Calophyllum brasiliense Cambess.

E.M. FLORES
Academia Nacional de Ciencias de Costa Rica, Costa Rica

CLUSIACEAE (MANGOSTEEN FAMILY)

Calophyllum lucidum Benth. (Hooker's Journal of Botany and Kew Garden Miscellany 2:370; 1843);
Calophyllum rekoi Standl. (Contributions of U.S. Natural Herbarium 20: 192; 1919);
Calophyllum antillanum Britton (Scientific Survey of Porto Rico and the Virgin Islands 5:584; 1924);
Calophyllum brasiliense var. *antilliense* (Britton) Standl. Tropical Woods 30:7; 1932);
Calophyllum chiapense Standl. (Contributions of U.S. Natural Herbarium 20: 192; 1919);
Calophyllum piaroanum A. Castillo & C. Gil (Ernstia (2nd series) 1[1]: 41, f.1; 1991)

Aca, aceite, aceito, aceito de maria, acuje, alfaro, arary, balsamaria, baré, barí, baría, barillo, Brazil beauty-leaf, cachicamo, calaba, calambuca, cascarillo, cedro cimarrón, cedro de pantano, cedro maria, chagualo, chaqualo, cojón, crabwood, cupia, dalemarie, damage, dame marie, edaballi, galopa, galpa, guanandi, guaya, jacaréuba, korakrie, kurahara, kurahura, lagarto caspi-blanco, lagarto-crespi, lech, leche, leche amarilla, leche maria, lechoso, limoncillo de Córdoba, lorahara, mangue, mani kwaha, manzano, mara, maria, maria blanco, maria colorado, mario, ocu, ocuje, ocuje macho, olandi, palo de maria, palo rey rosado, penoga, santa maria, varilla, wild cabash (Barajas and others 1979, Flores 1994b, Pennington and Sarukhán 1968, Record and Hess 1949, Salas Estrada 1993)

Calophyllum L. is a tropical genus composed of about 100 species, distributed in America, Asia, Madagascar, and Australia. *Calophyllum brasiliense* is the most important of the American species. The natural range of the species extends from Mexico throughout Central America to northern South America. The species also grows in the West Indies (Flores 1994b, Record and Hess 1949, Standley and Williams 1961).

Calophyllum brasiliense is a tree 40 to 50 m in height and 1.80 m d.b.h. The tree has a straight, cylindrical bole, sometimes with a moderate vertical torsion (on slopes); the basal two-thirds is branch free. The crown is round and dense, with ascending, thick, irregular branches. The young twigs are minutely puberulous. The bark is gray or brownish gray, coarse, thick, and vertically fissured with exfoliating small plates, a bitter taste, and many laticifers with resinous, greenish yellow or yellow latex (Cálix-Pizatti 1970, López and others 1987, Standley and Williams 1961). Leaves are decussate, simple, petiolated, exstipulated, coriaceous, and variable in size (López and others 1987, Standley and Williams 1961). Leaf blades are dorsiventral, elliptic, oblong or obovate, entire, glabrous, shiny green above, and dull and light green below. Secondary veins are closely parallel. *Calophyllum brasiliense* is a canopy tree typical of the humid tropical forests (evergreen lowlands to montane forests, gallery forests, and periodically flooded riverbanks) with an annual rainfall above 3000 mm and a temperature of 24 to 28 ^{o}C. Its elevational range is from sea level to 1500 m. The species grows well in slightly sloped areas with alluvial or clayey soils rich in silica, humid, saturated, and acid (pH 4.5 to 6.0). In Central America, the trees are commonly found in coastal areas with soils rich in iron and aluminum but poor in phosphorous and potassium, and in plains with rivers, creeks, or marshes (Chaves and Chinchilla 1994, Flores 1994b). The species is frequently found in the Amazon varzeas. *Calophyllum brasiliense* var. *rekoi* has been recorded in Central America.

The timber has excellent characteristics and is widely used. The wood is grayish red, heavy or moderately heavy; the average specific gravity (green volume/dry weight) varies from 0.45 to 0.55 and the green weight from 761 to 950 kg per m^3, along the geographical range of the species (Flores 1994b, Picado and others 1983, Simpson and Sagoe 1991). It has interlocked or sometimes straight grain, medium and quite uniform texture, and medium luster; and the figure is characterized by wide stripes in the radial surface (Creemers and Lemckert 1981, Longwood 1962, Record and Hess 1949). Odor and taste are not characteristic (Longwood 1962). It has good

physical and mechanical properties; it is stable and durable and has an attractive figure (Flores 1994b, Record and Hess 1949). It is moderately stable in use and can be compared to mahogany (*Swietenia macrophylla*), Douglas fir (*Pseudotsuga meziesii* (Mirb.) Franco), and scotch pine (*Pinus sylvestris* L.), although it has superior values in rupture module, maximum load, and hardness (González and others 1990, Longwood 1962). Air drying is moderately fast and shows minor defects, mainly twisting or splitting (Instituto Nicaragüense de Recursos Naturales y del Ambiente 1993a, Longwood 1962). It is easy to saw and cut. The polishing properties are medium; 50 percent of polished pieces have a clean surface, 20 percent have irregular grain, and 30 percent show a ripped grain (Flores 1994b, González and others 1990). The wood is commonly used in internal and external construction, general carpentry, floors, furniture, posts, cabinetwork, blackboards, bridge structures, masts, railroad foundations, veneers, and canoes (Barajas and others 1979; Flores 1994b; Herrera and Morales 1993; Instituto Nicaragüense de Recursos Naturales y del Ambiente 1993a, 1993b; Kribs 1968). The Runkel Factor is approximately 0.98 (Group III), and the fibers may be used for papermaking. The timber is resistant to termites (*Captotermes niger*, *Heterotermes convexinotatus*, *H. tennuis*, and *Nasutitermes corniger*) and fungi during the first 2 years (Bultman 1976). The heartwood is difficult to impregnate; absorption is poor (58 kg per m^3), and penetration is null (Instituto Nicaragüense de Recursos Naturales y del Ambiente 1993b). The latex has been used in Central America to reduce fevers and heal cuts (Betancourt 1987, Herrera and Morales 1993). In the Brazilian Amazon, it is used to control diabetes (Van der Berg 1993). The leaves are used as an anti-inflamatory and in infusions to control asthma and digestive problems (Herrera and Morales 1993). In South America, the fruits are used to feed pigs. The seeds provide oils. The bark produces an excellent brown dye (Acuña and Rivera 1990). Xanthones and coumarin derivatives have been found in some species of the genus; triterpenes and bioflavonoids have been formed from the species (Schultes and Raffauf 1990). The species is used as an ornamental in parks and along road borders. Its high-quality timber and silvicultural characteristics have led to its use in monospecific plantations.

The tree primarily flowers in June and July with a minor bloom in November and December. Variations in the flowering pattern are found along the geographical range of the species. Blooming is usually annual. Flowers are andromonoecious, grouped in axillary panicles, pedunculated, with a subtending leaf, sometimes inconspicuous. The main axis is 3 to 9 cm long; bisexual and staminate inflorescences have 2 to 20 flowers, and flower distribution is irregular, opposed, or grouped in monochasia or dichasia. Staminate and hermaphrodite flowers are actinomorphic; the calyx is tetramerous, greenish; sepals are decussate, round, and adaxially concave; the corolla is tetramerous; the petals are decussate, ovate, glabrous with a round apex, and white, creamy, or yellowish. The staminate flowers have a soft and sweet scent; the androecium has numerous stamens centrally grouped. The filaments are filiform and narrow; the anther is oblong, basifixed, and longitudinally dehiscent. The bisexual flowers have 8 to 10 stamens. The flower is epigynous; the ovary is ovoid and unilocular. The ovary has a single pseudobasal ovule, anatropous, crassinucellate, with hypostase, massive outer integument, and thin inner integument. The style is narrow, short, and hollow; the stigma is tetralobed, obtuse, papillary; the lobes expand distally.

Fruits are globular berries, apiculate, yellow-greenish or maroon, 2.5 to 3.0 cm in length and diameter. Immature fruits are green, mature fruits yellow or yellowish brown. The exocarp is coriaceous, thin, and dull, with glandular dots. The mesocarp is fleshy, whitish turning to yellow at maturity, with a granulose texture and astringent taste. The endocarp is thin and fragmentary in the mature fruit. Bats, birds, rodents, and fish (riparian or marshy trees) disperse the fruits and seeds. Seeds are ovoid or globose; the seedcoat is brown. The testa is thick, hard, woody, and irregular; the tegmen is thin and sometimes fragmentary in the mature seed. Seed size (1.8 to 2.3 cm) is correlated to fruit size (Flores 1994b).

Fruits must be collected from the trees or gathered from the ground under trees with a d.b.h. range of 40 to 70 cm; trees with greater diameters may have physiological deterioration and usually have a hollow pith (Flores 1994b). Seed weight is 2.2 to 2.5 g and seeds average 415 to 440 per kg; 25 to 28 percent of this weight is moisture. The pericarp must be removed, and seeds must be sown directly in greenhouse beds. Seeds do not tolerate desiccation or drastic temperature fluctuations and may be considered recalcitrant.

Germination is hypogeal and the seedling is cryptocotylar (Flores 1994b). Although seeds do not require pregerminative treatments, it is convenient to soak them for 24 hours to soften the seedcoat. This soaking contributes to uniform germination and diminishes the percentage of seedlings with anomalous plumule development. Seeds planted in greenhouse beds must be transferred to plastic bags when radicles emerge (Flores 1994b). All young seedlings with anomalous development (twisted epicotyls, shoots originating from buds of the cotyledonar axils) or slow growth must be eliminated. Roots must be pruned twice using a shovel or knife (Flores 1994b). The first pruning must be done when seedlings reach a height of 20 cm; the second, 1 month before seedlings are transferred to the field (Chaves and Chinchilla 1994). Seedlings must be transferred to plantation in adobe and the extended leaves must be cut. This technique permits trans-

planting of seedlings at different ages, including 9 months, with very low mortality. Transferring seedlings from the greenhouse generates homogeneous plantations and trees with better boles (Flores 1994b).

ADDITIONAL INFORMATION

The leaf apex is acute, obtuse, or truncate; the leaf base is cuneiform and the margin is thick. The leaf is hypostomatic and stomata are mainly anomocytic, sometimes paracytic. Leaf venation is pinnate craspedodromous; the midrib has a straight course and projects abaxially. Secondary veins are fine, with a divergence angle of 80 to 90 degrees.

Pollination is entomophilous; the flowers are visited by numerous insects, small or medium-sized. No specific pollinator has been found.

The seed has a small hilum containing the micropyle. The endosperm is nuclear and is gradually consumed during seed development. The mature seed lacks endosperm or perisperm. The embryo is straight and massive, developing in the last stages of seed development. Cotyledons are broad, fleshy, oily, anisocotylous, gamocotylous in the distal three-quarters and concave adaxially in the basal three-quarters. The plumule is enclosed in the formed cavity. The embryo axis is poorly developed; the radicle is small and syntropous; a laticifer system extends to the whole embryo (Flores 1994b).

Calophyllum brasiliense has been planted in monospecific plots with a planting distance of 3 by 3 m. In the monospecific plots at Escuela de Agricultura de la Región Tropical Húmeda, Guácimo, Limón Province, Costa Rica, the species reached an average height of 1.36 m and an average diameter of 1.62 cm in the first year (Russo and Sandí 1993). In La Selva, Sarapiquí, Costa Rica, 3-year-old saplings in plantation reached an average increment in height of 1.4 m per year, an average increment in diameter of 1.3 cm per year, and an average increment in basal area of 0.8 m^2 per ha per year (González and others 1990). Evaluations carried out in 7-year-old plantations in Colpachí, La Virgen, Sarapiquí, Costa Rica show that juvenile trees had an average increment in height of 1.4 m per year, an average increment in diameter of 1.82 cm per year, and an average increment in basal area of 1.66 m^2 per ha per year (Chaves and Chinchilla 1994). In this location, the plantation on a slight slope (45 degrees) showed higher survival (90 percent) and higher longitudinal growth (1.47 m per year). The longitudinal growth of the species in plantation is adequate from an economic point of view and may be enhanced with appropriate silvicultural management (Chaves and Chinchilla 1994).

Applying 40 g of fertilizer (nitrogen-phosphorous-potassium) to the bottom of the hole before planting seedlings has a positive effect, increasing longitudinal growth and vigor. When planting density is high (1,100 to 1,200 seedlings per ha), the species prunes well until it reaches a height of 5 m. Clearing the ground three to four times in the first year is recommended, because the species has an adaptation period of 2 to 3 years (González and others 1990).

1cm
1cm