

Garcinia apostoloi: a new species of Clusiaceae from the Brazilian Amazon forest

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Abstract. While studying specimens of *Garcinia gardneriana* from the Brazilian Amazon we detected problems in reconciling the morphology of these collections to that of the type-collection (with the basionym of *Rheedia gardneriana*) and similar specimens from other regions of Brazil. An investigation led us to the conclusion that the Amazonian collections represent a new species, described herein as *Garcinia apostoloi*. We present a taxonomic treatment comprising a morphological description, a distributional map in southern Amazonia, a description of the habitat, a preliminary conservation assessment, and other taxonomic comments.

Keywords: *Garcinia gardneriana*, Guttiferae, Malpighiales, southern Amazon, taxonomy.

Garcinia L. is the second largest genus of Clusiaceae, with ca. 240 spp. distributed throughout the global tropics (Sweeney, 2008; Stevens, 2001). The center of diversity for the genus is found in the paleotropics, especially in the regions of Indo-Malaya and Madagascar (Sweeney, 2008), whereas only 5% of known *Garcinia* species occur in the neotropics. Although the genus is not very diverse in the Americas, some taxonomic issues remain to be resolved (Medellín-Zabala, 2015; Mouzinho et al., 2022).

Planchon & Triana (1860) provided one of the earliest worldwide taxonomic treatments for the genus, but they treated *Rheedia* as distinct from *Garcinia*. In that study, the authors presented descriptions for 19 species and described *Rheedia gardneriana* Planch. & Triana, based on a collection from the Brazilian Cerrado (*Gardner 1922* – K “Brésil, prov. de Ceará [Gardner, s.n.]”). In *Flora brasiliensis*, Engler (1888) proposed two varieties based on specimens from the Atlantic

Forest: *R. gardneriana* var. *glaziovii* Engl. and *R. gardneriana* var. *parvifolia* Engl. Ninety years later, van den Berg (1979) used the fruits as the main characteristic to delimit *Rheedia* species (= *Garcinia*), citing the occurrence of eight species in Brazil. That author pointed out the occurrence of *R. gardneriana* for the Brazilian Amazon and, in addition to the two varieties proposed by Engler, included in the synonymy of *R. gardneriana* the names *R. spruceana* Engl., *R. spruceana* var. *cuneata* Engl., *R. tenuifolia* Engl., *R. calyptrata* (Schltdl.) Triana & Planch. and *Tovomita calyptrata* Schltdl. Subsequently, Zappi (1993) transferred *R. gardneriana* to *Garcinia*, as *G. gardneriana* (Planch. & Triana) Zappi.

In a taxonomic review of *Garcinia* for Colombia, Medellín-Zabala (2015) treated *G. gardneriana* as a species complex and maintained the occurrence of the species for the Amazon, citing only two synonyms,

R. spruceana and *G. brasiliensis* Mart. *Garcinia brasiliensis* was considered distinct from *G. gardneriana* in the treatment of Flora do Brasil 2020 (Muniz, 2020), but Mouzinho et al. (2022) later removed *R. spruceana* from synonymy and provided a new combination of this taxon within *Garcinia* as *Garcinia spruceana* (Engl.) Mouzinho.

When analyzing specimens identified as *G. gardneriana* throughout its distribution, including specimens from the Cerrado, Amazon and Atlantic Forest, we realized that there were problems in delimiting the species morphologically, particularly when compared to the type collection of *R. gardneriana*. Our investigation allowed us to confirm that the Amazonian specimens that had previously been identified as *G. gardneriana* are morphologically distinct from the specimens collected from eastern Brazil, the Cerrado, and the Atlantic Forest, which more closely match the type. Among features that differentiate the Amazonian specimens from those from other regions include the texture of the leaf blade, the number of secondary veins, the shape of the petals, and the number and organization of the stamens, as well as the thickness and length of the pedicels in fruit. Here, we delimit the Amazonian specimens as a new species, *Garcinia apostoloi* Mouzinho.

Materials and Methods

The terminology and definitions in the morphological descriptions follow Hickey (1973) and Gonçalves & Lorenzi (2011) for the vegetative and reproductive characters, respectively. The distribution map was made using SimpleMapp (Shorthouse, 2010), and herbaria acronyms follow Thiers (2022). The conservation threat assessment following the criteria adopted by the IUCN (2012) based on the extent of occurrence (EOO) and area of occupation (AOO) data generated from GeoCAT (Bachman et al., 2011).

Taxonomic Treatment

***Garcinia apostoloi* Mouzinho, sp. nov.**—Type: Brazil, Pará: Mun. Pau d'Arco, Marajoara, 15 June 1997, (fl. ♂), *J. Grogan 150* (holotype: INPA barcode INPA 0057815; isotype: IAN barcode IAN171975). (Figs. 1, 2, 3).

Diagnosis.—*Garcinia apostoloi* differs from *G. gardneriana* by the texture of the leaf blade (membranaceous vs. chartaceous in *G. gardneriana*), number of secondary veins (> 35 pairs vs. < 25 pairs), staminate flowers in 2 series with 20 stamens (vs. 3 series with 30 stamens), and circular to oblong inner petals (vs. obovate).

Shrubs or trees of up to 15 m in height; cylindrical branches, young branches smooth; exudate yellow. Petioles 5–11.3 mm long, slightly striated transversely; hood-shaped structures on the base of petiole inconspicuous, discrete, oblong *in sicco*. Leaf blades 6.4–12.2 cm long × 2.5–4.0 cm wide, membranaceous, discolorous, greenish-brown *in sicco*, usually glossy on the abaxial surface, reddish when young, elliptic, rarely elliptic-ovate, apex acuminate to attenuate, margin slightly revolute *in sicco*, base acuminate to attenuate; secondary veins > 35 pairs, unbranched and reaching the inframarginal vein, rarely branched; intersecondary veins similar and parallel to the secondary ones, reticulated near the margin; inframarginal vein inconspicuous; exudate canals blackish *in sicco*, running perpendicular between the veins on the abaxial surface. Staminate inflorescence axillary, fasciculate, bracteoles 2, diminutive; pedicels 6.8–15.3 mm long. Staminate floral buds 2–2.5 mm long × 1.7–2.6 mm wide, globose to slightly oblong. Staminate flowers with 2 sepals, ca. 1 mm long × 0.9 mm wide, deltoid; petals 4, the outer ones 2.8–3.2 mm long × 2.7–3 mm wide, circular to oblong, the inner ones 3.4–4.5 mm long × 3–3.3 mm wide, circular to oblong; nectariferous disc ca. 2 mm diam., convex; stamens ca. 20 per flower, arranged around the disc in 2 series, filaments 2.6–4 mm long, filiform, anthers ellipsoid, thecae 0.32–0.34 mm long × 0.22–0.25 mm wide. Inflorescence and pistillate flowers not seen. Fruit a berry, epicarp smooth, sepals, staminodes and stigmas persistent, easily caducous *in sicco*, when immature 18.4–21.3 mm long × 10.8–13.1 mm wide, green, ovoid to globose, rostrum 1.81–2.54 mm long, when mature 24.6–40.2 mm long × 19.0–30.9 mm wide, orange, globose-ovoid, rostrum 3.8–8.7 mm long, stigma < 3 mm diam., usually with undefined lobes, bi- to trilobate, slightly flattened; pedicels thin and elongated 14.6–30 (–33) mm long. Seeds 2, 14.7–19.3 mm long × 7.3–9.7 mm wide, ellipsoid.

Distribution, habitat and conservation status.—*Garcinia apostoloi* is distributed in the



Fig. 1. Holotype (INPA0057815) of *Garcinia apostoloi* Mouzinho deposited in the INPA herbarium.

southern Brazilian Amazon (Acre, Amazonas, Mato Grosso, Pará, Rondônia and Tocantins) (Fig. 4). Most specimens are associated with *terra firme* and floodplain environments. In Brazil, areas close to riverbanks are considered

Permanent Preservation Areas by Brazilian law (see Brasil, 2012). Also, *G. apostoloi* was collected in some conservation units as Jurema National Park, in Mato Grosso state, and Carajás National Forest, in Pará state. According to IUCN (2012)

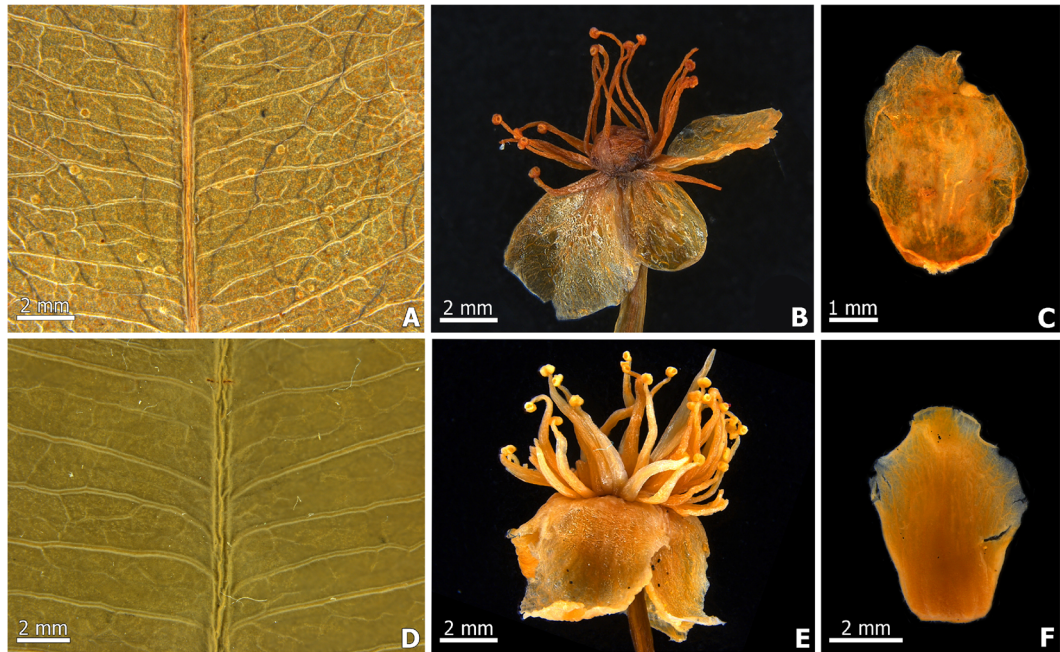


FIG. 2. A-C. *Garcinia apostoloi* Mouzinhos. A. Detail of leaf abaxial surface. B. Staminate flower. C. Inner petal. D-F. *Garcinia gardneriana* (Planch. & Triana) Zappi. D. Detail of leaf abaxial surface. E. Staminate flower. F. Inner petal

Red List Criterion B (geographic range), we preliminarily assess this species as Least Concern (LC) due to its wide extent of occurrence (EOO 1,154,914.626 km²) and area of occupancy (AOO 64,000 km²). Moreover, the species does not appear to be directly threatened, and its edible fruits represent an important non-timber forest product, which discourages harvesting for wood extraction.

Etymology.—The epithet honors the Brazilian parobotanist Paulo Apóstolo Costa Lima Assunção (1956–2021). Known as “Paulo Boca” or “Seu Paulinho”, who was a great connoisseur and scholar of the Amazonian flora, and contributed to numerous identifications in the INPA herbarium, as well as other Amazonian herbaria.

Additional specimens examined.—**BRAZIL.** **Acre:** Fazenda Bom Sossego, 07°40’S, 73°09’W, 27 September 1985, (sterile), *D.G. Campbell* et al. 9197 (NY). **Amazonas:** Mun. Manicoré, Reserva Extrativista do Lago do Capanã Grande, 06°03’03’’S, 61°49’57’’W, 16 October 2014, (fr.), *T.E. Almeida* et al. 3648 (INPA). **Mato Grosso:** Mun. Aripuanã, 09 November 1976, (fr.), *M. Gomes* et al. 366 (INPA); 59°21’N, 10°12’S, 15 October 1973, (fr.), *C.C. Berg* et al. P18554 (INPA); 23 September 1976, (fl. ♂), *M. Gomes* et al. 88 (INPA); Mun. Cotriguaçu, Parque Nacional do Jurueña, 08°58’7’’S, 58°34’15’’W, 24 October 2017, (fr.), *R.C. Forzza* et al. 9329 (INPA). **Pará:** Mun. Altamira, Estação

Experimental da Embrapa, 19 August 1978, (fr.), *R.P. Bahia* 87 (NY); Mun. Marabá, Serra dos Carajás, 30 May 1983, (bud), *M.F.F. da Silva* et al. 1346 (INPA); 16 October 1977, (fr.), *A.S. Silva* et al. AS38 (INPA); Serra Norte, Parauapebas, 12 August 1982, (sterile), *U.N. Maciel* et al. 805 (IAN, INPA, MBM, NY); Mun. Jacundá, PA-150, 26 November 1980, (fr.), *J. Ramos* et al. 738 (INPA); Mun. Tucuruí, (fl. ♂), *M.G. Silva* 5477 (INPA, NY); Rio Tocantins, 28 June 1980, (fr.), *J. Revilla* et al. 4549 (INPA); Mun. Vitória do Xingu, 03°11’17’’S, 51°46’13’’W, 20 October 2015, (fr.), *B.K. Braun s.n.* (RB-642764). **Rondônia:** Mun. Ouro Preto do Oeste, BR-364, 30 September 1988, (fr.), *J.L. dos Santos* et al. 1031 (INPA); Rio Madeira, 18 July 1968, (fl. ♂), *G.T. Prance* et al. 6176 (INPA, NY, UEC); **Tocantins:** Mun. Araguaatins, 05°21’S, 48°35’W, 12 November 1983, (fr.), *E. Mileski* 331 (HCDAL, RB).

Morphological note.—*Garcinia apostoloi* differs from two other Amazonian species [*G. spruceana* and *G. fluviatilis* Mouzinhos & L. Marinho] chiefly due to its leaf blade texture, number of secondary veins, presence or absence of rostrum on the berries and pedicel length. These two additional, Amazonian species are now accepted as the result of recent investigations of *G. gardneriana*, leading to the description of *G. fluviatilis*, and the reinstatement of *G. spruceana* (Mouzinhos et al., 2022).

Garcinia apostoloi can be distinguished from *G. fluviatilis* by the leaf blade texture (membranaceous vs. chartaceous in *G. fluviatilis*),

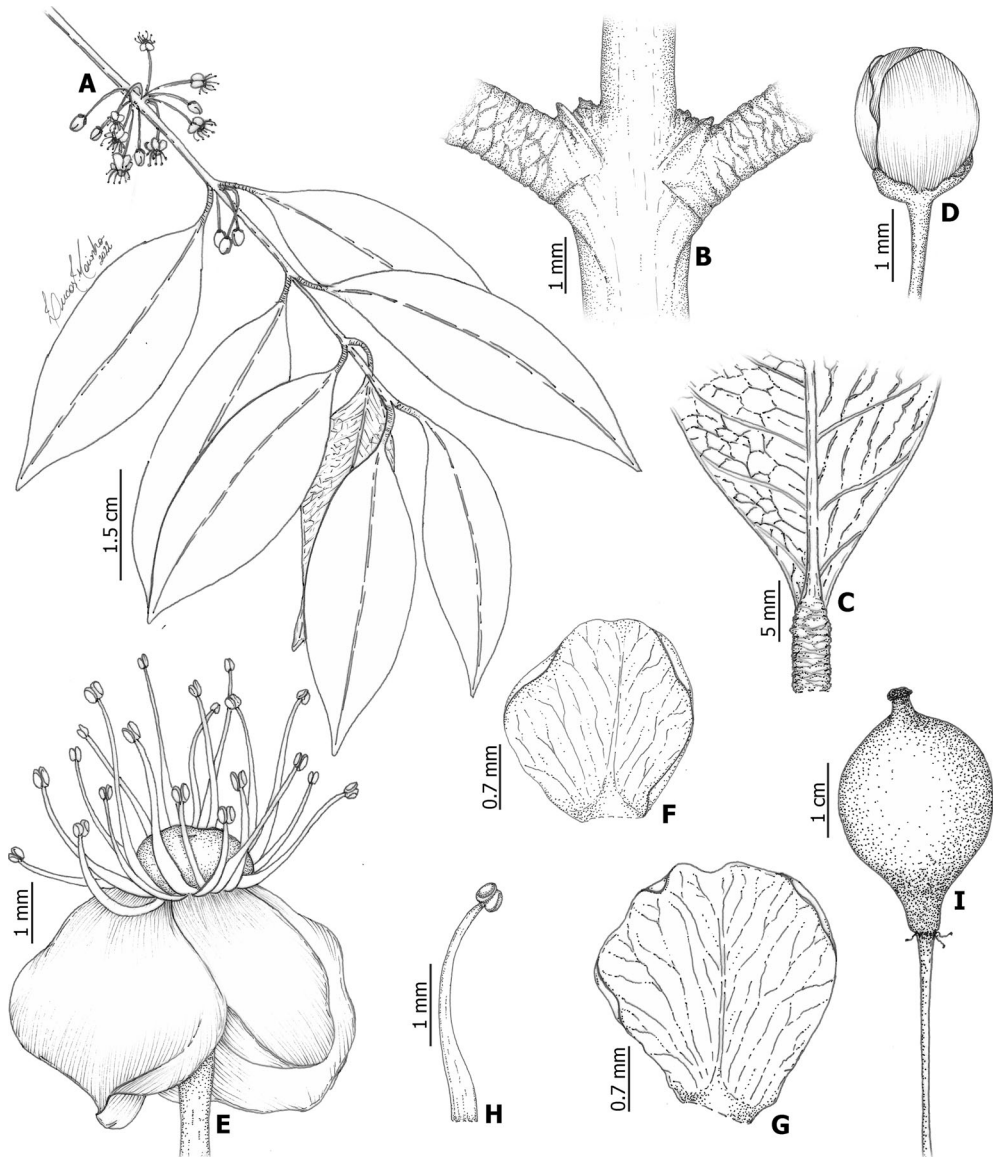


FIG. 3. *Garcinia apostoloi* Mouzinho. **A**. Branch with staminate flowers and buds. **B**. Detail of petiole base dilatation. **C**. Detail of the leaf abaxial surface, arrangement of secondary veins (left) and pattern of exudate canals (right). **D**. Floral bud. **E**. Staminate flower. **F**. Outer petal. **G**. Inner petal. **H**. Stamen. **I**. Mature berry. **A-H**. from the holotype, **I**. from the paratype *Bahia* 87 (NY01304019). Illustrated by Lucas Marinho.

conspicuous exudates canals (vs. inconspicuous in *G. fluviatilis*), > 35 pairs of secondary veins (vs. < 30 pairs in *G. fluviatilis*), secondary veins reaching the margin (vs. arcuate near the margin blade in *G. fluviatilis*), staminate flowers with 20 filiform stamens arranged in 2 series (vs. 33 terete stamens arranged in 3 series in *G. fluviatilis*). The

berries in *G. apostoloi* bear a rostrum > 3.8 mm long. (vs. < 3 mm long in *G. fluviatilis*) and elongated pedicels (> 14 mm long. vs. < 10 mm long in *G. fluviatilis*). *Garcinia apostoloi* differs from *G. spruceana* (an endemic species of the Peruvian Amazon) by the texture of leaf blades membranaceous (vs. chartaceous in

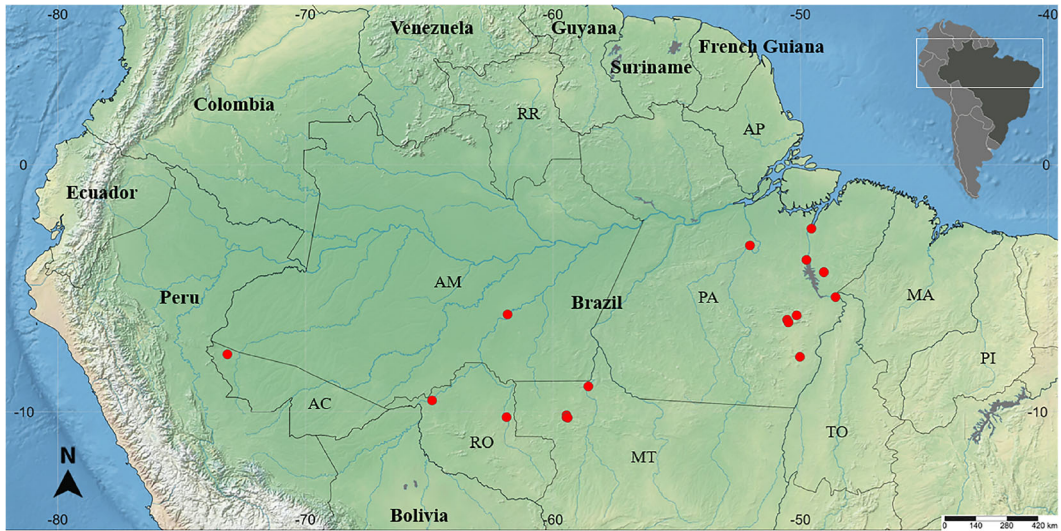


FIG. 4. Distribution of *Garcinia apostoloi* in the Brazilian Amazon.

G. spruceana), smooth texture of young branches (vs. verrucose in *G. spruceana*), inconspicuous inframarginal vein (vs. conspicuous in *G. spruceana*). See Table 1 for a morphological comparison between *Garcinia apostoloi* and related species.

The description proposed here for *G. apostoloi* does not match these species or any of the currently recognized synonyms assigned to *G. gardneriana* by van den Berg (1979). With

the description of this new species, the reestablishment of *G. spruceana*, and the description of *G. fluviatilis* (see discussion in Mouzinho et al., 2022), we suggest that the occurrence of *G. gardneriana* in the Amazon is now doubtful. We emphasize that it is extremely important to review the names and specimens related to *G. gardneriana* in other phylogeographic domains, especially in the southeast and south of Brazil.

TABLE 1. MORPHOLOGICAL COMPARISON BETWEEN *GARCINIA APOSTOLOI* AND RELATED SPECIES. DATA COLLECTED *IN SICCO*.

	<i>G. apostoloi</i>	<i>G. fluviatilis</i>	<i>G. gardneriana</i>	<i>G. spruceana</i>
Texture of branches	smooth	smooth	smooth	verrucose
Leaf blade shape	elliptic, rarely elliptic-ovate	oblong-elliptic to elliptic-ovate	oblong-elliptic	elliptic
Texture/reflection (abaxial face)	membranaceous/glossy	chartaceous/opaque	chartaceous/glossy or opaque	chartaceous/glossy
Intramarginal vein	inconspicuous	inconspicuous	inconspicuous	conspicuous
Exudate canals	conspicuous	inconspicuous	conspicuous	inconspicuous
Number of secondary vein (pairs)	> 35	< 30	< 25	< 30
Petals shape (fl. ♂) outer/inner	circular to oblong	circular/obovate	circular/obovate-oblong	circular
Series of stamens	2	3	3	3
Filaments shape (fl. ♂)	filiform	terete	terete	terete
Anthers shape (fl. ♂)	ellipsoid	ellipsoid	globose	globose
Fruit shape	ovoid to globose	globose	ovoid	not seen
Rostrum	> 3.8	< 3	< 3	not seen

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Literature Cited

- Bachman, S., J. Moat, A. W. Hill, J. De La Torre, & B. Scott.** 2011. Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. *ZooKeys* 150: 117.
- Brasil.** 2012. Lei nº 12.727, de 17 de outubro de 2012. https://www.planalto.gov.br/ccivil_03/ato2011-2014/2012/lei/112727.htm (Accessed: 04 January 2023).
- Engler, H. G. A.** 1888. Guttiferae: *Rheedia*. *Flora brasiliensis*, 12: 457–466.
- Gonçalves, E. G. & H. Lorenzi.** 2011. *Morfologia Vegetal: organografia e dicionário ilustrado de morfologia de plantas vasculares*. Instituto Plantarum de Estudos da Flora, São Paulo.
- Hickey, L. J.** 1973. Classification of the architecture of dicotyledonous leaves. *American Journal of Botany* 60: 17–33. <https://doi.org/10.2307/2441319>
- IUCN.** 2012. IUCN Red List categories and criteria, Version 3.1, Second Edition. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland, and Cambridge, U.K.
- Medellín-Zabala, D. M.** 2015. Sistemática del género *Garcinia* (Clusiaceae): revisión taxonómica para Colombia y filogenia de las especies Neotropicales. Universidad Nacional de Colombia, Bogotá, Colombia.
- Mouzinho, T., M.D.L. Soares, F.N. Cabral, & L.C. Marinho.** 2022. Nomenclatural and taxonomic novelties in *Garcinia* (Clusiaceae) from Amazonian forest. *Phytotaxa* 548 (1): 91–98. <https://doi.org/10.11646/phytotaxa.548.1.8>.
- Muniz, F. H.** 2020. *Garcinia*. Flora do Brasil 2020. Jardim Botânico do Rio de Janeiro. Available from: <http://floradobrasil.jbrj.gov.br/reflora> (Accessed: 11 September 2020).
- Planchon, J. E. & J. Triana.** 1860. Mémoire sur la famille de Guttifères. *Annales des Sciences Naturelles, Botanique, Séries IV* 13: 303–376.
- Shorthouse, D. P.** 2010. SimpleMappr, an online tool to produce publication-quality point maps. <https://www.simplemappr.net> (Accessed: 22 July 2021).
- Stevens, P. F.** 2001 onwards. Angiosperm Phylogeny Website. Version 14, July 2017 [and more or less continuously updated since]. Available from: <https://www.mobot.org/MOBOT/research/APweb/> (accessed 2 January 2021).
- Sweeney, P.** 2008. Phylogeny and floral diversity in the genus *Garcinia* (Clusiaceae) and relatives. *International Journal of Plant Sciences* 169 (9): 1288–1303. <https://doi.org/10.1086/591990>.
- Thiers, B.** 2022 (continuously updated). **Index Herbariorum.** <http://sweetgum.nybg.org/ih/>. (Accessed: 20 July 2022).
- van den Berg, M. E.** 1979. Revisão das espécies brasileiras do gênero *Rheedia* L. (Guttiferae). *Acta Amazonica* 9(1): 43–74. <https://doi.org/10.1590/1809-43921979091043>.
- Zappi, D. C.** 1993. A new combination in *Garcinia* (Guttiferae). *Kew Bulletin* 48(2): 410. <https://doi.org/10.2307/4117953>.

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