionally with 1–3 pairs of lateral veins. Inflorescence an axillary cyme 1–5 cm long, short-hairy, many-flowered. Flowers unisexual or bisexual, regular, usually 5-merous, small,

white to greenish, sessile; tepals 1–1.5 mm long, hairy; stamens free, incurved in bud and later spreading; ovary superior, ovoid, densely hairy, 1-celled, styles 2, 2-lobed; male flowers numerous and densely clustered, with rudimentary ovary; female flowers and/or bisexual flowers at tops of upper inflorescences, female flowers with rudimentary stamens. Fruit an ovoid to globose drupe 1.5–2 cm long, reddish when ripe, glabrous, crowned at top by remains of styles; stone globose, 1–1.5 cm long, pitted, whitish, 1-seeded. Seedling with epigeal germination; hypocotyl c. 5 cm long, epicotyl 3–4 cm long; cotyledons c. 1.5 cm long, thick and fleshy, notched at apex; first two leaves opposite, toothed.

Other botanical information *Celtis* comprises about 100 species and is widespread in all tropical, subtropical and temperate regions. For tropical Africa 11 species have been recorded, 2 of which are endemic to Madagascar. *Celtis* is taxonomically a difficult genus, showing much morphological variability. Traditionally, it has been treated as part of the family *Ulmaceae*, but later it was often considered to belong to a separate family *Celtidaceae*, whereas from most recent research it was proposed to take up the latter family into *Cannabaceae*.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 1: growth ring boundaries distinct. Vessels: 5: wood diffuse-porous; 7: vessels in diagonal and/or radial pattern; 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; 40: mean tangential diameter of vessel lumina ≤ 50 μm; 50: ≥ 100 vessels per square milllimetre; 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: 76: axial parenchyma diffuse; 78: axial parenchyma scanty paratracheal; 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; 104: all ray cells procumbent; (106: body ray cells procumbent with one row of upright and/or square marginal cells); 116: ≥ 12 rays per mm. Storied structure: 118: all rays storied; 120: axial parenchyma and/or vessel elements storied.
(C. Essien, H. Beeckman & P. Baas)

Growth and development *Celtis adolfi-friderici* is a non-pioneer light demander. Seedlings attain a maximum height of 40 cm after 1 year, and subsequently grow 20–100 cm per year. The tree is partly deciduous and the crown is never completely leafless. In West Africa flowering trees have been recorded from May to June and November to December. Fruits ripen about 4 months later. The fruits are relished by animals such as birds, monkeys, chimpanzees and gorillas, which probably disperse the seeds.

Ecology *Celtis adolfi-friderici* is most common in semi-deciduous forest; it markedly prefers drier forests. It is often found in secondary forest and gallery forest, and occurs up to 900 m altitude. It prefers well-drained fertile soils.

Propagation and planting The weight of 1000 seeds is about 65 g. Seeds germinate after 15–30 days with a quite low germination rate. Under natural conditions, seedlings are usually found in small to medium-sized forest gaps. Although they are more light-demanding than other *Celtis* spp., some shade is required for young seedlings; for older seedlings exposure to more light is necessary for optimal growth. Seedlings can be quite abundant in forest that has been subject to logging, but they are less common in burnt forest.
In the nursery, germination of seeds is rather erratic and usually takes about 1 month. Pretreatment by soaking seeds in water and exposing them to the sun can accelerate germination and increase the germination rate.

Harvesting In Ghana the minimum bole diameter allowed for harvesting *Celtis adolfi-friderici* is 70 cm, in Cameroon 50 cm.

Handling after harvest After felling, logs should be extracted from the forest as soon as possible or treated rapidly with preservatives because they are susceptible to attacks by blue-stain fungi and insects.

Genetic resources *Celtis adolfi-friderici* is locally common and occurs often in secondary forest. It is unlikely to suffer from genetic erosion.

Prospects *Celtis adolfi-friderici* has potential to serve as substitute for other *Celtis* species that are more commonly traded on the international timber market, such as *Celtis mildbraedii* Engl. and *Celtis zenkeri* Engl. Very little research has so far been done on *Celtis adolfi-friderici* and research on its growth rates, propagation methods and management

requirements is therefore warranted.

Major references Bolza & Keating, 1972; Burkill, 2000; Hawthorne, 1995; Keay, Onochie & Stanfield, 1964; Oteng-Amoako (Editor), 2006; Polhill, 1966; Sattarian, 2006; Siepel, Poorter & Hawthorne, 2004; Takahashi, 1978; Vivien & Faure, 1985.

Other references CIRAD Forestry Department, 2008; Cousins & Huffman, 2002; de la Mensbruge, 1966; Eggeling & Dale, 1951; Hauman, 1948; Hawthorne & Jongkind, 2006; Irvine, 1961; Letouzey, 1968; Neuwinger, 2000; Sallenave, 1971.

Sources of illustration Engler, 1911; Letouzey, 1968.

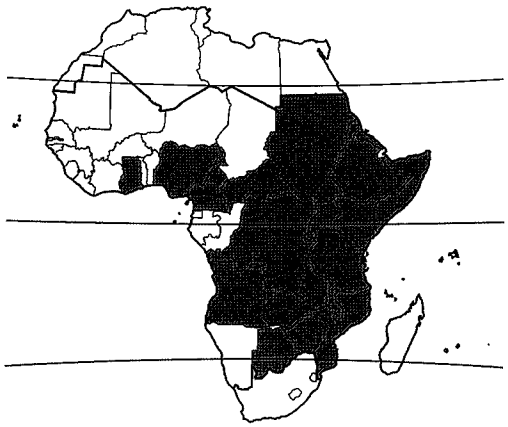
Authors R.B. Jiofack Tafokou

CELTIS AFRICANA Burm.f.

Protologue Fl. indica: 31 (1768).
Family Celtidaceae (APG: Cannabaceae)
Chromosome number $2n = 20$
Synonyms *Celtis kraussiana* Bernh. (1845).
Vernacular names White stinkwood, Camdeboo stinkwood (En).

Origin and geographic distribution *Celtis africana* is widespread in tropical Africa, occurring from Ghana eastwards to Somalia and south to South Africa and Lesotho. It is also found in Yemen.

Uses The wood (trade name 'celtis') is used for construction, flooring, joinery, interior trim, mine props, furniture, ladders, toys, novelties, sporting goods, agricultural implements, tool handles, pestles, tent-bows, yokes, wagon-making, spoons, boxes and crates. It is suitable for ship building, railway sleepers, veneer and plywood. It is also used as firewood and for charcoal production.



Celtis africana – wild

Several plant parts are used in traditional medicine. In Nigeria pounded bark is used to treat fever, headache and general malaise. A leaf decoction is applied to sore eyes. In Lesotho unspecified plant parts are used to treat pleurisy. The leaves serve as fodder for livestock; they are often fed to goats to relief them of indigestion. In Lesotho the fibrous bark is commonly used for making ropes, in Congo for clothes. The tree is commonly planted as ornamental shade tree and roadside tree.

Production and international trade The wood of *Celtis africana* is rarely traded on the international market and is mostly used locally.

Properties The heartwood is yellowish white or pale brown to greenish brown, occasionally with dark irregular streaks, and not distinctly demarcated from the whitish sapwood. There is often a dark brown to black stain around the pith. The grain is usually straight, sometimes interlocked, texture fine to moderately coarse and even. Freshly cut wood has an unpleasant smell, which has sometimes been described as 'apple-like'.

The wood is moderately heavy with a density of (640–)710–770(–820) kg/m^3 at 12% moisture content, and moderately hard. It dries fairly well with moderate degrade, but checking and end splitting may occur. Close stacking in air drying is recommended. The rates of shrinkage are moderate, from green to 12% moisture content 1.9–3.0% radial and 3.4–5.9% tangential, and from green to oven dry about 4.4% radial and 7.9% tangential. Once dry, the wood is stable in service.

At 12% moisture content, the modulus of rupture is 103–130 N/mm^2, modulus of elasticity 11,950–16,400 N/mm^2, compression parallel to grain 53–71 N/mm^2, shear 12–17 N/mm^2, Janka side hardness 7340–7750 N and Janka end hardness 8660–9340 N.

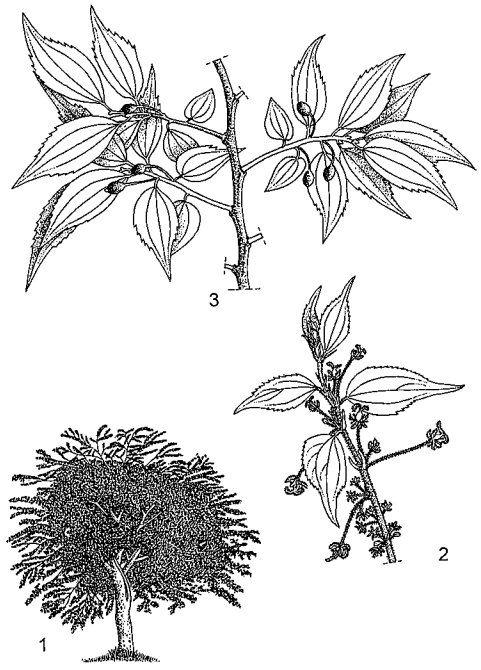
The wood is fairly easy to saw and work with both machine and hand tools, and has moderate blunting effect on cutting edges. In planing a reduced cutting angle is needed to avoid tearing at surfaces. The wood takes a good finish with nice polish without the use of a filler. It has good nailing properties, but with some tendency to splitting. It glues well. Boring and mortising should be done with good support. The bending properties are excellent, but turning properties poor. The wood peels well. It has a low durability and is susceptible to attacks by

blue-stain fungi, termites, *Lyctus* and marine borers. The heartwood is moderately resistant to impregnation with preservatives, but the sapwood is permeable; however, both can be treated well under pressure.

Methanol extracts from leaves and stems showed significant antioxidant activity, which is likely due to the presence of polyphenolic compounds. Root and leaf extracts showed only slight or no activity on cestodes of the tapeworm *Hymenolepis diminuta* after one hour, but significant activity after 24 hours. The bark has a high content of phenolic compounds, deterring porcupines from damaging the bark. The pollen has been recorded as an allergen.

Adulterations and substitutes At the beginning of the 20th century *Celtis africana* wood has been used as a substitute of ash, hickory and oak with some success.

Description Deciduous shrub or small to medium-sized tree up to 30(–40) m tall; bole usually straight, cylindrical, branchless for up to 15 m but often low-branching, up to 90 cm in diameter, often slightly fluted, usually without buttresses; bark surface smooth, whitish grey, often pinkish blotched, inner bark greyish with brown blotches, rapidly becoming dark brown upon exposure; crown rounded, dark green, with branches drooping towards tips; twigs densely yellowish brown short-hairy. Leaves alternate, simple; stipules linear, 3–8 mm long, hairy, caducous; petiole up to 0.5(–1) cm long, slightly grooved above; blade ovate to ovate-lanceolate, 3–10 cm × 2.5–6 cm, cuneate to rounded and very asymmetrical at base, with acuminate apex, margins coarsely toothed, papery, slightly hairy below especially on veins, rough above, prominently 3-veined from the base and additionally with 1–2 pairs of lateral veins. Inflorescence an axillary cyme up to 2.5 cm long, densely short-hairy. Flowers unisexual or bisexual, regular, 4–5-merous, small, white to greenish; tepals 1.5–2.5 mm long, hairy; stamens free, c. 1.5 mm long; ovary superior, ovoid, densely hairy, 1-celled, styles 2, unbranched; male flowers 3–many together in lower leaf axils, with pedicel 1.5–5 mm long and rudimentary ovary; female flowers and/or bisexual flowers 1–few together in upper leaf axils, with pedicel 10–17 mm long, female flowers with rudimentary stamens. Fruit an ellipsoid to globose drupe 4–8 mm long, pointed, orange when ripe, short-hairy; stone ovoid to globose, c. 4 mm long, slightly pitted, grey, 1-seeded. Seedling with epigeal germination.



Celtis africana – 1, tree habit; 2, flowering twig; 3, fruiting branch.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Celtis* comprises about 100 species and is widespread in all tropical, subtropical and temperate regions. For tropical Africa 11 species have been recorded, 2 of which are endemic to Madagascar. *Celtis* is taxonomically a difficult genus, showing much morphological variability. Traditionally, it has been treated as part of the family *Ulmaceae*, but later it was often considered to belong to a separate family *Celtidaceae*, whereas from most recent research it was proposed to take up the latter family into *Cannabaceae*.

Growth and development *Celtis africana* grows fast, 1–2 m per year. First fruits may appear when trees are 4 years old. Flowering trees have been recorded from August to October in southern Africa, and in May in Ghana. The flowers are usually pollinated by insects such as bees. Fruits ripen about 2 months after flowering. They are relished by birds such as bulbuls, mousebirds and barbets, they are an important component of the diet of colobus monkeys, and are also eaten by baboons. All these animals may contribute to seed dispersal.

Ecology *Celtis africana* occurs in a very wide range of habitats, from savanna to dry evergreen forest, riverine forest, montane rain-

forest and coastal forest, from sea-level up to 2400 m altitude. In Somalia it is typical of evergreen *Juniperus* and *Buxus* forest at altitudes of 1650–2000 m. Although it prefers relatively fertile and deep moist soils, it can also be found on sandy dunes and river banks, as well as on rocky soils, but under these conditions it usually only develops into a shrub. It is moderately drought resistant and can withstand light frost. In South Africa trees have been recorded to be severely affected by water logging conditions, leading to death of trees.

Propagation and planting In Uganda it has been recorded that *Celtis africana* does not regenerate under the canopy. In gaps regeneration was prolific. *Celtis africana* is propagated by seed and wildlings. The 1000-seed weight is 40–60 g. Seeds collected from the ground are mostly infested by insects, and it is recommended to harvest fruits directly from the trees when they turn from yellowish to brownish, and to dry them in the sun before extracting stones. These should be cleaned from fruit flesh before sowing. Fresh seeds germinate within 60 days and may have a high germination rate. Treatment is not necessary, but germination is hastened by soaking stones in cold water for 24 hours before sowing. They can be stored for some time in airtight containers. In South Africa seeds are sown in flat seedling trays filled with a mixture of 5 parts river sand and 1 part well decomposed compost placed in a warm but shaded place. To promote germination, seeds should be covered with a thin layer of river sand and kept moist; under these circumstances germination takes 15–30 days with a germination rate up to 70%. It is recommended to transplant seedlings into fertile soil. They should be watered sparingly.

Management *Celtis africana* is easy to grow under a wide range of conditions. Trees can be managed by side pruning.

Diseases and pests Fruits are heavily attacked by insects. *Celtis africana* is a host plant for the butterfly *Libythea labdaca*, the caterpillars feeding on the leaves.

Genetic resources *Celtis africana* is widespread and locally common, and does not appear to be liable to genetic erosion. Moreover, in South Africa it is commonly planted as an ornamental tree in gardens.

Prospects *Celtis africana* is a multipurpose tree valued for its timber, firewood and forage, and as ornamental and medicinal plant. It has potential to serve as substitute for other *Celtis* species that are more commonly traded on the international timber market, such as *Celtis mildbraedii* Engl. and *Celtis zenkeri* Engl. Little research has so far been done on *Celtis africana* and research on its growth rates, propagation methods and management requirements is therefore warranted. Research is needed to confirm its suitability for plywood production.

Major references Bekele-Tesemma, 2007; Bolza & Keating, 1972; Burkill, 2000; Coates Palgrave, 1983; Dale & Greenway, 1961; Fici, 1999; Letouzey, 1968; Mbambezeli & Notten, 2008; Polhill, 1966; Wilmot-Dear, 1999.

Other references Adedapo et al., 2009; Aggarwal, 1998; Beentje, 1994; Bryce, 1967; Chikamai et al., undated; Irvine, 1961; Johnson & Johnson, 2002; Kasenene, 1998; Katende, Birnie & Tengnäs, 1995; Kokwaro, 1993; Liu et al., 2008d; Maundu & Tengnäs (Editors), 2005; Mølgaard et al., 2001; Neuwinger, 2000; Palmer & Pitman, 1972–1974; Sattarian, 2006; Sommerlatte & Sommerlatte, 1990; Takahashi, 1978; Wilmot-Dear, 1991b; Wimbush, 1957.

Sources of illustration Dale & Greenway, 1961; Maundu & Tengnäs (Editors), 2005.

Authors N. Nyunaï

CELTIS GOMPHOPHYLLA Baker

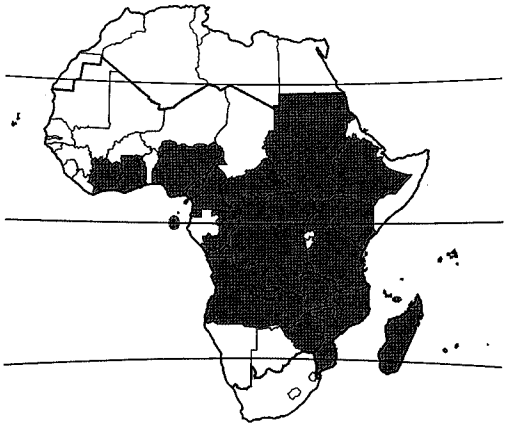
Protologue Journ. Linn. Soc., Bot. 22: 521 (1887).

Family Celtidaceae (APG: Cannabaceae)

Synonyms *Celtis durandii* Engl. (1900).

Vernacular names Bastard white stinkwood, forest celtis (En).

Origin and geographic distribution *Celtis gomphophylla* is widespread, from Côte d'Ivoire



Celtis gomphophylla – wild

east to Ethiopia and Kenya, and south to Angola, Zimbabwe, Mozambique and eastern South Africa. It is also found in Mayotte and Madagascar.

Uses The wood, sometimes traded as 'ohia', is commonly used for light construction, light flooring, joinery, furniture, cabinet work, canoes, ladders, sporting goods, agricultural implements, tool handles and matches. It is suitable for ship building, vehicle bodies, hardboard and particle board. It is also used as firewood and for charcoal production.

In traditional medicine, a leaf decoction is used for the treatment of cardiovascular disorders in Cameroon. In southern Nigeria a root decoction is used to treat fever and menstrual pains. *Celtis gomphophylla* is planted as a shade tree for crops and to improve soil conditions.

Properties The heartwood is whitish, turning slightly darker upon exposure, and not distinctly demarcated from the sapwood. The grain is usually interlocked, texture moderately fine. The wood has a persistent unpleasant smell.

The wood is medium-weight, with a density of 510–600 kg/m^3 at 12% moisture content. It is softer and less strong than that of the other *Celtis* spp. It usually air dries rapidly without serious degrade, but is liable to blue stain attack; dipping in anti-stain solution before stacking is recommended. It kiln dries fairly well, but some cupping and collapse around knots may occur. The rates of shrinkage from green to oven dry are 2.1–4.0% radial and 3.6–6.5% tangential.

The wood saws and works well with both machine and hand tools, but cutting edges should be kept sharp. A reduced cutting angle of 15° is recommended when machining quarter-sawn stock to prevent tearing along the grain. The wood holds nails and screws moderately well, but has a tendency to split; pre-boring is therefore advised. Boring and mortising should be done with strong support. The gluing properties are good, steam bending properties moderate. The wood does not turn well. Generally, it has a low durability, being susceptible to attack by fungi and *Lyctus*, but it is reported to be moderately durable in DR Congo and southern Africa. The wood can readily be treated with preservatives when using pressure methods. Wood dust may cause irritation to nose and throat.

Leaf extracts showed a vaso-relaxant effect on thoracic aorta of rats.

Botany Evergreen or deciduous shrub or small to medium-sized tree up to 30(–60) m tall; bole branchless for up to 13 m, often irregular and gnarled, up to 40(–120) cm in diameter, often fluted, sometimes with low but spreading buttresses; bark surface smooth, whitish grey to greenish grey, inner bark granular, with yellow and brown bands; crown with spreading branches; twigs sparsely whitish hairy. Leaves alternate, simple; stipules linear, 2–6 mm long, whitish hairy, caducous; petiole 0.5–1 cm long, slightly grooved above; blade ovate-elliptical to oblong-elliptical or lanceolate, 5–16 cm × 2–5(–8) cm, cuneate to rounded and asymmetrical at base, usually with long-acuminate apex, margins entire or sometimes toothed in upper part, papery, glabrous, often rough above, prominently 3-veined from the base and additionally with 3–5 pairs of lateral veins. Inflorescence an axillary cyme up to 1.5 cm long, short-hairy. Flowers unisexual or bisexual, regular, 4–5-merous, small; tepals 1–2 mm long, hairy; stamens free, c. 1.5 mm long; ovary superior, ovoid, slightly hairy or glabrous, 1-celled, styles 2, unbranched; male flowers few to many together, with pedicel 3–7 mm long and rudimentary ovary; female flowers and/or bisexual flowers 1–few together, with pedicel often longer, female flowers with rudimentary stamens. Fruit a conical-ovoid drupe 4–7 mm long, dark yellow when ripe, glabrous; stone angular-ovoid, c. 4 mm long, pitted, dark brown, 1-seeded.

Celtis gomphophylla grows rapidly in full sunlight, but growth is poor or stops completely under shaded conditions. In Côte d'Ivoire trees flower in March. The flowers are pollinated by insects such as bees. Fruits mature about 2 months after flowering. Trees produce fruits in abundance and these are relished by monkeys, chimpanzees and probably also birds, which may serve as seed dispersers.

Celtis comprises about 100 species and is widespread in all tropical, subtropical and temperate regions. For tropical Africa 11 species have been recorded, 2 of which are endemic to Madagascar. *Celtis* is taxonomically a difficult genus, showing much morphological variability. Traditionally, it has been treated as part of the family *Ulmaceae*, but later it was often considered to belong to a separate family *Celtidaceae*, whereas from most recent research it was proposed to take up the latter family into *Cannabaceae*.

Ecology *Celtis gomphophylla* has a wide ecological amplitude. In Central Africa it mostly occurs in the understorey of moist evergreen

and semi-deciduous rainforest and riverine forest, often in secondary forest. In West Africa it seems to be nearly restricted to upland forest. In Uganda it is an early successor of forest gaps and is also found in forest edges, thickets, woodland and wooded grassland. In western Kenya it is locally dominant in rainforest in areas with a mean annual rainfall of 1400–1900 mm. In South Africa it is restricted to coastal regions, whereas in Madagascar it is often found along watercourses on alluvial soils. *Celtis gomphophylla* can be found up to 1750(–2000) m altitude.

Management *Celtis gomphophylla* is propagated by seed and wildlings. Fruit stones are obtained from fallen mature fruits. After cleaning and drying they can be stored for up to 2 months in sealed containers, or they are sown directly in the nursery or in the field. Presowing treatment is not necessary as seeds germinate readily.

Genetic resources and breeding In view of its wide distribution and acceptance of variable habitat conditions, *Celtis gomphophylla* is not likely to be threatened by genetic erosion. It is locally common and is currently not overexploited. However, it is rare in West Africa and is a protected species in South Africa.

Prospects It is unlikely that *Celtis gomphophylla* will become commercially more important as a timber tree because of its often poorly shaped and small-sized bole and because of the persistent unpleasant smell of the wood. The vaso-relaxant properties of the leaf support its use in traditional medicine for cardiovascular disorders; this warrants further research for potential drug development. *Celtis gomphophylla* seems to be useful for forest restoration and possibly also for planting in agroforestry systems.

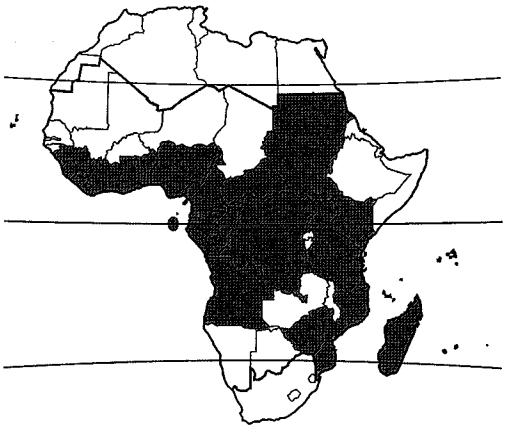
Major references Bolza & Keating, 1972; Burkill, 2000; Katende, Birnie & Tengnäs, 1995; Sattarian, 2006; Wilmot-Dear, 1991b.

Other references CIRAD Forestry Department, 2008; Coates Palgrave, 1983; Dale & Greenway, 1961; Dimo et al., 2005; Ehiagbonare, Onyibe & Ehiagbonare, 2008; Hawthorne, 1995; Irvine, 1961; Keay, 1958l; Keay, Onochie & Stanfield, 1964; Polhill, 1966.

Authors E.A. Obeng

CELTIS MILDBRAEDII Engl.

Protologue Bot. Jahrb. Syst. 43: 309 (1909).
Family Celtidaceae (APG: Cannabaceae)



Celtis mildbraedii – *wild*

Vernacular names Red-fruited white stinkwood, Natal white stinkwood, red-fruited celtis (En). Celtis d'Afrique (Fr). Mokolongo, mokalungo (Sw).

Origin and geographic distribution *Celtis mildbraedii* occurs from Guinea eastward to Sudan and southern Kenya and northern Tanzania, and southward to DR Congo and northern Angola. It also occurs in a disjunct area in southern Africa, from eastern Zimbabwe and southern Mozambique to northern South Africa and Swaziland. Finally it is found in the most northern part of Madagascar.

Uses The wood of *Celtis mildbraedii*, traded as 'ohia' or 'African celtis', is used for a variety of purposes. Traditionally, it is used for poles in house building and for pestles, tool handles and spoons. The wood is suitable for heavy construction, flooring, joinery, interior trim, mine props, railway sleepers, ship building, vehicle bodies, furniture, ladders, sporting goods, boxes, crates, agricultural implements, veneer, plywood, hardboard and particle board. It is an excellent firewood, burning slowly.
In Côte d'Ivoire and Uganda, trees are left for shade in plantations of banana, cocoa, coffee and tea. *Celtis mildbraedii* is planted as an ornamental tree in large gardens, parks and along streets, mainly in South Africa. The bark has analgesic properties. In Cameroon bark decoctions are used as a wash to invigorate seriously weakened babies. They are also taken together with *Solanum anguivi* Lam. fruits to treat venereal diseases. In Congo bark decoctions enter into a medicine taken orally or as enema against menstrual problems. In Angola a decoction of the root bark is drunk to treat

malaria. In Cameroon root ash mixed with palm oil is applied to scarifications as a treatment of headache. In Angola a tea of the root is given to children against constipation, but also against diarrhoea, cough, urinary complains and heart problems. A tea of the root or leaves is drunk against intercostal pain. A maceration of leafy twigs is applied as a bath or lotion to treat headache and as vermifuge. In Angola a hot water extract of the flowers with ash is rubbed onto the belly to promote childbirth. Flowers also enter into a rub against hernia. In Angola pounded leaves are made into a fish poison.

Production and international trade The wood of *Celtis mildbraedii*, traded together with that of several other *Celtis* species, occasionally enters the international market, but data on amounts traded are limited. It is more important in local markets. In 2005 Ghana exported 4000 m^3 of *Celtis* veneer at an average price of US$ 310, and in 2006 3000 m^3 at US$ 363, and in 2009 3100 m^3 of rotary veneer, 80 m^3 of sliced veneer and 120 m^3 of plywood. The wood is regarded as valuable in local markets.

Properties The heartwood is white to pale yellow or greenish, darkening upon exposure to greyish white, and indistinctly demarcated from the sapwood. The grain is often interlocked, sometimes straight, texture rather fine and even. Surfaces are often lustrous. Freshly cut wood has an unpleasant smell.

The wood is medium-weight, with a density of 600–785 kg/m^3 at 12% moisture content, and hard. On drying there is some risk of end splitting and distortion. Some reports indicate that defects may be serious and recommend application of an end-coating product and weighing down drying piles. The rates of shrinkage are moderate, from green to oven dry 4.1–5.2% radial and 7.7–9.1% tangential. The wood is often discoloured by blue or black stains if it is not dried rapidly after felling. Once dry, the wood is moderately stable in service.

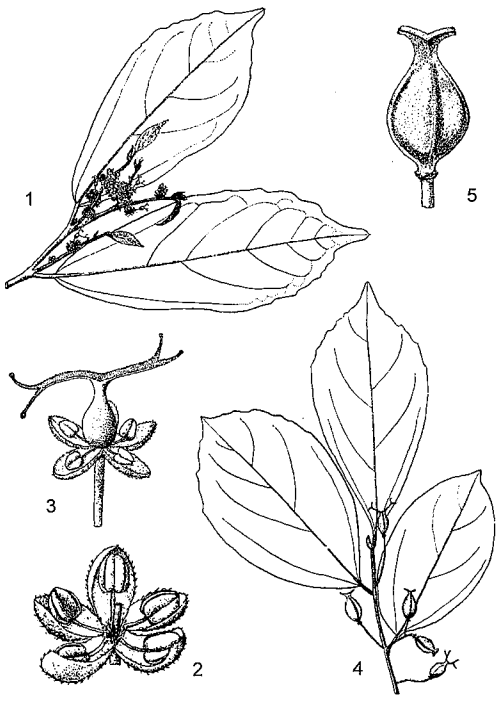
At 12% moisture content, modulus of rupture is (49–)75–182 N/mm^2, modulus of elasticity 8200–16,500 N/mm^2, compression parallel to grain 46–82 N/mm^2, shear 17–26 N/mm^2, cleavage 14–25 N/mm and Chalais-Meudon side hardness 3.4–6.5.

The wood of *Celtis mildbraedii* works fairly well with machine tools and slightly more difficult with hand tools. It has a moderate to fairly high blunting effect on saw teeth and cutting edges, and stellite-tipped saws and tungsten-carbide tool edges are recommended. Ripsawing and band-sawing require considerable force. Straight-grained wood planes well, but a reduced cutting angle of 15° is recommended to avoid tearing in wood with interlocked grain. The wood is difficult to nail and screw; preboring is recommended. It glues well. The veneering properties are variable as is the quality of veneer. The wood has a low durability. It is susceptible to attacks by blue-stain fungi and insects, including termites and *Lyctus* borers. The heartwood is moderately resistant to treatment with preservatives, the sapwood is permeable. Wood dust may cause allergic reactions and skin irritation in wood workers.

In a test in Congo, chemically pulped wood yielded about 50% pulp. Wood thicker than 1.5 cm is moderately easily inflammable, thinner wood is easily inflammable. On burning, the wood of samples tested in Nigeria gave less than 1% ash.

Adulterations and substitutes The wood of *Celtis mildbraedii* is similar in appearance and properties to that of *Celtis zenkeri* Engl. and *Celtis gomphophylla* Baker; they are all traded as 'ohia' or 'African celtis'. It is also similar to that of *Celtis adolfi-friderici* Engl., which may also be traded as 'African celtis'.

Description Evergreen or deciduous, medium-sized to large tree up to 50 m tall; bole branchless for up 30 m, slender, straight, up to 100 cm in diameter, with sharp buttresses up to 5 m high and 2 m wide; bark surface smooth or scaling in small disks, silvery to pale brown, inner bark fibrous, dark brown with yellow to off-white layers; crown small and dense; branches often drooping, with conspicuous pale lenticels; twigs rusty hairy. Leaves alternate, simple; stipules lanceolate, 4–5 mm long, tawny-hairy; petiole 3–10 mm long; blade elliptical to elliptical-obovate, (7.5–)9–15 cm × 4–5(–8) cm, base slightly obliquely cuneate, apex acuminate, margins obscurely to coarsely toothed in the upper half, papery to thin-leathery, glabrous, 3-veined from the base and additionally with (2–)3–6 pairs of lateral veins. Inflorescence an axillary cyme 0.5–1.5 cm long, short-hairy, many-flowered. Flowers unisexual or bisexual, regular, usually 5-merous, small, greenish; pedicel 0.5–2 mm long; tepals 1.5–2.5 mm long, hairy; stamens free, incurved in bud and later spreading; ovary superior, ovoid, often with a ring of sparse hairs at the base, otherwise nearly glabrous, 1-celled, styles 2, 2-lobed; male flowers numerous and densely clustered, with rudimentary ovary; female flowers and/or bisexual flowers at tops of upper



Celtis mildbraedii – 1, flowering twig; 2, male flower; 3, female flower; 4, fruiting twig; 5, fruit.
Source: Flore analytique du Bénin

inflorescences, female flowers with rudimentary stamens. Fruit an ovoid-ellipsoid drupe 0.5–1 cm long, reddish when ripe, glabrous, crowned at top by remains of styles; stone rhomboid-polygonal, c. 6 mm long, rough, 1-seeded. Seedling with epigeal germination; hypocotyl 4–5 cm long, epicotyl c. 1 cm long, hairy; cotyledons leafy, 1.5–2 cm long, 2-lobed at apex; first leaves alternate.

Other botanical information *Celtis* comprises about 100 species and is widespread in all tropical, subtropical and temperate regions. For tropical Africa 11 species have been recorded, 2 of which are endemic to Madagascar. *Celtis* is taxonomically a difficult genus, showing much morphological variability. Traditionally, it has been treated as part of the family *Ulmaceae*, but later it was often considered to belong to a separate family, *Celtidaceae*, whereas from most recent research it was proposed to take up the latter family in *Cannabaceae*.
Celtis mildbraedii resembles *Celtis zenkeri* Engl. and these species have been confused in the literature; they have both been called *Celtis soyauxii* Engl., which is now considered a synonym of *Celtis zenkeri*. The latter species usually has entire leaves with straight and parallel tertiary veins (reticulate in *Celtis mildbraedii*), and ovoid fruit stones. Moreover, *Celtis mildbraedii* often has a straighter and more slender and cylindrical bole than *Celtis zenkeri*. *Celtis prantlii* Priemer ex Engl. (synonyms: *Celtis brownii* Rendle, *Celtis philippensis* auct. non Blanco, *Celtis wightii* auct. non Planch.) resembles *Celtis mildbraedii* and has a similar area of distribution, although it does not occur in southern Africa and Madagascar. It is a small, deciduous tree up to 15 m tall. Its yellowish white, quite heavy and hard wood is used for construction, carpentry, pestles and canoes, and also as firewood. In Kenya root decoctions are taken to treat diarrhoea and in Côte d'Ivoire leaf preparations are applied to eczema.

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; 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; 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. Axial parenchyma: 80: axial parenchyma aliform; (81: axial parenchyma lozenge-aliform); 82: axial parenchyma winged-aliform; 83: axial parenchyma confluent; (85: axial parenchyma bands more than three cells wide); (86: axial parenchyma in narrow bands or lines up to 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; 98: larger rays commonly 4- to 10-seriate; 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; 137: prismatic crystals in upright and/or square ray cells; (138: prismatic crystals in procumbent ray cells); 141: prismatic crystals in non-chambered axial parenchyma cells; 142: prismatic crystals in chambered axial parenchyma cells; 154: more than one crystal of about the same size per cell or chamber; (155: two distinct sizes of crystals per cell or chamber); (157: crystals in tyloses).

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

Growth and development *Celtis mildbraedii* is classified as a shade-bearer. Germination is depressed in larger gaps in the forest, but established saplings grow well in forest gaps. Growth response of seedlings did not show a clear correlation with rainfall or soil fertility. Young trees may grow 1–2 m in length per year. In Ghana seedlings reached 1–3 m tall when 4 years old.

In Ghana *Celtis mildbraedii* flowers in January–April and August–September, and fruits ripen in February–April and August–September. In Benin it flowers in August and fruit can be found in August–October. In Zimbabwe and South Africa trees flower in September–October and fruits ripen in October–November. Trees with a bole diameter of 10 cm may already produce fruits. These are eaten by birds, including hornbills, and primates, which disperse the seeds. Seedlings may be abundant near mother trees.

Ecology *Celtis mildbraedii* is common in lowland to submontane, evergreen and semi-deciduous forest, except in wetter localities, up to 1600 m altitude. In southern Africa and Madagascar, it is less common and occurs in somewhat drier conditions.

Propagation and planting Fruit stones are usually collected from the ground; they are usually produced in large quantities in the fruiting season. There are about 2500 stones per kg. Germination takes 2–4 weeks, and the germination rate is generally low. Wildlings are sometimes also collected for planting.

Management In natural forest in Côte d'Ivoire, *Celtis mildbraedii* showed a positive response to thinning, about doubling the volume growth during the first 3 years after thinning. The trees can be pollarded.

Diseases and pests Leaves often have dark brown galls 3–5 mm in diameter on both surfaces.

Harvesting Logs should be extracted from the forest soon after felling or treated with preservatives to avoid attacks by blue-stain fungi and pinhole borers.

Handling after harvest Logs should be converted soon after felling to avoid losses by blue-stain fungal attack.

Genetic resources *Celtis mildbraedii* is very widespread. There are no indications that it is at risk of genetic erosion in tropical Africa. In South Africa it has been classified as vulnerable, but additional stands have been discovered later. The conservation status in Madagascar is not known.

Breeding No selection programmes are known to exist.

Prospects The wood of *Celtis mildbraedii* is likely to remain important for a variety of local uses. It may maintain its small role in international trade and even become more important, as it is a suitable substitute for several European timbers.

Major references Bolza & Keating, 1972; Burkill, 2000; CIRAD Forestry Department, 2008; Coates Palgrave, 2002; Hauman, 1948; Hawthorne, 1995; Polhill, 1966; Sattarian, 2006; Takahashi, 1978; Wilmot-Dear, 1991b.

Other references Ahonkhai, 1988; Anonymous, 1965; Aubréville, 1959b; Baerts & Lehmann, 2012; Bouquet, 1969; de la Mensbruge, 1966; Farmer, 1972; Herzog, 1994; Irvine, 1969; Istas, 1956; Katende, Birnie & Tengnäs, 1995; Letouzey, 1968; Lovett et al., 2007; Neuwinger, 2000; Ocloo & Laing, 2003; Ofori et al., 2009a; Ofori et al., 2009b; Veenendaal et al., 1996; Whitney et al., 1998; Wilmot-Dear, 1999.

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

Authors L.P.A. Oyen

CELTIS ZENKERI Engl.

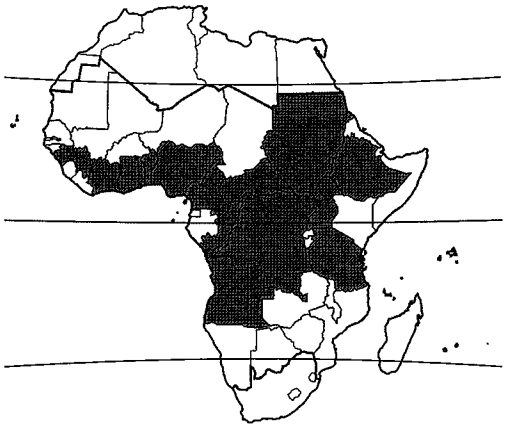
Protologue Notizbl. Bot. Gart. Berlin 3: 22 (1900).

Family Celtidaceae (APG: Cannabaceae)

Synonyms *Celtis soyauxii* Engl. (1900).

Origin and geographic distribution *Celtis zenkeri* occurs from Guinea eastward to southern Sudan and Ethiopia and southward to DR Congo, Tanzania and Angola.

Uses The wood of *Celtis zenkeri*, traded as 'ohia' or 'African celtis', is used for construction, especially in house building, for flooring and traditionally for poles, pestles and tool handles. It is suitable for joinery, interior trim, vehicle bodies, furniture, ladders, sporting



Celtis zenkeri – wild

goods, toys, novelties, agricultural implements, turnery, veneer and plywood. It is regarded as excellent firewood.

In Nigeria the leaves are recorded to be edible and they also serve as fodder for livestock. Various parts of the plant are used in traditional medicine. In southern Nigeria a preparation made from the macerated wood is applied to cuts on the skin. Bark decoctions are drunk to treat cough, and powdered bark with palm oil is rubbed on the body to ease pain associated with epilepsy, whereas in Côte d'Ivoire leaves are applied for the same purpose. Leaf preparations are applied to the legs for the treatment of elephantiasis. The tree produces large quantities of litter which decays readily after fall and serves as a good green manure.

Production and international trade Côte d'Ivoire and Ghana are the main exporting countries, but volumes are small. In 2005 Ghana exported 4000 m³ of *Celtis* veneer at an average price of US$ 310, in 2006 3000 m³ at US$ 363, and in 2009 3100 m³ of rotary veneer, 80 m³ of sliced veneer and 120 m³ of plywood. The wood is regarded as valuable in local markets.

Properties The heartwood is whitish to pale yellowish or greyish, darkening to pale brown upon exposure, and indistinctly demarcated from the sapwood. Patches of black or brown changing to pale green with age may be seen in some logs. The grain is straight or interlocked, texture fine but locally rather coarse. Freshly cut wood has a 'sugar-like' odour.

The wood is medium-weight to fairly heavy, with a density of 610–920 kg/m³ at 12% moisture content, and is fairly hard. It air dries and kiln dries slowly but well, with little degrade, although some reports mention a risk of distortion and end splitting. The rates of shrinkage are moderate, from green to oven dry 4.9–5.5% radial and 8.0–9.1% tangential. Once dry, the wood is moderately stable to unstable in service.

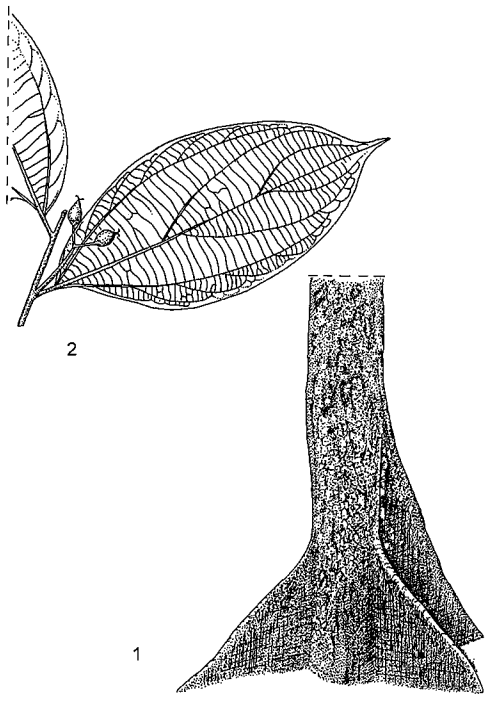
At 12% moisture content, the modulus of rupture is (97–)125–182(–203) N/mm², modulus of elasticity 11,750–17,050 N/mm², compression parallel to grain 43–71 N/mm², shear 22 N/mm², cleavage 16–19 N/mm, Janka side hardness 7470 N and Chalais-Meudon side hardness 3.6–5.4.

The wood works fairly well with both machine and hand tools, but difficulty is experienced in wood with black or brown patches, which have a strong blunting effect on cutting edges. In planing operations, a reduced cutting angle is advised to prevent tearing along the grain. Nailing and screwing are quite difficult, and pre-boring is required. Moulding, mortising and carving properties are good. The wood glues and finishes well when a filler is used. It has good resistance to abrasion and moderate steam-bending properties. The turning properties are better than in other *Celtis* species. Veneering properties are satisfactory, but steaming is needed; drying of veneer does not pose problems. The wood is of low durability. It is susceptible to attack by blue-stain fungi and many insects. The wood is permeable to preservatives under pressure, but poor results are obtained when hot and cold tank treatments are used. Saw dust may cause irritation in wood workers.

The wood contains about 39% cellulose, 25% lignin, 25% pentosan, 2.1% ash and 0.01% silica. The solubility is 2.1% in alcohol-benzene, 2.8% in hot water and 25.7% in a 1% NaOH solution.

Adulterations and substitutes The wood of *Celtis zenkeri* is similar in appearance and properties to that of *Celtis mildbraedii* Engl. and *Celtis gomphophylla* Baker; they are all traded as 'ohia' or 'African celtis'. It is also similar to that of *Celtis adolfi-friderici* Engl., which may also be traded as 'African celtis'.

Description Deciduous, medium-sized tree up to 30(–50) m tall; bole branchless for up 15(–20) m, slender, straight or twisted, up to 80(–120) cm in diameter, often irregularly fluted and with sharp buttresses up to 3 m high; bark surface smooth, scaling in round patches, silvery grey to yellowish or pale brown, inner bark fibrous, dark brown with yellow to off-white layers; crown dense, slightly spreading;



Celtis zenkeri – 1, base of bole; 2, part of twig with fruits.
Redrawn and adapted by J.M. de Vries

twigs densely brownish short-hairy. Leaves alternate, simple; stipules ovate-lanceolate, 5–7 mm long, short-hairy, caducous; petiole 5–8 mm long; blade ovate to oblong-elliptical, 6–15 cm × 3.5–8 cm, base obliquely cuneate to rounded, apex acuminate, margins usually entire, papery to thin-leathery, soft reddish-brown hairy below, 3-veined from the base and additionally with 2–4 pairs of lateral veins. Inflorescence an axillary cyme 1–5 cm long, short-hairy, many-flowered. Flowers unisexual or bisexual, regular, usually 5-merous, small, greenish, nearly sessile; tepals 2–3 mm long, hairy; stamens free, incurved in bud and later spreading; ovary superior, ovoid, brownish hairy, 1-celled, styles 2, 2-lobed; male flowers numerous and densely clustered, with rudimentary ovary; female flowers and/or bisexual flowers at tops of upper inflorescences, female flowers with rudimentary stamens. Fruit a globose to ovoid drupe 0.5–1 cm long, reddish when ripe, glabrous, crowned at top by remains of styles; stone ovoid-polygonal, c. 5 mm long, rough, 1-seeded. Seedling with epigeal germination; hypocotyl 3–4 cm long, epicotyl c. 1 cm long, hairy; cotyledons leafy, c. 1.5 cm long, 2-lobed at apex; first leaves alternate.

Other botanical information *Celtis* comprises about 100 species and is widespread in all tropical, subtropical and temperate regions. For tropical Africa 11 species have been recorded, 2 of which are endemic to Madagascar. *Celtis* is taxonomically a difficult genus, showing much morphological variability. Traditionally, it has been treated as part of the family *Ulmaceae*, but later it was often considered to belong to a separate family, *Celtidaceae*, whereas from most recent research it was proposed to take up the latter family in *Cannabaceae*.

Celtis zenkeri resembles *Celtis mildbraedii* Engl. and these species have been confused in the literature; they have both been called *Celtis soyauxii* Engl., which is now considered a synonym of *Celtis zenkeri*. *Celtis mildbraedii* usually has toothed leaves with reticulate tertiary veins (straight and parallel in *Celtis zenkeri*), and rhomboid fruit stones.

Celtis tessmannii Rendle (synonym: *Celtis brieyi* De Wild.) is a medium-sized to fairly large tree up to 40 m tall with bole up to 100 cm in diameter, occurring in Cameroon, Equatorial Guinea, Gabon, Congo and DR Congo. Its yellowish wood, which has a density of 620–790 kg/m^3 at 12% moisture content, resembles that of *Celtis zenkeri*, has similar technical characteristics and is suitable for similar purposes. In traditional medicine, the bark and roots are administered as anodyne. Bark preparations are taken to treat diarrhoea and fever, whereas leaf preparations are used in the treatment of inflammation of the respiratory organs, tachycardia and anaemia.

Celtis toka (Forssk.) Hepper & J.R.I.Wood (synonym: *Celtis integrifolia* Lam.) is a small to medium-sized tree up to 25 m tall with short bole up to 6 m long and 100 cm in diameter, occurring in dry forest and savanna from Senegal eastward to Ethiopia and Kenya, and in Yemen. Its yellowish white wood also resembles that of *Celtis zenkeri* and is suitable for similar purposes such as construction, handles, implements and canoes, although it appears to have a lower density (about 560 kg/m^3 at 12% moisture content) and to be less hard. It is also used as firewood. Young leaves are eaten as a vegetable and the fruits are also edible. The foliage is browsed by livestock. The fibrous bark is used to make mattings and rope. Bark preparations are used to treat rheumatism, and root preparations to treat rheumatism,

paralysis and sterility, and as a tonic. Leaf decoctions are administered as a treatment for measles, headache, rheumatism, smallpox and oedema, and to promote childbirth, whereas leaf powder is applied to wounds and abscesses. *Celtis toka* is planted as ornamental shade tree. It is a multipurpose tree which has been promoted for planting in the Sahel region.

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; 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; 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 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; 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: 80: axial parenchyma aliform; 82: axial parenchyma winged-aliform; 83: axial parenchyma confluent; (85: axial parenchyma bands more than three cells wide); 86: axial parenchyma in narrow bands or lines up to three cells wide; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 98: larger rays commonly 4- to 10-seriate; 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); 115: 4–12 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; 142: prismatic crystals in chambered axial parenchyma cells; 144: druses present; 145: druses in ray parenchyma cells.
(F.D. Kamala, H. Beeckman & P. Baas)

Growth and development Seedlings can reach a height of 15 cm in the first year. Bole diameter increments vary strongly between individual trees. In a survey in a semi-deciduous forest in Côte d'Ivoire, annual diameter growth rates of trees with a bole diameter of 6.5–20 cm were 0.5–1 cm, diminishing to about 0.3 cm for trees with a bole diameter of 25 cm. Extreme annual growth rates measured over the survey period were 1.5 cm for a tree with an initial bole diameter of 8.5 cm, and 2 cm for a tree with an initial bole diameter of 45 cm.
Celtis zenkeri is a common constituent of the upper canopy, which tolerates shade at initial stages of its growth. The tree is deciduous and begins to shed it leaves from November in Ghana, and leafless trees are common in February. Flushes of new, pale green leaves usually appear before all old leaves are shed. Flowering of trees is difficult to notice; it has been recorded in Ghana in March and August–September, whereas fruits mature in March–May and in November. In Nigeria flowering is reported in February–April and fruiting in March–May. In Uganda, fruits have been observed on trees with a bole diameter of 40 cm; fruits were present during more than 10 months. The fruits are eaten by birds and primates, which disperse the fruit stones.

Ecology *Celtis zenkeri* characteristically occurs in semi-deciduous and deciduous forest, often in drier localities, up to 1800 m altitude. It is also found in savanna woodland, fringing forest and drier forest remnants. *Celtis zenkeri* prefers soils with pH above 6, and does not grow well on acid soils and in swampy conditions.

Propagation and planting *Celtis zenkeri* can be propagated by seed, but the germination rate is low. Seeds start germinating after 2–4 weeks.

Diseases and pests *Lasiodiplodia theobromae* ('diplodia pod rot of cocoa') also affects *Celtis zenkeri.*

Harvesting The minimum bole diameter allowed for felling in Ghana and the Central African Republic is 70 cm, and 50 cm in Cameroon. The length of the merchantable bole is rarely more than 15 m. Tension wood is present in some logs.

Handling after harvest Logs should be extracted quickly from the forest or treated with preservatives because they are prone to blue stain and insect attacks. They float in water and can be transported by river.

Genetic resources *Celtis zenkeri* is widespread and locally common, and does not appear to be liable to genetic erosion.

Prospects Although *Celtis zenkeri* does not have much economic importance on the international markets, its wood has a high value for

local markets, and it is also appreciated as a medicinal plant. Although its relatively low durability is a disadvantage, the timber may gain importance in the international market because it can be used for a variety of applications. Although current demand is low, production could be increased substantially since the species is abundant and is widely distributed. It is considered of potential economic importance in both Uganda and Ghana.

Major references Bolza & Keating, 1972; Burkill, 2000; CIRAD Forestry Department, 2008; Irvine, 1961; Keay, 1989; Letouzey, 1968; Neuwinger, 2000; Ofori et al., 2009a; Ofori et al., 2009b; Polhill, 1966.

Other references Akoègninou, van der Burg & van der Maesen (Editors), 2006; ATIBT, 1986; Aubréville, 1959b; Babweteera & Brown, 2010; de la Mensbruge, 1966; de Saint-Aubin, 1963; Devineau, 1991; Hawthorne, 1995; Hawthorne & Jongkind, 2006; Normand & Paquis, 1976; Ocloo & Laing, 2003; Oteng-Amoako (Editor), 2006; Sallenave, 1955; Sattarian, 2006; Savill & Fox, 1967; Songwe, Okali & Fasehun, 1995; Takahashi, 1978; Taylor, 1960; Vivien & Faure, 1985; White & Abernethy, 1997.

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

Authors C. Essien & A.A. Oteng-Amoako

CEPHALOSPHAERA USAMBARENSIS (Warb.) Warb.

Protologue Bot. Jahrb. Syst. 33: 383 (1904).

Family Myristicaceae

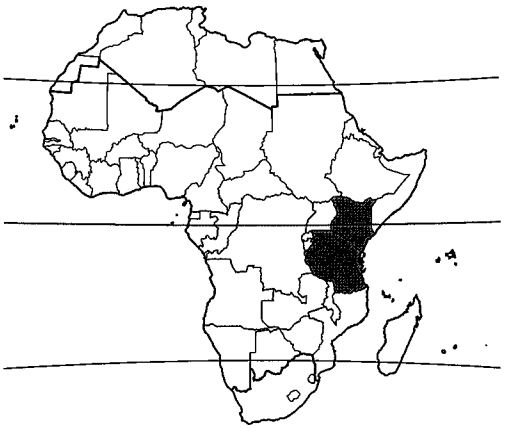
Vernacular names Mtambao, mtambara (Sw).

Origin and geographic distribution *Cephalosphaera usambarensis* is restricted to eastern Kenya and Tanzania.

Uses The wood is most commonly used for veneer and plywood, but is also suitable for light construction, light flooring, joinery, interior trim, furniture, toys, novelties, agricultural implements, boxes, crates, carving, turnery, matches, hardboard, particle board and pulpwood.

The bark yields a brown dye that has been used for dyeing cloth. The tree, with its crown providing comparatively light shade, is planted in agroforestry systems and along river banks to reduce erosion. The roots are used in local medicine in Tanzania to treat hernia.

Production and international trade In 1960 *Cephalosphaera usambarensis* was considered one of the most useful multi-purpose timber trees of Tanzania. At the beginning of the 1970s it was a major source of plywood. In 1985 it was ranked eighth on the list of most important timbers (in volume) of the East Usambara Mountains in Tanzania, and tenth in 2001. In 1990 the price of a plank was US$ 2.40, in 2001 US$ 2.90. *Cephalosphaera usambarensis* seems no longer to be harvested for commercial purposes because of declining populations due to over-exploitation.



Cephalosphaera usambarensis – wild

Properties The heartwood is pale reddish brown and indistinctly demarcated from the sapwood. The grain is usually straight, texture medium.

The wood is medium-weight, with a density of 510–650 kg/m^3 at 12% moisture content. It air dries rather slowly, and shows little degrade during drying even when kiln-dried rapidly. The rates of shrinkage are moderately high, from green to 12% moisture content 3.0% radial and 6.5% tangential. It takes 5–6 weeks to air dry boards of 2.5 cm thick from 65% to 14% moisture content and 4 months to dry boards of 5 cm thick. Once dry, the wood may be unstable in service. At 12% moisture content, the modulus of rupture is 93 N/mm^2, modulus of elasticity 16,900 N/mm^2, compression parallel to grain 44 N/mm^2, shear 12.5 N/mm^2 and Janka side hardness 2670–3290 N.

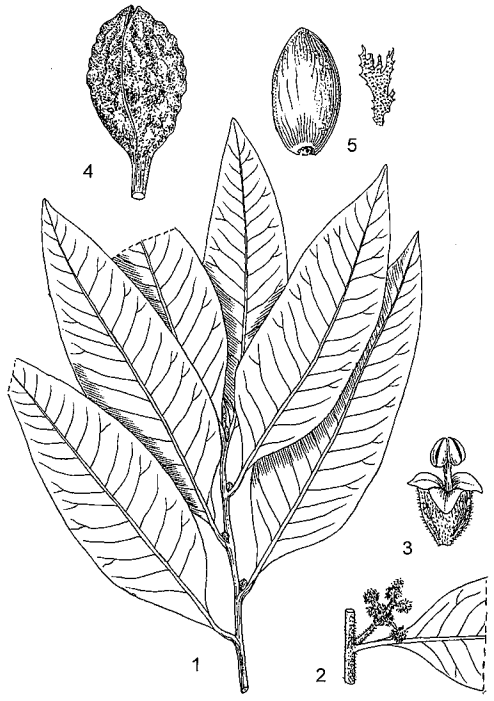
The wood saws and works easily with both hand and machine tools, although a reddish gum may cause some problems. The wood planes well, but a 30° cutting angle is recommended. The wood moulds and mortises well, and it finishes smoothly and polishes well. The

nailing and gluing properties are good. The wood peels well, but the veneer may split during drying. The turning properties are satisfactory. The wood is not durable, being susceptible to fungal and insect attacks. The wood is moderately resistant to impregnation with preservatives, but can be treated satisfactorily under pressure.

The gum from the bark is about 73% soluble in water and contains tannin. The semi-solid fat in the seed has been recorded to cause dermatitis in susceptible people.

Adulterations and substitutes The wood of *Cephalosphaera usambarensis* resembles that of *Pycnanthus angolensis* (Welw.) Warb., which is used for similar purposes.

Description Evergreen, dioecious, medium-sized to large tree up to 50(–60) m tall; bole branchless for up to 25(–30) m, straight and cylindrical, up to 90(–160) cm in diameter, sometimes with small buttresses; bark surface smooth, whitish to pale brown or dark grey, inner bark granular, pale orange-brown with paler markings, exuding copious red gum; crown small, rounded, rather open; young twigs reddish brown short-hairy, soon becoming glabrous. Leaves alternate, simple and entire; stipules absent; petiole c. 1 cm long; blade oblong to oblong-lanceolate, 8.5–29 cm × 3–7.5 cm, cuneate at base, acute to short-acuminate at apex, glabrous, pinnately veined with 13–20 pairs of lateral veins. Inflorescence an axillary panicle up to 7 cm long, reddish brown hairy, with flowers in many-flowered heads. Flowers unisexual, regular, up to 3 mm long, yellowish, sessile, perianth cup-shaped, 3–4(–5)-lobed, reddish brown short-hairy; male flowers with 3–4(–5) fused stamens, filaments merged into a column; female flowers with superior 1-celled ovary. Fruit an ellipsoid to oblong-ellipsoid drupe 5.5–6.5 cm × 3–4 cm, yellow-green, dehiscent with 2 spoon-shaped valves, 1-seeded. Seed ellipsoid to oblong-ellipsoid, 4–5 cm long, cream-coloured to pale brown, with yellow to pale brown, glandular-dotted, laciniate aril. Seedling with hypogeal germination.



Cephalosphaera usambarensis – 1, leafy twig; 2, male inflorescence; 3, male flower; 4, fruit; 5, seed with part of aril.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Cephalosphaera* comprises a single species. It seems most closely related to the small genus *Brochoneura* from Madagascar.

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; 14: scalariform perforation plates; 15: scalariform perforation plates with ≤ 10 bars; 21: intervessel pits opposite; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 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); 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; 63: fibre pits common in both radial and tangential walls; 65: septate fibres present; 66: non-septate fibres present; 68: fibres very thin-walled; 69: fibres thin- to thick-walled. Axial parenchyma: 78: axial parenchyma scanty paratracheal; 79: axial parenchyma vasicentric; (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; 106: body ray cells procumbent with one