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Two New Species of *Carapa* (Meliaceae) From Western Ecuador

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Abstract*—**A taxonomic revision of *Carapa* (Meliaceae) in Ecuador is provided with the recognition of four species, *C. megistocarpa* which has cauliflorous inflorescences, *C. nicaraguensis* previously described and currently placed as synonym of *C. guianensis* and two new species (C. alticola*** and ***C. longipetala*****)**. The new species are close to *C. guianensis* based on their 4-merous flowers borne at the end of the branches. However, ***C. alticola*** differs from *C. guianensis* in having larger leaflets with prominent secondary veins, seeds with rounded edges and short poorly ramified inflorescences, while ***C. longipetala*** can be distinguised from *C. guianensis* in having distinctly pedicellate flowers and 6-ovulate ovary loculi. The new species are described, illustrated, and a key to the four species recognized in Ecuador is provided.

Keywords*—Carapa*, Ecuador, Meliaceae.

Carapa Aubl., commonly known in South America as Crabwood (English), cedro bateo or cedro macho (Spanish) or Andiroba (Portuguese) belongs to the pantropical mahogany family (Meliaceae). It consists of small to large trees disjunctly distributed in tropical Africa and America. The genus was last revised by Noamesi (1958) who recognized seven species worldwide, with four in the New World (*C. guianensis* Aubl., *C. surinamensis* Miq., *C. macrocarpa* Ducke, and *C. nicaraguensis* C. DC). Styles (1981) in the treatment of Meliaceae of the Neotropics recognized only *C. guianensis* and *C. surinamensis* (but as synonym under *C. procera* DC). Gentry (1988) described the distinctive cauliflorous *C. megistocarpa* A. H. Gentry & Dodson from the western slopes of the Andes (trans-Andes) in Ecuador and today only two species, *C. megistocarpa* and *C. guianensis,* are recognized in Ecuador (Palacios 2007).

A recent systematic revision of *Carapa* based on field observations and a multivariate analysis of morphological characters analyzed in the context of a molecular phylogeny (Kenfack 2008) suggested instead that there are four species of *Carapa* in Ecuador. All Ecuadorian specimens of *Carapa* examined in the course of the study came from the northern trans-Andean part of the country (Fig. 1). Although many botanical surveys have been carried out in the Ecuadorian Amazon, *Carapa* has never been found there (David Neil, pers. comm.), probably due to drier habitats in this area that may constitute an ecological barrier to their dispersal. Of all the specimens, those of *C. megistocarpa* were easily separated from the others based on their poorly ramified inflorescences borne on the main trunk, and their large acuminate leaflets. The remaining specimens, all with inflorescences borne on branches, were grouped into three morphospecies. The first morphospecies comprises specimens with a rusty farinose indumentum on leaves, inflorescences, and flowers, and ovaries with 2-ovulate loculi. These specimens are assigned to *C. nicaraguensis*, a species described from Nicaragua and treated by Styles (1981) as a synonym of *C. guianensis*. The geographical range of *C. nicaraguensis* extends along the pacific coast from Nicaragua to Ecuador (Kenfack 2008). The second morphospecies includes specimens that have sessile to subsessile flowers but differ from *C. guianensis* in having leaflets with rounded to shortly cuspidate apices and prominent secondary veins, short and poorly ramified inflorescences (less than 20 cm long), and seeds with rounded edges and a hilum less than 2 cm long. The third morphospecies comprises specimens that differ from *C. guianensis* in having distinctly pedicellate flowers and ovaries with 6-ovulate loculi. Furthermore phylogenetic inferences from sequence data of the nuclear ITS (Kenfack and Coleman in prep.) show that the three Ecuadorian ramiflorous morphospecies belonged to the "trans-Andean clade" including species that occur west of the Andes, while *C. guianensis* s. s. belongs to the "Cis-Andean clade" comprising species that occur east of the Andes. The second and third morphospecies are described below under the names *C. alticola* Kenfack & A. J. Peréz and *C. longipetala* Kenfack respectively.

Material and Methods

Our findings are based on a worldwide reassessment of species boundaries in *Carapa*. For the Neotropics, we carried out fieldwork in Ecuador, Guyana, and Panama and examined New World herbarium specimens from 12 herbaria; BR, F, GH, K, MO, NY, P, PANAMA, QCA, QCNE, STRI, and US (herbarium abbreviations follow Holmgren et al. 1990). In Ecuador, fieldwork was carried out in the provinces of Pichincha and Esmeraldas. All four species recognized herein were collected and studied in the field. Specimens were examined for 72 morphological characters with emphasis on those used in the past to distinguish between species such as the number of pairs of leaflets, the length of the petiole, the shape and dimensions of the leaflets, the indumentum of the leaves, inflorescences, and flowers, the length of the flower pedicel, and the number of ovules per locule. Eighteen quantitative and four qualitative characters, mainly floral, were analyzed using principal coordinate analysis (Gower 1966) to explore the patterns of variation of these characters (Kenfack 2011). We consider groups of specimens that present obvious morphological discontinuities and that occur in sympatry as belonging to different species.

Key to the Ecuadorian Species of *Carapa*

1. Indumentum present on leaves, inflorescences, and flowers; ovary locules 2-ovulate ..... *C. nicaraguensis*
1. Indumentum absent on leaves, inflorescences, and flowers; ovary locules 4- or 6-ovulate
   2. Inflorescence borne on main trunk, locules 6-ovulate ..... *C. megistocarpa*
   2. Inflorescence in axils of expanded or reduced leaves, locules 4- or 6-ovulate 3
      3. Flower pedicel up to 2.5 mm long; petals 4–5 mm long, ovary locules 4-ovulate; hilum less than 2 cm long ..... *C. alticola*
      3. Flower pedicel 2.5–4 mm long; petals 7–9 mm long; ovary locules 6-ovulate; hilum 2–5.5 cm long ..... *C. longipetala*

Taxonomic Treatment

Carapa alticola Kenfack & A. J. Pérez sp. nov.—TYPE: ECUADOR. Pichincha: Along highway from Quito, about 5 km from Pero Vicente Maldonado, 00°00′52.3″S, 78°44′40.8″W, 1,711 m, 24 Mar. 2007, fl, *D. Kenfack, E. Narvaez, A. Perez, G. Buitron, M. D. Proano, J. Iglesias, R. Valencia. 2150* (holotype: MO, isotypes: QCA, QCNE).

Arbores usque ad 30 m altas *C. guianensis* in inflorescentiis axillaribus et floribus subsessilibus valde affine sunt, sed in foliolis venis secondariis conspicuis apicibusque rotundatis vel truncatis usque ad emarginata et seminibus rotundatis testis laevibus, different.

A medium sized tree to 30 m tall, 80 cm dbh. Bole straight and unbranched high in primary forest, variously branched in disturbed forest; buttresses up to 2 m high; bark smooth, thin, slash pinkish; branches spreading upwards. Leaves 35–60(–100) cm long, with petiole 12–20 cm long, 0.5–1.2 cm in diameter, base swollen, generally with 2 nectaries; rachis 20–40(–65) cm long, glabrous; leaflets in 4–6(–7) pairs, with petiolule 0.8–1.7 cm long; blade 13–20 cm long, 8–11 cm wide (basal leaflets) to 20–44 cm long and 8–13 cm wide (apical leaflets), glabrous beneath, oblong to obovate, the apex rounded, truncate to emarginate, not mucronate, the base cuneate; midrib prominent beneath, glabrous, secondary veins prominent, 8–16 on each side, network of tertiary venation loose and flat. Inflorescence in the axils of fully developed or reduced scale-like leaves, less than 20 cm long, erect, poorly branched, peduncle 2.5–8 cm long, lowermost branches less than 2 cm long. Carpellate flowers unknown. Staminate flowers 4-merous, sessile or subsessile, pedicel 0.8–2.5 mm long, glabrous. Calyx 4-lobed, green, glabrous, lobes 1.1–1.3 mm long. Petals 4, 4–5 mm long, 3–3.5 mm wide, green, glabrous, each with one or two glands. Staminal tube 4.5–5.5 mm long, with 8 lobes, lobes 1.3–1.7 mm long, straight. Anthers 0.7–1 mm long, ca. 0.7 mm wide. Disk 0.8 mm high, 2.2–3.2 mm diameter, yellow. Ovary 0.9–1.5 mm long and 0.9–1.4 mm diameter, conical and more or less continuous with style; locules 4-ovulate; style 1–1.7 mm long; stigma ca 1.2 mm in diameter. Fruit 12–20 cm long, 10–15 in diameter, globose, narrowed basally into a stipe, beaked at apex, green to brown and densely lenticellate, 4-valved, each with a median rib, lacking warty excrescences, surface with numerous nectaries. Seeds 3.5–4.7 cm long, 3.7–6.5 cm wide, up to 4 per valve; hilum 1.3–2.3 mm long, 0.5–1.5 mm wide, rounded; testa dark brown, smooth. Figure 2.

Phenology—Flowering, March to August; fruiting, September to March.

Distribution and Habitat—Western Ecuador, in premontane moist forest, 600–2,200 m altitude (Fig. 1)

Additional Specimens Examined—ECUADOR. Carchi: Norte del Carmen, camino a Chical, 00°51′N 78°13′W, *Palacios et al. 9689* (MO); Reserva Golondrinas, Las Juntas, 00°48′N, 78°10′W, *Vargas et al. 4565* (MO). Esmeraldas: Bilsa Biological Station, Mache Mountains, 35 km W of Quinindez, 5 km W of Santa Isabel, along old road to Mono, 0°21′N 79°44′W, *Clark et al. 152* (MO, QCNE); Parroquia Alto Tambo, frente Finca del Sr. Lalama, a 1,5 km del sector de El Cristal, 00°50′N, 78°30′W, *Quelal & Luteyn 520* (MO). Pichincha: carretera Quito-Puerto Quito, km 113, 00°05′N, 79°02′W, *Brado 429(A)* (QCA); Reserva forestal Endesa, 00°05′N, 79°02′W, *Jamarillo 6635* (NY); *Jaramillo 6970* (QCA); *Jaramillo 7039* (QCA); 00°08′02.2″N, 79°02′53.1″W, *Kenfack et al. 2151* (QCA); 00°06′09.5″N, 79°01′38.9″W, *Kenfack et al. 2155* (MO, QCA, QCNE).

Carapa alticola, with its inflorescences in the axils of fully developed or reduced scale-like leaves and subsessile flowers, has been confused with *C. guianensis*. However, *C. alticola* grows on terra firme and at higher elevations, while *C. guianensis* prefers inundated forest and grows at lower altitudes. *Carapa alticola* differs substantially from *C. guianensis* by its larger leaflets with prominent secondary veins, its shorter and almost unbranched inflorescences, the beaked and stipitate fruits, and perhaps most importantly its rounded seeds with smaller hilum and smooth seed coat. In *C. guianensis* the leaflets are distinctly acuminate, with diffuse secondary veins, the fruits are not beaked, and the seeds are angular, with a long hilum up to 3.3 cm long. *Carapa alticola* may occur in southern Colombia, but we have not seen any collections from there.

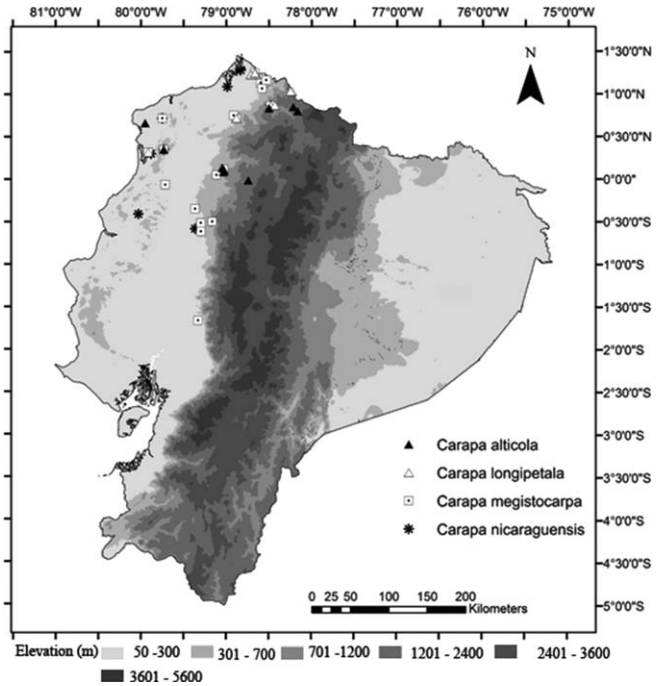

Fig. 1. Distribution of *Carapa alticola, C. longipetala, C. megistocarpa*, and *C. nicaraguensis* in Ecuador.

Carapa longipetala Kenfack sp. nov.—TYPE: ECUADOR. Esmeraldas: Limit of the Reserva Ethnica Awá, 01°13′46.9″N, 78°39′06.2″W, 139 m, 26 Mar. 2007, fl, *D. Kenfack & E. Narvaez 2159* (holotype: MO, isotypes: NY, US, K, QCA, QCNE)

Arbores usque ad 25 m altas *C. guianense* in inflorescentiis axillaribus et floribus 4-meris simile sunt, sed in floribus longe

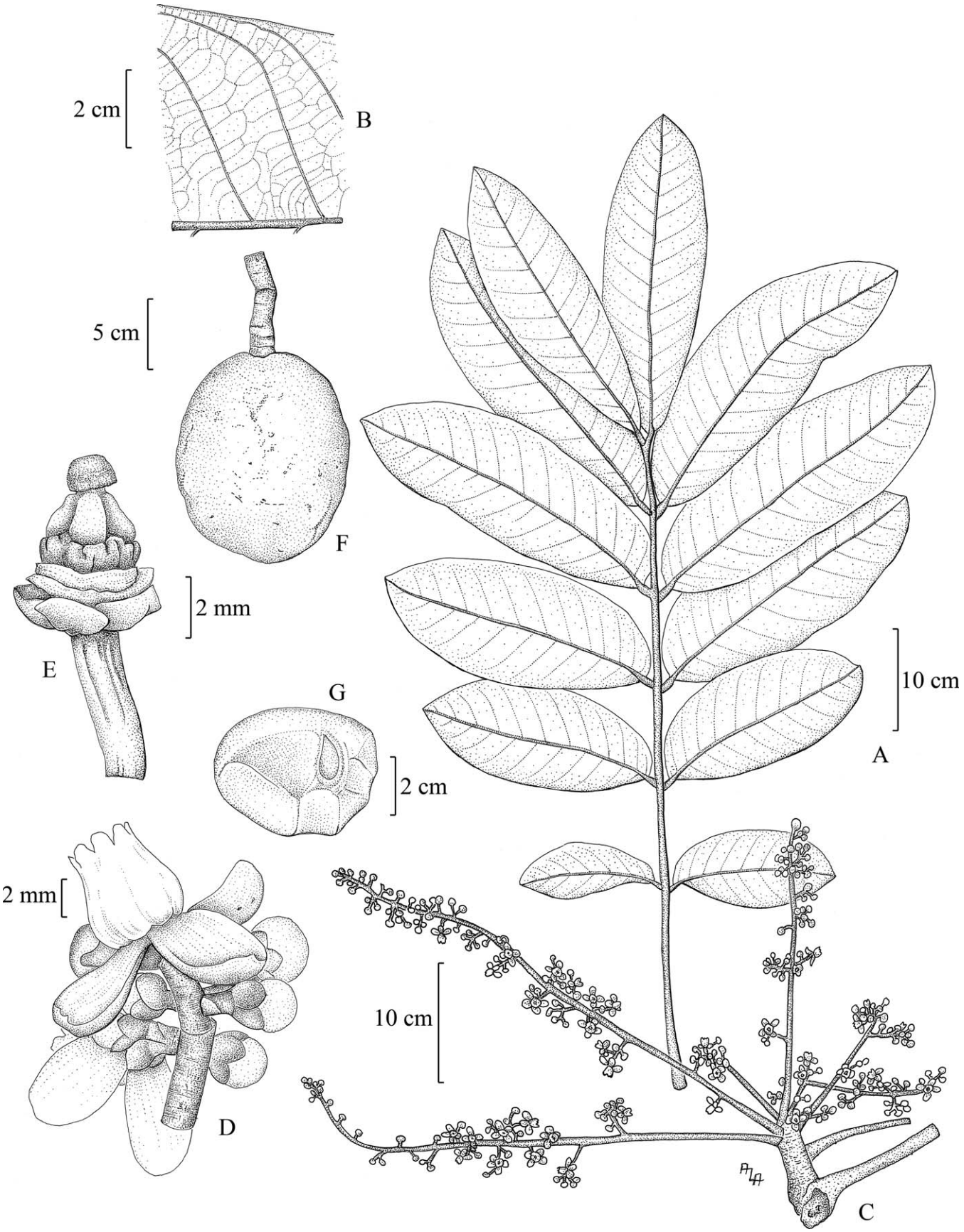

Fig. 2. *Carapa alticola*. A. Leaf. B. Detail of the tertiary venation. C. Inflorescences. D. Opened flowers. E. Fruit. F. seed (based on: A, C, D, *Kenfack et al. 2150*; B, *Neil 11697*; E, F, *Kenfack et al. 2155*).

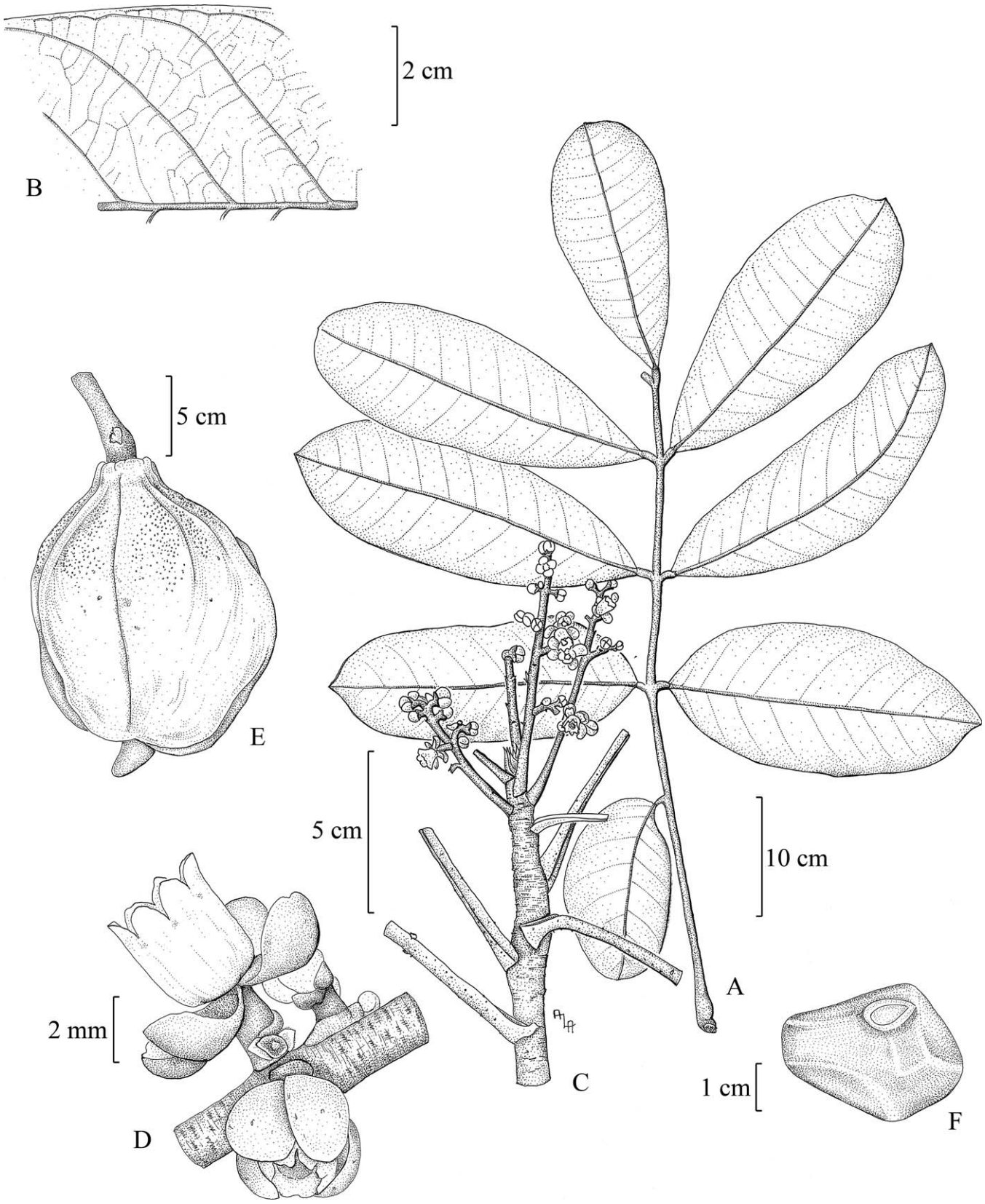

Fig. 3. *Carapa longipetala*. A. Leaf. B. Detail of the tertiary venation. C. Inflorescence. D. Opened flowers. E. Ovary. F. Fruit. G. seed (based on: A, B, C, D, E, F, *Kenfack & Narvaez. 2159*; G, H, *Kenfack & Narvaez 2160*).

pedicellatis, foliolis apicibus breviter cuspidatis et ovariis loculis 6-ovulatis, different.

A small to medium-sized tree to 25 m tall, 30 cm dbh, single stemmed when young, becoming branched with age, buttresses low to 1 m tall; bark whitish; branches spreading. Leaves 50–75 cm long, with petiole 15–30 cm long, 0.7–0.9 cm in diameter, base swollen, generally with 2 nectaries; rachis 30–48 cm long, glabrous; leaflets in 5–7 pairs, with petiolule 1–1.5 cm long; blade 15–27 cm long, 7–13 cm wide in basal leaflet pairs; 25–72 cm long and 9–20 cm wide in ultimate pairs, glabrous beneath, oblong, the apex shortly cuspidate, not mucronate, the base rounded; midrib prominent beneath, glabrous, secondary veins 9–23 on each side, network of tertiary venation loose and inconspicuous. Inflorescences in the axils of fully developed or reduced scale-like leaves, 18–45 cm long, erect, peduncle 2–11 cm long, lowermost branches up to 2 cm long. Flowers 4-merous, distinctly pedicellate, the pedicel 2.5–4 mm long, glabrous. Calyx 4-lobed, green, glabrous, lobes 1.3–1.8 mm long. Petals 4, 7–9 mm long, 4–7 mm wide, green, glabrous. Staminal tube 6–7.5 mm long, with 8 lobes, lobes 1.7–2.2 mm long, not reflexed. Anthers 1.2–1.5 mm long, 0.5–0.8 mm wide; antherodes 0.8–1.2 mm long, ca. 0.6 mm wide. Disk 0.8–1 mm high, 1.2–4 mm diameter, red. Ovary 1.7–2.2 mm long, 2.4–3.3 mm wide, 4-locular, 4-ridged, ovoid in carpellate flowers; ca. 1 mm long and 1.2–1.4 mm diameter, conical and more or less continuous with style in staminate flowers; locules 6-ovulate; style 0.3–0.7 mm long in carpellate flowers, 1.8–2.5 mm long in staminate flowers; stigma 1–1.5 mm in diameter. Fruit 18–22 cm long, 20–24 in diameter, elliptic to widely globose, not beaked, light brown, 4-valved, lacking ribs, warty excrescences, lenticels and nectaries. Seeds 4.3–6.4 cm long, 4–8 cm wide, up to 6 per valve; hilum 2–5.5 mm long, (1–)2–3.8 mm wide; testa whitish, smooth. Figure 3.

Phenology—Flowering, March to September; fruiting, December to March.

Distribution—Western Ecuador, in lowland forest, generally below 600 m (Fig. 1).

Additional Specimens Examined—ECUADOR. Carchi: Reserva Ethnica Awá, Parroquia El Chical, sector Gualpí Medio, río Canumbí, 01°02′N, 78°15′W, *Grijalva et al. 503* (MO); *Rubio et al. 1681* (MO). Esmeraldas: 50 km north of Pedernales along new coastal highway, 3 km north of Río Cojimíes crossing, 00°19′N, 79°55′W, *Neill & QCNE 11697* (MO); Awá indigenous territory, 01°00′N, 78°33′W, *Ortiz et al. 123* (NY); limit of the Reserva Ethnica Awá, 01°13′54.8″N, 78°39′26.9″W, *Kenfack & Narvaez 2158* (MO, QCA, QCNE); 01°13′46.9″N, 78°39′06.2″W, *Kenfack & Narvaez 2159* (MO, QCA, QCNE); near Lita, 00°52′N 78°29′W, *van der Werff et al. 9501* (MO); reserva ethnica Awá, 01°14′46.9″N, 78°42′42.6″W, *Kenfack & Narvaez 2160* (MO, QCA, QCNE); centro Guadualito, 01°43′N, 78°53′W, *Tirado et al. 287* (MO); 01°15′N 78°40′W, *Aulestia et al. 105* (MO); *Aulestia et al. 173* (MO, QCNE); *Aulestia et al. 227* (MO); Parroquia Alto Tambo, 00°52′N 78°26′W, *Aulestia & Aulestria 1427* (MO, QCNE).

Carapa longipetala, like *C. alticola*, has been confused with *C. guianensis* in western Ecuador. *Carapa longipetala* has distinctly pedicellate flowers while *C. guianensis* and *C. alticola* have sessile to subsessile flowers. Furthermore, *C. guianensis* and *C. alticola* have whitish floral nectaries (also known as a disk) unlike *C. longipetala*, which has orange to red nectaries. The population of *Carapa guianensis* mentioned by Gentry (1988) in western Ecuador as having orange nectaries clearly refers to *C. longipetala*. The seeds of *C. longipetala* and *C. nicaraguensis* are comparable in size and both have whitish and smooth seed coats. However the seeds of *C. longipetala*, up to six per valve, are more angular while those of *C. nicaraguensis*, only two per valve, have rounded edges. *C. megistocarpa* is sympatric with *C. longipetala* in the Reserva Ethnica Awá.

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