



# A look at endemic *manihot* species for northeastern Brazil: Taxonomy, richness, distribution and conservation

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## ABSTRACT

*Manihot* includes about 150 species with a Neotropical distribution. Wild species of *Manihot* constitute a plant genetic heritage that can be used in breeding programs for the cultivable species *Manihot esculenta* Crantz (cassava). However, wild populations, especially endemic ones, are under constant threat due to habitat destruction and climate change. The objective of this manuscript was to elaborate a taxonomic treatment of the endemic species of *Manihot* recorded in Northeast Brazil; determine the geographical distribution of species, richness, their conservation status, and solve typification problems. The study was based on the analysis of specimens deposited in national and international herbaria, as well as on field observations. Fifteen endemic species of *Manihot* were found, we propose lectotypes for five of them and one neotype. Most species are distributed in the state of Bahia, growing in Caatinga, Cerrado, and Atlantic Forest environments. Only *M. breviloba* was found in the states of Sergipe and Alagoas. The richest area was found in the Chapada Diamantina of the Espinhaço Range. In terms of conservation status, 80% of endemic species are in some threatened category, 13% are in the near threatened category and only 7% are in the least concern category.

**Keywords:** Crotonoideae, Euphorbiaceae, Conservation status, Richness, Typification

## Introduction

*Manihot* Mill. (1754) is placed in the tribe Manihoteae, subfamily Crotonoideae (Euphorbiaceae) (Webster 1994; Wurdack *et al.* 2005; Tokuoka 2007) and is characterized by a shrub, subshrub, arboreal or, vine habit, presence of latex, leaves simple, alternate, entire to lobed blades, with margin entire wavy or pandurate, unisexual flowers with nectariferous disk, androecium with 10 stamens, trilobed stigma, capsular fruits, and carunculated seeds (Pax 1910; Rogers & Appan 1973; Orlandini 2016).

The genus stands out for its great cultural, economic and social importance in different regions of the planet, especially so in the case of *Manihot esculenta* Crantz (cassava) whose roots are one of the main sources of starch for approximately 800 million people in the world (FAO 2013), mainly in developing countries, being widely cultivated in tropical America, Africa and Asia (Hershey 2008). Wild *Manihot* species constitute a genetic reservoir that can be used in crop genetic improvement programs through the transfer of genes of interest, bringing solutions to various problems that affect the crops, providing higher tolerance to drought, higher protein content, larger roots, greater

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resistance to pests, among others (Nassar & Dorea 1982; Allem 1999; Akinbo *et al.* 2015).

Nearly 150 species are circumscribed in the genus *Manihot*. They are distributed exclusively in the Neotropics, with South American as the probable origin (Simon *et al.* 2022). Currently, approximately 120 species are registered in Brazil, of which approximately 105 are endemic to the country (Flora e Funga do Brasil 2020). The Northeast is the second region of Brazil with the largest number of species (31) (Flora e Funga do Brasil 2020). In this region, the state of Bahia stands out with the greatest diversity with 26 species, mostly restricted in small areas of Caatinga, Cerrado and Atlantic Forest (Flora e Funga do Brasil 2020). These phytogeographic domains are characterized by high biodiversity and endemism and are also considered threatened by fragmentation, habitat destruction, introduction of exotic species, environmental pollution, and climate change (Nassar 2000; Reed 2004; Martins *et al.* 2011; Martins 2013; Newbold *et al.* 2015).

The taxonomy of *Manihot* has already been addressed in a large number of studies in the Neotropics (Miller 1754; Müller 1866; 1874; Rogers & Appan 1973; Allem 1989; Martins 2013; Orlandini 2016; Mendoza 2018; Mendoza & Cavalcanti 2020). Nevertheless, nomenclatural problems persist due to the great phenotypic plasticity and homogeneity of its taxa (Rogers & Appan 1973) also, typification and nomenclatural propositions are still necessary, especially for the species endemic to Northeast Brazil.

In this context, the objective of this study was to elaborate a taxonomic treatment of *Manihot* species endemic to Northeast Brazil, providing data on their geographic distribution, conservation status, richness, and solving typification problems. This work is part of an investigation that includes ecological niche modeling of *Manihot* species endemic to Northeast Brazil under current and future scenarios. The results of this work will help reduce taxonomic problems and contribute to knowledge that is relevant for the conservation of endemic *Manihot* taxa.

## Material and methods

For the morphological analysis, the collections, including the type specimens, deposited in the following herbaria were consulted: ALCB, ASE, CEN, CEPEC, F, G, HBG, HEPH, HUEFS, HUESB, HURB, HVASF, IAN, IPA, K, L, M, MA, MAC, MBM, MG, MNHN, MO, NY, P, PEUFR, R, RB, SP, SPF, UB, UEC, UFP and HST (not indexed) (acronyms according to Thiers, updated continuously). Geographic distribution, altitude, phenology, and phytophysiognomies were obtained from exsiccate labels, available reference literature, and online databases such as Flora Neotropica (Rogers & Appan 1973), SpeciesLink (CRIA 2022), Reflora Virtual Herbarium and the Global Biodiversity Information Facility (GBIF

2020) and field expeditions carried out between 2010-2018 and 2021-2022.

Vegetative (stem, latex, leaves, stipules, petioles) and reproductive characters (inflorescences, bracts, bracteoles, sepals, fruits, and seeds) were used to delimit the species. The terminology used in the descriptions follows Rogers and Appan (1973), Harris and Harris (2001), and Beentje (2010). Stipule and bract terminologies and definitions are based on Rogers and Appan (1973) and Martins (2013): foliaceous (greater than 5 mm wide), semifoliaceous (2-4 mm wide), and setaceous (about 1 mm wide). The illustrations presented here are based on the field and herbarium material analyzed. The illustrations of *Manihot alterniflora* P. Carvalho & M. Martins, *Manihot macrocarpa* P. Carvalho & M. Martins, *Manihot pandurata* M. Martins & M. Mend., *Manihot quinquefolia* Pohl, and *Manihot reflexifolia* P. Carvalho & M. Martins were not included in this work because they were recently described and illustrated (Martins *et al.* 2017; Mendoza & Martins 2018; Santos *et al.* 2019).

The current conservation status of taxa was defined based only on the “B” criterion proposed by the International Union for Conservation (IUCN) Red List, version 13 (IUCN 2017). Based on this criterion, the species had their “Extent of occurrence” (EOO) and “Area of occupancy” (AOO) calculated using the GeoCAT tool (<http://geocat.kew.org/>) (Bachman *et al.* 2011), using the IUCN default cell width of 2 km. The altitude data for each geographic record of the species were extracted from the altitude layer obtained from the WorldClim website with a spatial resolution of 2.5 arc minutes (<http://www.worldclim.org>) using the “point sampling tool” function of Quantum GIS. Using this information, an altitude record matrix was built for each of the species, boxplots were produced using the ‘boxplot’ function of the ‘graphics’ package (R Core Team 2022) to visualize the altitude range of *Manihot* species endemic to Northeast.

The richness in the Northeast was calculated as the total number of species present per grid square (1° x 1°) using the DIVA-GIS 7.5 program (Hijmans *et al.* 2004) using the geographic distribution database for all the endemic species of *Manihot* to Northeast Brazil. The distribution and richness of *Manihot* taxa was represented through maps made using the Quantum GIS 3.8 program (QGIS 2020).

## Results

Fifteen endemic species of *Manihot* were found in Northeast Brazil: *M. alterniflora*, *Manihot bellidifolia* P. Carvalho & M. Martins, *Manihot breviloba* P. Carvalho & M. Martins, *Manihot compositifolia* Allem, *Manihot diamantinensis* Allem, *Manihot dichotoma* Ule, *Manihot jacobinensis* Mull. Arg., *Manihot longiracemosa* P. Carvalho & M. Martins, *M. macrocarpa*, *Manihot maracasensis* Ule, *M. pandurata*, *M. quinquefolia*, *M. reflexifolia*, *Manihot reniformis*

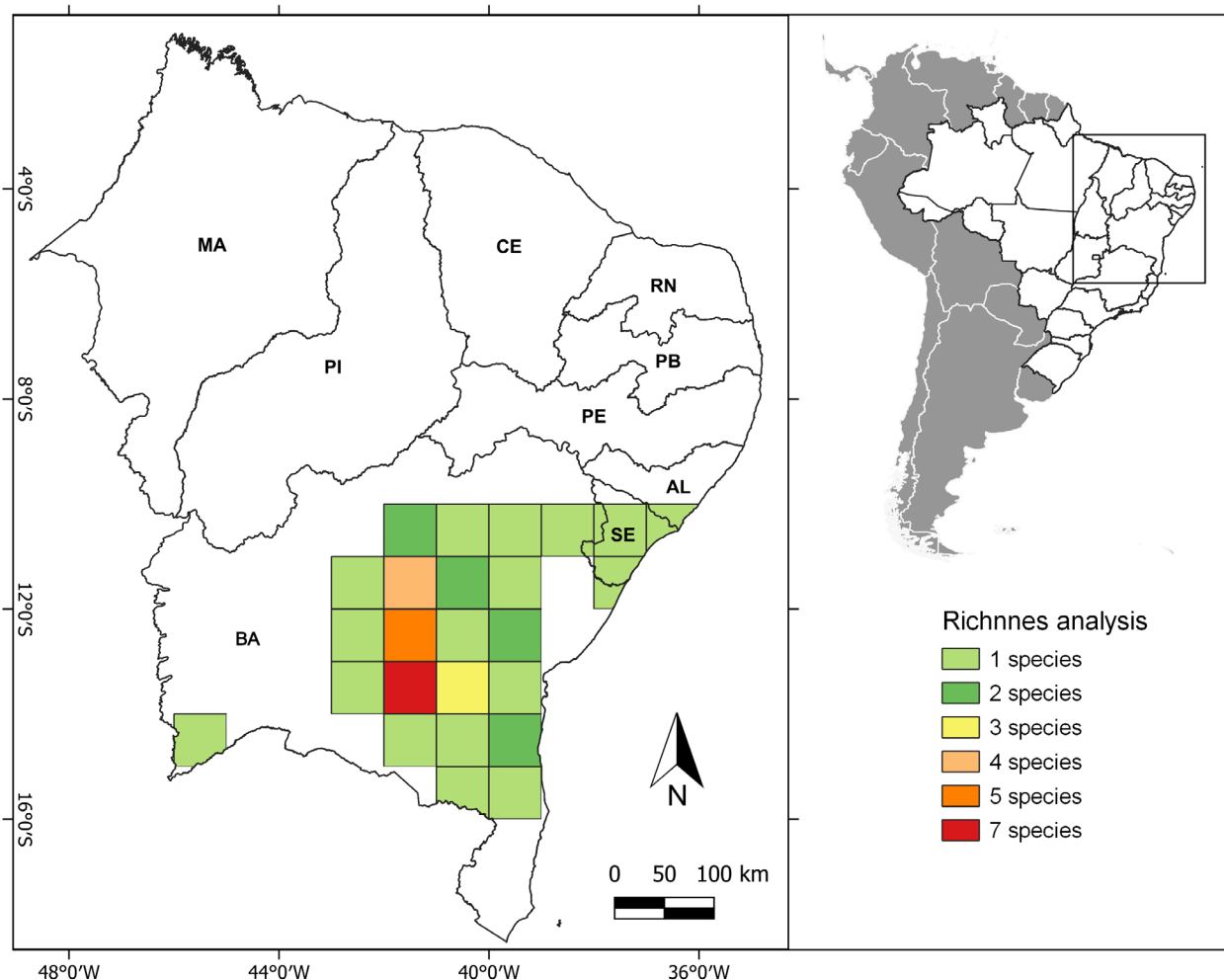


Pohl, *Manihot zehntneri* Ule. Some typification problems were found during the revision of the protologues, type specimens, and historical collections. Thus, we propose lectotypes for 5 species: *M. dichotoma*, *M. jacobinensis*, *M. maracasensis*, *M. reniformis*, and *M. zehntneri*. Regarding the conservation status, 47% of the species were categorized as Endangered (EN), 33% as Critically Endangered (CR), 13% as Least Concern (LC), and 7% as Near Threatened (NT).

Regarding the habit, 47% of the species were shrubs, 13% vines, 13% shrub to vines, 13% subshrubs, 7% shrub or subshrub, and 7% were trees. The arboreal habit was found exclusively in Caatinga, the shrub and subshrub habit were found in Caatinga and Cerrado, and the vine habit was observed in Atlantic Forest. The domain with the greatest number of species was Caatinga and Cerrado with 33% each, followed by Atlantic Forest with 20%, 7% in Caatinga-Cerrado and 7% Caatinga-Atlantic Forest. The results on the distribution of the endemic species of *Manihot* to Northeast

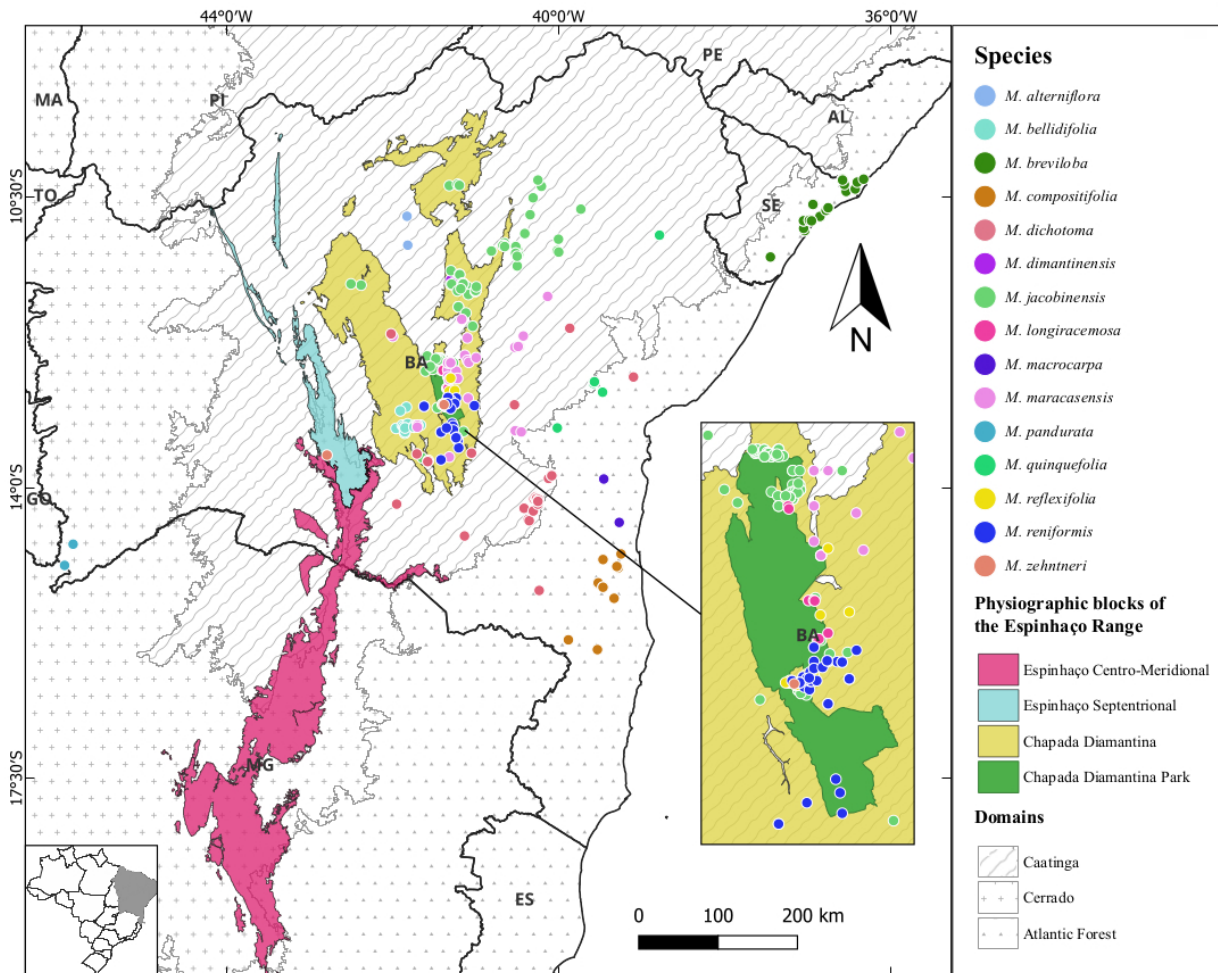
Brazil, showed that all of them except *M. jacobinensis* have a restricted distribution: 87% occurred exclusively in one domain and 13% in more than one domain.

Most species were found in the state of Bahia and only *M. breviloba* was found exclusively in Sergipe and Alagoas. The species were distributed from 0 m to 1700 m (**Supplementary material S1**), mostly between 500 and 1000 m. The richest area was found in the northern area of the Chapada Diamantina in the Espinhaço range (Fig. 1 and 2) with seven species (*M. bellidifolia*, *M. dichotoma*, *M. jacobinensis*, *M. maracasensis*, *M. reflexifolia*, *M. reniformis*, and *M. zehntneri*) occurring in this area. We also found six species associated with the Chapada Diamantina National Park (*M. jacobinensis*, *M. longiracemosa*, *M. maracasensis*, *M. reflexifolia*, *M. reniformis*, and *M. zehntneri*) (Fig. 2), being *M. longiracemosa* and *M. reflexifolia* exclusive to this area.



**Figure 1.** Map showing the richness of *Manihot* species endemic to Northeast Brazil.





**Figure 2.** Map showing the geographic distribution of *Manihot* species endemic to Northeast Brazil.

## Taxonomic treatment

***Manihot* Miller**, Gard. Dict. Abr., vol. II, ed. 4. 1754.

Type:—*Manihot esculenta* Crantz

**Trees**, shrubs, subshrubs or vine, which may be erect or prostrate. **Roots** sometimes tuberous. **Stem** cylindrical, smooth, rarely with swollen knots, green to purple, glabrous or pubescent; latex white to lightly cream or translucent, abundant. **Stipules** foliaceous, semifoliaceous or setaceous, triangular, ovate, filiform or linear to linear-lanceolate, with entire edges, lacinate or dentate, generally not persistent. **Petioles** dorsiventrally flattened or cylindrical, pubescent, or glabrous, greenish to purple, basally or peltate inserted. **Leaves** 3–5–7-lobed or not lobed, sometimes with deeply lobed leaves, with a large constriction at the base of the lobes, rarely with lateral lobes smaller or extremely reduced, glabrous or pubescent, green or greenish with purple ribs, lobes oblong, elliptic, lanceolate, suborbicular, oval, ovate or reniform to cordate, margin entire, pandurate or revolute, apex acute, acuminate or cuspidate, base acute, obtuse to slightly decurrent, venation camptodromous.

**Inflorescences** terminal in racemes or panicle; bracts and bracteoles setaceous, semifoliaceous or foliaceous, pubescent or glabrous, oval, ovate, lanceolate, filiform or triangular, with margin entire, lacinate or serrated, apex acute to obtuse, sometimes semi-reflexed or rarely arched over the floral buds. **Staminate buds** orbicular, ovoid, bifusiform, pyramidal or conical. **Staminate flowers** sympetalous, fused to halfway or 1/3 of the length, greenish, yellowish, purple, sometimes green with purplish lines or yellow with purple margins, glabrous or pubescent, staminal disk white or yellow. **Pistillate buds** 2, pyramidal, bifusiform or ovoid, opposite to subopposite. **Pistillate flowers** apetalous, green, purple or sometimes green to purple with purple lines, glabrous or pubescent, nectary disk yellow, orange or purple. **Capsules** ovoid, globose, ellipsoid or short-cylindrical, smooth or with straight ribs, or sometimes with evident undulating ribs, green or green with purplish lines, apex rounded or slightly acuminate or apiculate. **Seeds** subglobose, ovoid, ellipsoid or short-cylindrical, brown or gray, sometimes with small dark spots. **Caruncle** triangular, rarely extending beyond the apex of the seed, yellowish, brown or white.

## Key to *Manihot* species endemic to Northeast Brazil

1. Plants with leaves not lobed.
  2. Leaf lobes reniform to cordate; petioles dorsiventrally flattened; seeds oblongoid ..... 4. *M. reniformis*
  - 2'. Leaf lobes elliptic to ovate, oblong, lanceolate to linear lanceolate; petioles cylindrical to slightly canaliculate on the adaxial face; seeds ellipsoid or oblongoid.
    - 3 Subshrub 15-25 cm tall; leaf lobes oblong, lanceolate to linear-lanceolate, margin strongly to slightly pandurate .. ..... 11. *M. pandurata*
    - 3'. Shrub to vine, 10-15 m tall; leaf lobes elliptic-oval, margin entire ..... 9. *M. macrocarpa*
- 1'. Plants with leaves lobed.
  4. Petioles dorsiventrally flattened, leaf lobes lanceolate to suborbicular.
    5. Leaf lobes lanceolate, leaf blade held descending parallel to the stem axis ..... 2. *M. bellidifolia*
    - 5'. Leaf lobes suborbicular, leaf blade not held descending parallel to the stem axis ..... 7. *M. jacobinensis*
  - 4'. Petioles cylindrical; leaf lobes obovate, elliptic, ovate, or oblong.
    6. Tree, 2-12 m tall; stipules brown; capsules with slight undulating ribs..... 6. *M. dichotoma*
    - 6'. Shrub, subshrub to vine, 0.5-8 m tall; stipules green or black; capsules without undulating ribs.
      7. Stem, petioles and leaves pubescent; capsules with linear ribs ..... 10. *M. maracasensis*
      - 7'. Stem, petioles and leaves glabrous; capsules without ribs.
        8. Stipules persistent; leaf lobes acute at the apex.
          9. Subshrub, prostrate, ≤ 50 cm tall; stem without swollen knots; stipules semifoliaceous; inflorescence a pseudoterminal single raceme, 9.5–12.5 cm long ..... 1. *M. alterniflora*
          - 9'. Shrub or tree habit, erect, 1-4 m tall; stem with swollen knots; stipules foliaceous; inflorescence a terminal panicle, 6-9 cm long ..... 15. *M. zehntneri*
        - 8'. Stipules deciduous; leaf lobes acuminate, apiculate or cuspidate at the apex.
          10. Stipules semifoliaceous, triangular, black; leaf lobes apiculate at the apex; fruits baccaceous, 4 cm diam ..... 4. *M. compositifolia*
          - 10'. Stipules setaceous, filiform, green; leaf lobes acuminate or cuspidate at the apex; fruits not baccaceous, 1-2,5 cm diam.
    11. Bracts setaceous; capsules 2-2.5 cm diam, with straight ribs, green without white lines.
      12. Leaves 3-lobed with lateral lobes extremely reduced, margin entire; capsules ovoid to ellipsoid. .... 3. *M. breviloba*
      - 12'. Leaves 3–5-lobed with lateral lobes not extremely reduced, margin pandurate; capsules globose ..... 5. *M. diamantinensis*
  - 11'. Bracts foliaceous or semifoliaceous; capsules 1-1.5 cm diam, without straight ribs, green with white lines.
    13. Petiole greenish; leaves deciduous, deeply lobed, with a large constriction at the base of the lobes, resembling compound leaves, margin slightly pandurate; bracts semifoliaceous, linear ..... 12. *M. quinquefolia*
    - 13'. Petiole purple, leaves permanent, not deeply lobed, without a large constriction at the base of the lobes, not resembling compound leaves margin entire; bracts foliaceous, ovate.
      14. Leaf lobes lanceolate, 15-21 cm long; inflorescence 20-25 cm long, bracts arched over the flower buds, ovate with obtuse apex ..... 8. *M. longiracemosa*
      - 14'. Leaf lobes elliptic to lanceolate, 5–8 cm long; inflorescence 6-15 cm long, bracts semi-reflexed, ovate to lanceolate with acute apex ..... 13. *M. reflexifolia*



**1. *Manihot alterniflora*** P. Carvalho & M. Martins, *Nordic J. Bot.* 36(3)-e01615:2. 2018. Type:—Brazil, Bahia, Municipality of Jussara, 10°44'07.8" S, 41°14'50.9" W, 475 m. 13 Mar 2010, M. Martins, P.C.L. Carvalho & C.A.S. Ledo 1740. Holotype: HURB (398!). Isotypes: HVASF (23784!); CEN (108613!); CEPEC (92178!); HUEFS (247392!); K, NY, P, RB (01402719!). See Fig. 1 (Martins et al. 2018, p. 62).

**Subshrub** up to 50 cm tall, prostrate. **Roots** not tuberous. **Stem** glabrous, smooth, cylindrical, latex white. **Stipules** semifoliaceous, persistent, ovate, ca. 5 mm long, margin lacinate. **Petioles** cylindrical, 3–8.5 cm long, greenish, glabrous, basally inserted to the lamina. **Leaves** 3–5-lobed, rarely entire, glabrous, glaucous green, lobes obovate, median lobe 6.5–9 × 2–4 cm, margin entire to pandurate, acute at apex, venation camptodromous. **Inflorescence** a single pseudoterminal raceme, 9.5–12.5 cm long; bracts semifoliaceous, margin entire; bracteoles semifoliaceous, margin entire or lacinate. **Staminate buds** globose to ovoid, 0.9–1.2 × 0.6–0.8 cm; pedicel 2.5–4.2 cm long. **Staminate flowers** sympetalous, fused to halfway, green with purplish lines, glabrous, staminal disk white. **Pistillate buds** 2, ovoid, 0.7–1 × 0.5 cm, alternate; pedicel ca. 1.7 cm long. **Pistillate flowers** apopetalous, creamy green, glabrous, disk light yellow. **Capsules** globose, ca. 2 cm in diameter, smooth, green, rounded at apex. **Seeds** ellipsoid, ca. 1.5 × 0.6 cm, gray, with small dark spots. **Caruncle** triangular, ca. 4 mm long, light yellow, at apex with slight central recess, extending beyond the apex of the seed.

**Phenology:** Flowering and fruiting in February to March in the field, and from October to May under cultivation at Universidade Federal do Recôncavo da Bahia (UFRB).

**Distribution and habitat:** Bahia. Municipality of Jussara and Sento Sé (Fig. 3), in shrubby Caatinga.

**Conservation status:** Critically Endangered (CR B1a; IUCN), due to its small extent of occurrence (less than 100 km<sup>2</sup>).

**Notes:** *Manihot alterniflora* is similar to *M. carthagensis* (Jacq.) Müll. Arg. in the obovate leaf lobes, persistent semifoliaceous stipules and orbicular fruits, but it is easily distinguished by its subshrub habit, up to 50 cm, racemose inflorescences, and caruncle extending beyond the apex of the seed (vs. shrubby or arboreal habit, 1–5 m tall, paniculate inflorescences and caruncle restricted to the ventral part of the seed), respectively.

**Specimens examined:** BRAZIL. Bahia: Jussara, Baixão dos Honoratos, 3 Apr 1984, O. A. Salgado & H. P. Bautista 342 (HUEFS); Sento Sé, road Jussara–Sanharó, km 42, 13 Mar 2010, M. L. L. Martins et al. 1740 (HUEFS).

**2. *Manihot bellidifolia*** P. Carvalho & M. Martins, *Syst. Bot.* 39: (2) pp 485. 2014. Type:—Brazil, Bahia, Municipality of Catolés, 12 Dec 2013, M.L.L. Martins, P.C. Carvalho, C.A. Ledo & P.H. Marbach 2161. Neotype designated here: HURB (HURB8838!). Isonotype: CEPEC (148521!). Fig. 4 A–I.

**Shrub** 1.0–2.5 m tall, erect. **Roots** not tuberous. **Stem** glabrous, smooth, branches cylindrical, latex white.

**Stipules** setaceous, deciduous, filiform, ca. 0.5 mm long, margin entire. **Petioles** dorsiventrally flattened, (2–) 4–8 (–10) cm long, glabrous, basally inserted to the lamina. **Leaves** 3–5-lobed, alternate, glabrous, chartaceous, abaxial surface lighter, leaf blade held descending parallel to the stem axis, lobes lanceolate, median lobe (3–) 5–10 × 0.9–2.5 cm, margin entire to revolute, apex acuminate, venation camptodromous. **Inflorescence** a single terminal raceme, 15–25 cm long; bracts foliaceous, reflexed, oval-lanceolate with acute apex, margin entire, greenish at base and purplish at apex; bracteoles foliaceous, oval to lanceolate, acute apex, margin entire, white–purple. **Staminate buds** bifusiform, 0.5–1 × ca. 0.5 cm. **Staminate flowers** sympetalous, fused to halfway, greenish with purplish lines, glabrous, staminal disk yellow. **Pistillate buds** 2, pyramidal, 1–1.5 × 0.5–1 cm, subopposite. **Pistillate flowers** apopetalous, greenish to purplish with purple lines on the outside, disk purplish. **Capsules** ovoid to globose, 1.5–2 cm in diameter, smooth, green with purplish lines, apex rounded or slightly apiculate. **Seeds** ovoid, 0.5–0.7 × 0.5 cm, brown grayish. **Caruncle** triangular, ca. 2 mm long, yellowish.

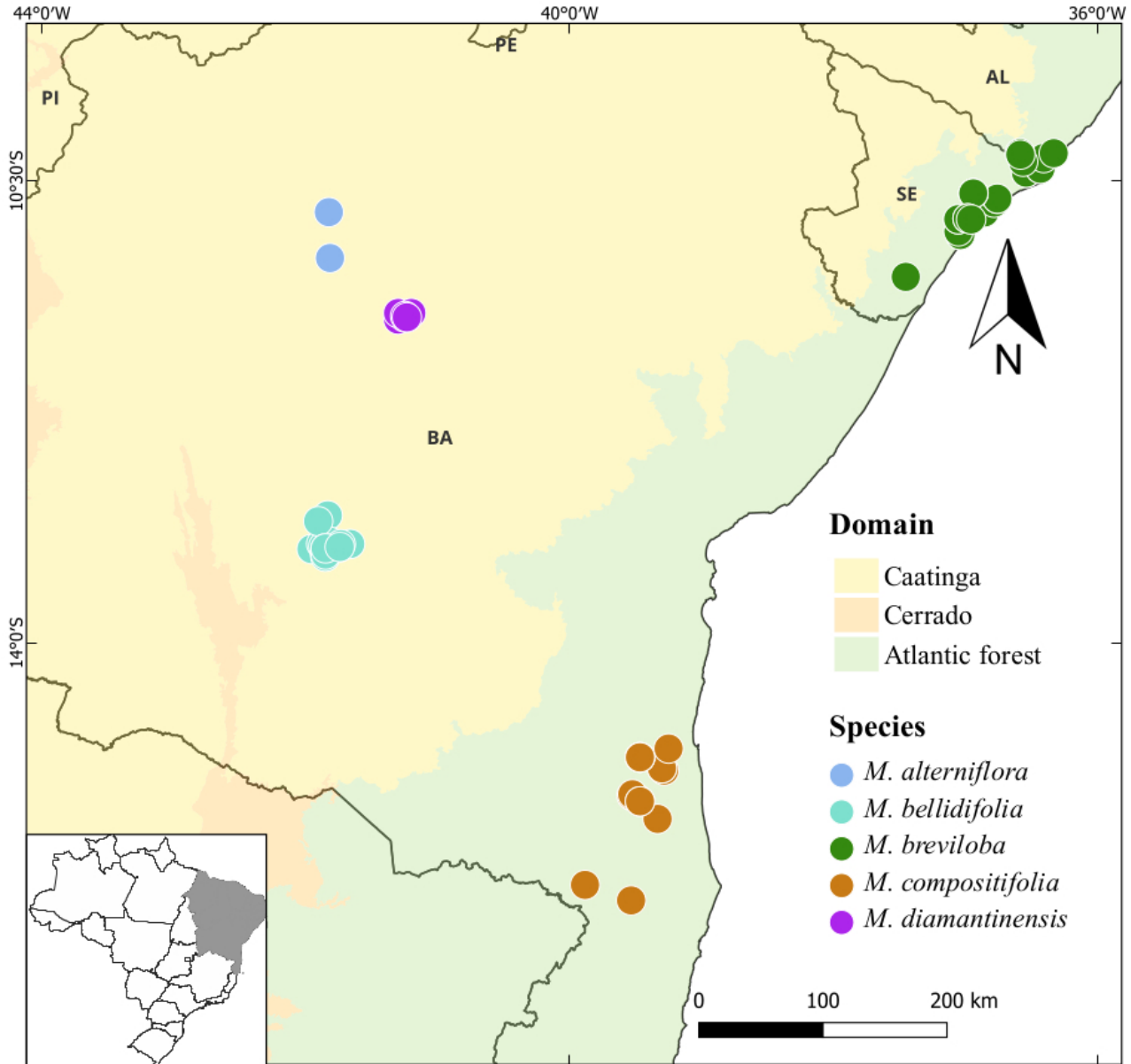
**Phenology:** Flowering and fruiting all year round.

**Distribution and habitat:** This species is endemic to rupestrian field vegetation in the southern region of the Chapada Diamantina, Bahia (Fig. 3), generally on rocky slopes and sandy ground, above 1,000 m altitude.

**Conservation status:** According to IUCN criteria, this species is considered Endangered (EN B2a), with an area of occurrence less than 500 km<sup>2</sup>.

**Notes:** *Manihot bellidifolia* has traditionally been identified as *M. acuminatissima* Müll. Arg. due the leaf lobes and apex shapes but differs by having 3–5-lobed leaves oriented descending parallel to the stem axis and inflorescences with long racemes (vs. exclusively 3-lobed leaves and short inflorescences), respectively.

**Taxonomic comments:** *Manihot bellidifolia* was described by Carvalho and Martins (Martins et al. 2014) based on the specimen collected by M. Martins and P. C. Carvalho 1713 at municipality of Catolés in 2010 and stored in the HUEFS herbarium, with duplicates supposedly sent and deposited in the CEN, CEPEC, HURB, K, P, RB, SP herbaria. After visiting some collections and contacting all herbaria where these types were supposed to be deposited, we did not find type material (holotype or isotypes) in any these collections. No specimens from the original collection have been found, neither the holotype nor the seven isotypes. Thus, it remains for us to conclude that the type materials were not deposited in any of the herbaria and, consequently, are lost. So, according to the International Code of Nomenclature (Turland et al. 2018), a neotypification is required for *Manihot bellidifolia*. We chose as a neotype the specimen Martins 2161 because it is compatible morphologically with the protologue, as it comes from the same locality as the original collection and is deposited in the HURB herbarium, where the author of the species works.



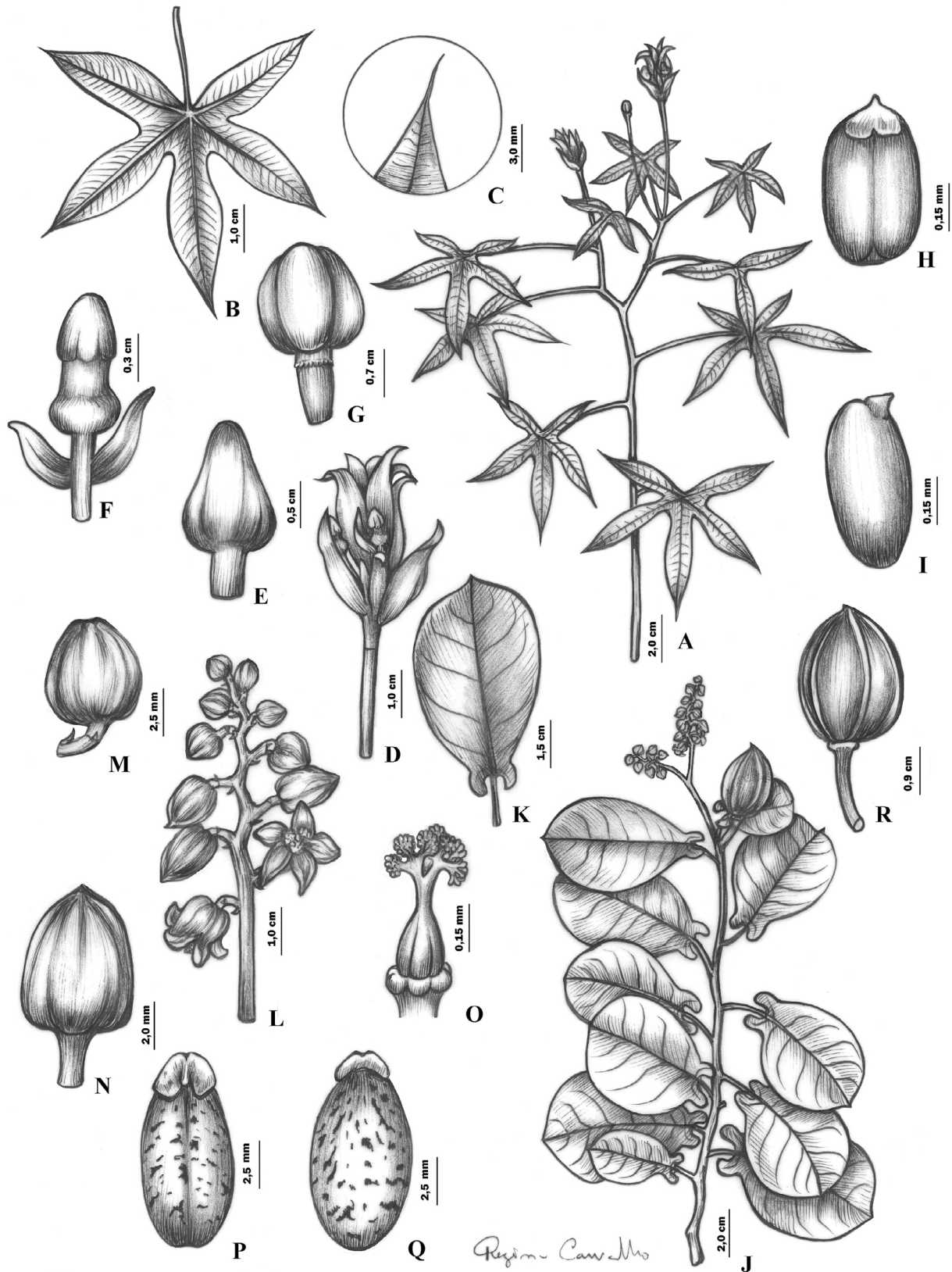
**Figure 3.** Distribution map of *M. alterniflora* P. Carvalho & Martins, *M. bellidifolia* P. Carvalho & Martins and *M. breviloba* P. Carvalho & Martins, *M. compositifolia* Allem and *M. diamantinensis* Allem species endemic to Northeast Brazil.

**Specimens examined:** BRAZIL. Bahia: Abaíra, Boa Vista, 12 Nov 1992, *W. Ganev* 1409 (HUEFS); Chapada Diamantina, 20 Dec 1991, *Harley et al.* 50159 (ALCB); Chapada Diamantina, 01 Nov 2014, *Guedes et al.* 22839 (ALCB); Bicota, between new Garimpo and Bicota. 15 Dec 1993, *W. Ganev* 2678 (HUEFS); Chapada Diamantina, 31 Dec 1996, *L. Queiroz & M. da Silva* 3848 (ALCB); Road Abaíra to Ouro Verde, 15 May 2016, *L. Brauner et al.* 69 (UB); Guarda-Mor, 15 Sep 1993, *W. Ganev* 2244 (HUEFS); Road to Serra do Barbado, 17 Nov 2015, *D. S. Carneiro* 1334 (HUEFS); Salão, 9 km from Catoles on the road to Abaíra, 28 Dec 1991, *R. M. Harley et al.* 50522 (HUEFS); trail from Boa Vista to Bicota, 09 Jul 1995, *F. França et al.* 1283 (HUEFS); trail from Ribeirão de Baixo to Piatã, 10 Jul 1995, *L. P. Queiroz et al.*

4413 (CEN); top of Morro da Serrinha, 31 May 2003, *M. J. Andrade et al.* 345 (HUEFS); Catolés, Serrinha, 19 Jun 2011, *P. L. Ribeiro* 700 (HURB); Road to Catolés, 12 Dec 2013, *M. L. L. Martins* 2161 (CEPEC), Piatã, road between Catolés/ Barra de Catolés, 13°16' S 41°52' W, 1,180 m a.s.l, 19 Oct 1992, *W. Ganev* 1276 (HUEFS).

**3. *Manihot breviloba*** P. Carvalho & M. Martins, *Phytotaxa*. 32: 57. 2011. Type:— Brazil, Sergipe, Santo Amaro das Brotas, 12°53' S, 41°18' W, 9.8 m. 14 May 2011, *M.L.L. Martins, P.C.L. Carvalho, C.A.S. Ledo & T.C. Silveira* 1800. Holotype: HUEFS (179120!). Isotypes: CEPEC (136510!); P (02090099!); SP (363773!). Fig. 4 J-R.





**Figure 4.** *Manihot bellidifolia* P. Carvalho & M. Martins, A. Fertile branch, B. Leaf, C. Detail of the apex, D. Inflorescence, E. Pistillate floral bud, F. Staminate floral bud, G. capsule, H-I Seed (Ganev, W. 1409 and Carneiro-Torres, D. 1334). *Manihot breviloba* P. Carvalho & M. Martins. J. Fertile branch, K. Leaf, L. Inflorescence, M. Staminate flower bud, N. Pistillate flower bud, O. Detail of the pistillate flower, P-Q. Seed, R. Capsule (Martins *et al.* 1800, Holotype).



**Vine**, 1.5–4 m tall. **Roots** not tuberous. **Stem** glabrous, smooth, cylindrical, latex white. **Stipules** setaceous, deciduous, and filiform. **Petioles** cylindrical, clasping, 1–4 cm long, slightly purple, glabrous, basally inserted to the lamina. **Leaves** 3-lobed, lateral lobes extremely reduced, glabrous, green, lobes obovate, median lobe 3–8 × 2–5 cm, margin entire, apex acuminate, venation camptodromous. **Inflorescence** terminal, racemose to paniculate, 10–17 cm long; bracts and bracteoles setaceous, margin entire. **Staminate buds** ovoid, 0.6–1.2 cm; pedicel ca. 2.5 mm long. **Staminate flowers** sympetalous, fused to halfway, yellow with purple margins, glabrous, staminal disk yellow. **Pistillate buds** 2, pyramidal, 0.7–1.2 cm long, opposite; pedicel 0.7–2.5 cm long. **Pistillate flowers** apopetalous, yellowish green with purple margins, glabrous, nectary disk orange with a purple base. **Capsules** ovoid to ellipsoid, 2–2.5 cm in diameter, smooth, green, with straight ribs, apex acuminate. **Seeds** oblongoid, ca. 1 cm long, greyish-brown, with small dark spots along the edges. **Caruncle** triangular, ca. 0.2 mm long, cream colored.

**Phenology:** Flowering and fruiting from February to November.

**Distribution and habitat:** *Manihot breviloba* occurs in Sergipe and Alagoas (Fig. 3) growing in restinga, in the shrubby vegetation of coastal sandy plains.

**Conservation status:** According to IUCN criteria, this species is considered Endangered (EN B1a), with an extent of occurrence less than 5000 km<sup>2</sup>.

**Notes:** *Manihot breviloba* is distinguished from all other species of the genus by its vine habit, leaf with extremely reduced or no lateral lobes, and clasping petioles. The species grows in the coastal sandy plains, an unusual habit for *Manihot* species; only *M. baccata* Allem, *M. pohlii* Wawra and *M. tripartita* (Spreng.) Müller have been reported from restingas (Pereira & Assis 2000; De Sá 2002; Mendoza *et al.* 2020).

**Specimens examined:** BRAZIL. Alagoas: Feliz Deserto, Várzea of Marituba, 12 Sep 2009, *Chagas-Mota* 5492 (MAC); Marituba, 23 Sep 1987, *M. N. Rodriguez* 1082 (MAC); Mun. Penedo, 9 km from Penedo towards Piaçabuçu, 27 Oct 1982, *M. N. Staviski et al.* 346 (MAC); Penedo, 10 km from Penedo, sentido Piaçabuçu, 30 Mar 2013, *M. L. L. Martins & P. A. S. Marbach* 1942 (HURB); Penedo, Marreca, 18 Oct 1988, *L. Lemos* 1572 (MAC); Piaçabuçu, 7 km after the bridge of Penedo/Piaçabuçu, 15 Mar 2003, *L. Lemos* 7414 (MAC); Piaçabuçu, 18 May 2011, *Chagas-Mota et al.* 10331 (MAC). Sergipe: Barra dos Coqueiros, close to the port of Sergipe, *M. Landim et al.* 590 (HUEFS); Barra dos Coqueiros, 20 Feb 1998, *A. Cruz & E. Santos* 11 (ASE); Farm Procace, 30 Jun 1981, *M. Fonseca* 534 (ASE); Ilha das Flores, Betume, Island of flores, 22 Jun 1982, *G. Viana* 524 (IPA). Ilha das Flores, Betume, 28 Jan 2011, *M. C. Santana* 900 (ASE), Japarutuba, Hugo Heredia, 24 Nov 2014, *S. A. Damasceno* 53 (ASE); Japarutuba, Sapucaia, *W. E. Santos et al.* 14 (ASE);

Japarutuba, São José Village, Right bank of the highway, 18 Jan 2013, *M. Farias et al.* 398 (ASE); Mun. Pirambu, Saint Sebastian, 13 Jul 2011, *D. M. Oliveira* 108 (ASE); Pirambu, Paraiso, 26 May 2012, *A. P. Prata et al.* 3048, 3104 (ASE); Pirambu, Paraiso, next to Lagoa Redonda, 18 Apr 2011, *M. C. Santana* 907 (ASE); Pirambu, 09 May 2013, *Farias et al.* 115 (ASE); Pirambu, road to São José Village, 14 Sep 1995, *M. Landim* 593 (HUEFS); Santo Amaro das Brotas, road to the Port of Sergipe, 16 Jun 2000, *G. Sousa et al.* 367 (CEPEC, SP); Santo Amaro das Brotas, farm Prhocase, 30 Jun 1981, *M. Fonseca* 27837 (IPA), Santo Amaro das Brotas, Jatobá, 18 Jun 2011, *J. Nascimento et al.* 821 (ASE); Santo Amaro das Brotas, 23 Apr 2012, *M. Farias et al.* 209 (ASE); Santo Amaro das Brotas, 30 Feb 2012, *S. Carvalho & H. Avila* 323 (ASE), Santo Amaro das Brotas, Village Hugo Heredia, 11 Feb 2016, *Felix et al.* 80 (ASE); Santo Amaro das Brotas, 14 May 2011, *M. L. L. Martins* 1800 (HUEFS); Santo Amaro das Brotas, next to Rio Poronga, 15 Nov 2002, *A. Ribeiro* 202 (UEC).

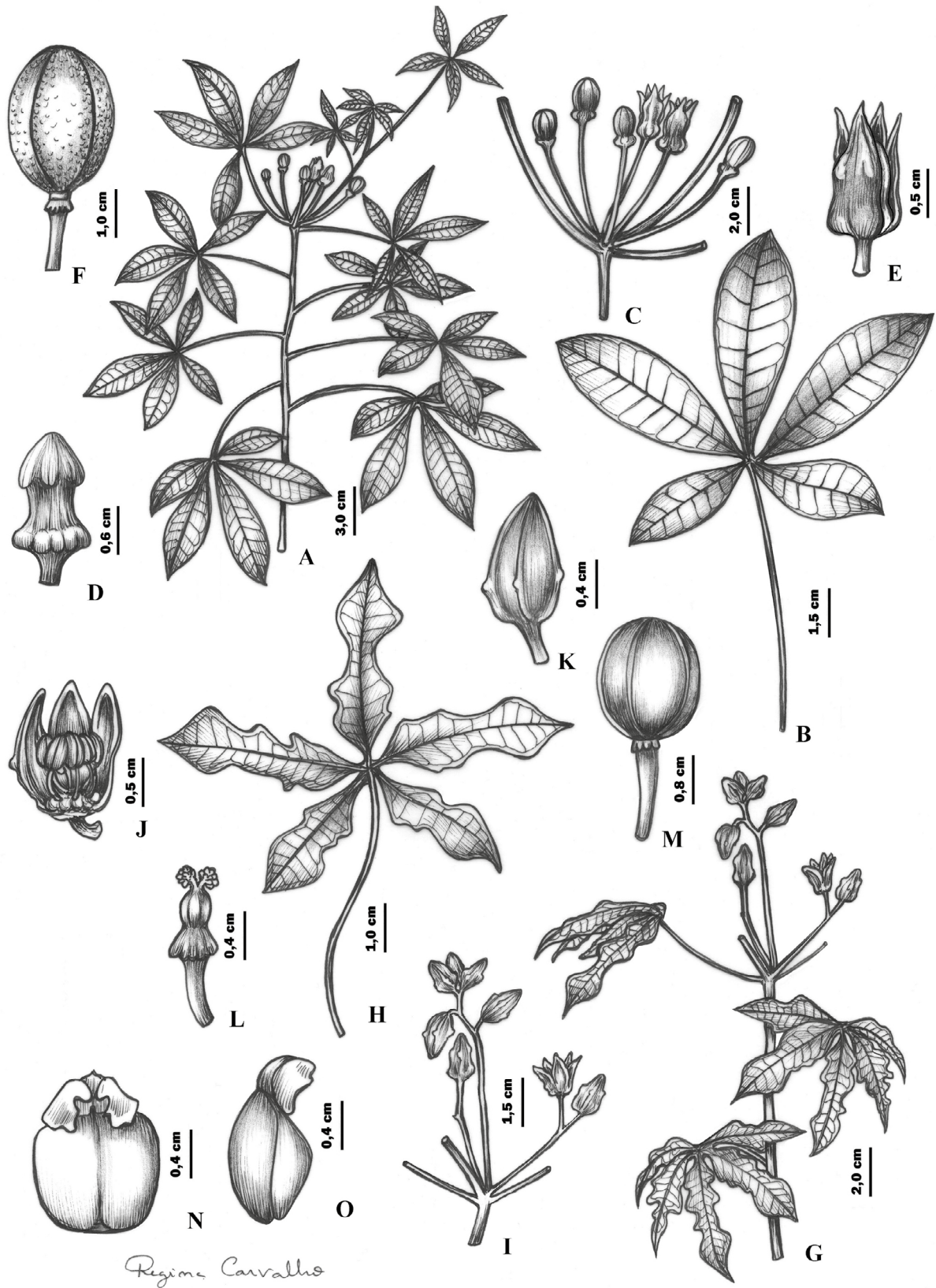
**4. *Manihot compositifolia*** Allem, Revista Brasil. Biol. 49: 650. 1989 publ. 1990. Type: —Brazil, Bahia, Jussari, 1 km E of Jussari, along the road that ends at BR-101 road, 14 Dec 1987, *Allem & Werneck* 3750. Holotype: CEN (37666!). Isotypes: K (000600409!); NY (00263621! [image]). Fig. 5 A-F.

**Shrub or vine**, 8.0 m tall. **Roots** not tuberous. **Stem** glabrous, smooth, cylindrical, latex white, abundant. **Stipules** semifoliaceous, deciduous, triangular, ca. 2 mm long, black. **Petioles** cylindrical, 5–15(–20) cm long, purple, glabrous, basally inserted to the lamina. **Leaves** (3–)5(–7) deeply lobed, with a large constriction at the base of the lobes, glabrous, lobes elliptic to ovate, median lobe 4–12(–14) × 2–4 cm, margin entire, persistent, apex apiculate, venation camptodromous. **Inflorescence** terminal, racemose to paniculate, 7–15 cm long; bracts and bracteoles setaceous, triangular, margin entire. **Staminate buds** bifusiform, 1–1.5 cm. **Staminate flowers** sympetalous, fused to 1/3 of the length, green to purple, glabrous, staminal disk yellow. **Pistillate buds** bifusiform, 1.5 cm long, opposite to subopposite; pedicel 4 cm long. **Pistillate flowers** apopetalous, greenish yellow to purple, glabrous, nectary disk yellow. **Fruits** baccaceous, ovoid to ellipsoid, 4 cm in diameter, indehiscent, smooth, green with purplish lines, apex rounded. **Seeds** obovoid, ca. 2 cm long, variably brown. **Caruncle** triangular, 1 mm long, yellow brown.

**Phenology:** Flowering and fruiting from December to May.

**Distribution and habitat:** *Manihot compositifolia* is reported from the Atlantic Forest of Bahia. It is usually found growing near cocoa and cassava plantations in ombrophilous forest, near roads and mixed with weeds (Allem 1989). The species grows in blackish and muddy organic soils and is locally known as “mandioca brava” (Fig. 3).





**Figure 5.** *Manihot compositifolia* Allem, A. Fertile branch, B. Leaf, C. Inflorescence (Kulkamp 608), D. Staminate flower bud, E. Detail of pistillate flower, F. Capsule (Martins et al. 8472). *Manihot diamantinensis* Allem. G. Fertile branch, H. Leaf, I. Inflorescence, J. Detail of staminate flower, K. Staminate floral bud, L. Detail of pistillate flower, M. Capsule, N–O. Seed (Suarez et al. 7).

**Conservation status:** According to IUCN criteria, this species is considered Endangered (EN B1a), with an extent of occurrence less than 5000 km<sup>2</sup>.

**Notes:** *Manihot compositifolia* can be recognized by the deeply lobed leaves (with a large constriction at the base of the lobes), pistillate flowers with long pedicels (4 cm) and baccaceous, conical to ovoid fruits. *Manihot compositifolia* resembles *M. baccata* in the vine habit, but differs from it by having black stipules, leaves with a large constriction at the base of the lobes, apiculate apex and ovoid to ellipsoid baccaceous fruits (vs. green stipules, leaves without a large constriction at the base of the lobes, acuminate apex, and ovate to orbicular baccaceous fruits in *M. baccata*).

**Specimens examined:** BRAZIL. Bahia: Camacan, BR-101- km 517, 23 Oct 1981, J. Vieira, 162 (CEN); Cruz das Almas, agronomy school UFBA, 03 Mar 1978. C. Allem 1976 (CEN); Mun. Cruz das Almas, agronomy school UFBA, 06 Mar 1978. C. Allem 1977 (CEN); Ibicaraí trail between Poçoões and Ibicaraí, 09 Apr 1988, C. Costa & Werneck 54 (CEN), Ibicaraí, towards Itabuna C. Allem 4073 (CEN, HUEFS); Ibicaraí, 18 km after the entrance to the city, towards Itabuna, 23 May 1993, C. Allem et al., 4526 (CEN, HUEFS); Ibicaraí, 18.6 km from Ibicaraí, along the BR - 415, 08 Feb 1995, A. C. Allem 4527, 4528, 4529 (CEN), Ilhéus, Pimenteira, 12 Dec 2014, A. M. Amorim 8472 (CEPEC); Itapebi, road to Itapebi, 8 Jul 1967, R. S. Pinheiro & T. S. Santos 383 (CEPEC); Itabuna, BR-101 Itabuna to Buerarema, 2.5 km after Posto Fiscal, 10 abril 1988, I. R. S. Costa et al., 55 (CEN); Itarantim, Boi Rajado, 14 km of Bandeira, 08 Oct 2003, A. Salino et al., 9148 (SP); Jussari, 1 km east of Jussar, along the BR-101, 14 Dec 1987, A. C. Allem & W. L. Werneck 3750, 3751, 3570 (CEN); Jussari, road to Jussari-Palmira, 7.5 km from Jussari, Farm teimoso, RPPN Serra of Teimoso, 21 Nov 1998, A. M. A. Amorim et al., 2711 (CEPEC, SP); Jussari, 3 km before Jussari BR-101, 19 Ago 2010, M. Martins et al., 1673 (HURB, CEPEC); Jussari, RPPN Serra do Teimoso, 13 Dec 2018, J. Kulkamp 608 (HUEFS); Burarema, 15 km southwest of Itabuna, 25 Aug 1985, C. Allem 3364 (CEN); Burarema, 15 km southwest of Itabuna, 14 Dec 1987, A. C. Allem 3749 (CEN); Mun. Burarema, 15 km southwest of Itabuna, 25 Aug 1985, C. Allem 3365 (CEN).

**5. *Manihot diamantinensis*** Allem, Revista Brasil. Biol. 49: 658, 1989 publ. 1990. Type: —Brazil, Bahia, Morro do Chapéu, ca. 10 km southwestward from the city, along the BA-052 road, towards Irecê, 10 Dec 1987, Allem & Werneck 3734. Holotype: CEN (00037667!). Isotypes: K (000600408!); NY (263623!); SP. Fig. 5 G-O.

**Shrub or subshrub**, 1.5–4 m tall, erect or prostrate. **Roots** not tuberous. **Stem** glabrous, smooth, cylindrical, green to purple, latex white. **Stipules** setaceous, deciduous, filiform. **Petioles** cylindrical, 3–7(9) cm long, green to purple, glabrous, basally inserted to the lamina. **Leaves** 3–5 (7)-lobed, glabrous, abaxial surface glaucous, adaxial surface

dark-green, lobes elliptic to ovate, median lobe 3–5(7) × 0.5–2 cm, outermost lobes smaller in size than median lobes, margin pandurate, apex acuminate to cuspidate, venation camptodromous. **Inflorescence** a single terminal raceme, 3–8(–10) cm long; bracts and bracteoles setaceous, deciduous, glabrous, filiform, margin lacinate. **Staminate buds** bifusiform to ovoid, 0.5–1.5 cm. **Staminate flowers** sympetalous, fused to halfway, green with purple lines, glabrous, staminal disk yellow. **Pistillate buds** 2, ovate to pyramidal, 1 × ca. 0.5 cm long, pedicel up to 3 mm long. **Pistillate flowers** apopetalous, yellow to purple, glabrous, nectary disk orange. **Capsules** globose, 2 cm in diameter, smooth, green, with straight ribs, apex rounded. **Seeds** subglobose, 1.3 cm long, yellow, with small grey spots. **Caruncle** triangular, 4 mm long, yellow-brown.

**Phenology:** Flowering and fruiting from December to April.

**Distribution and habitat:** It is found in Bahia growing in marginal areas of Caatinga, in sandy soil. It was found growing in an embankment close to a road together with *M. carthagenensis* (Fig. 3).

**Conservation status:** According to IUCN criteria, this species is considered Critically Endangered (CR B1a), with an extent of occurrence less than 100 km<sup>2</sup>.

**Notes:** *Manihot diamantinensis* is very distinctive by having prostrate habit, thin branches, deeply pandurate leaf margins, and orbicular fruits. Its individuals are very difficult to locate in the field because the darkened upper surface of the leaves make them inconspicuous in the surrounding environment. The species is used as food for cattle and it is frequently pruned because it grows near weeds.

**Specimens examined:** BRAZIL. Bahia: Morro do Chapéu, Rod. BA-052, about 10 km SW of the city, along highway BA-052, 10 Dec 1987, C. Allem 3734 & W. Werneck (CEN); Morro do Chapéu, 10 km SW of the city, along highway BA-052, 12 Dec 1987, C. Allem 3745 & W. Werneck (CEN); Morro do Chapéu, highway BA-052, about 10 km SW of the city, 11 Dec 1987, C. Allem 3744 & W. Werneck (CEN, HUEFS); Morro do Chapéu, highway BA-052, 16 Apr 1988, I. R. S. Costa et al. 71 (CEN); Morro do Chapéu, exactly 9.1 km (church, reference) SW of the city, along highway BA - 052 towards Irecê, 05 Feb 1995, C. Allem 4504 (CEN, HUEFS); Morro do Chapéu, exactly 9.9 km (church, reference) SW of the city, along highway BA - 052 towards Irecê, 05 Feb 1995, C. Allem 4505 (CEN, HUEFS); Morro do Chapéu, exactly 9.9 km (church, reference) SW of the city, along highway BA - 052 towards Irecê, 05 Feb 1995, C. Allem 4506 (CEN); Morro do Chapéu, BR - 052 Irecê towards Morro do Chapéu, 45.2 km after Ipanema, 11 Jun 1996, W. Werneck 881 (CEN); Morro do Chapéu, BR-052, km 10, 23 Feb 2012, M. L. L. Martins et al. 2039 (HURB); Morro do Chapéu, 11.4 km from Morro do Chapéu towards Irecê, 09 Mar 2013, M. L. L. Martins 2166 (CEPEC, HURB); Morro do Chapéu, towards Irecê. 23 Oct 2021, K. Suarez 07 (PEUFR).



**6. *Manihot dichotoma*** Ule, Notizbl. Königl. Bot. Gart. Berlin. 5: 2. 1907. Type:—Brazil, Bahia, Calderão, Oct 1906, *Ule 7045*. Lectotype **designated here**: MG (MG023959!). Isolectotypes: HBG (HBG515959! [Image]); G (G00441872! [Image]); K (K000600445!) ; L (0020816! [Image]). Fig. 6 A-J.

**Tree** 2-12 m tall, erect. **Roots** not tuberous. **Stem** glabrous, smooth, cylindrical, latex white, abundant. **Stipules** setaceous, deciduous, brown, margin lacinate. **Petioles** cylindrical, 5–15 cm long, glabrous, basally inserted to the lamina. **Leaves** 3–5-lobed, lateral lobes smaller, glabrous, lobes elliptic to ovate, median lobe 6–10 × 2–5 cm, margin entire to pandurate, apex acuminate, venation camptodromous. **Inflorescence** terminal, racemose and pendulous, 4–6 cm long; bracts and bracteoles setaceous, margin lacinate. **Staminate buds** pyramidal, 2–3 × 1–1.5 cm. **Staminate flowers** sympetalous, fused to halfway, green, glabrous, staminal disk yellow. **Pistillate buds** ovate to pyramidal, 1–2 × 0.5 cm long, opposite to subopposite; pedicel 1-3 cm long. **Pistillate flowers** apopetalous, green, glabrous, nectary disk orange. **Capsules** globose to oblongoid, 2–3.5 cm in diameter, smooth, with evident undulating ribs, apex rounded. **Seeds** oblongoid, 1.8 × 1.2 cm long, greyish-brown, smooth, with small dark spots. **Caruncle** triangular, ca. 1 mm long, yellow brown.

**Phenology**: Flowering and fruiting from November to May.

**Distribution and habitat**: *Manihot dichotoma* is recorded only in Bahia, in Caatinga phytophysiology (Fig. 7).

**Conservation status**: Least Concern, with an extent of occurrence of 77,480,332 km<sup>2</sup>

**Notes**: It is recognized by the orbicular fruits with undulating ribs evident from the beginning of its development. *Manihot dichotoma* resembles *M. elongata* P. Carvalho & M. Martins in the arboreal habit and leaves commonly with 3 to 5 lobes but differ by the stipules with lacinate margins and the green orbicular capsules with undulating ribs (vs. stipules with entire margins and oblongoid or ovoid, usually purplish capsules with discrete, straight ribs in *M. elongata*).

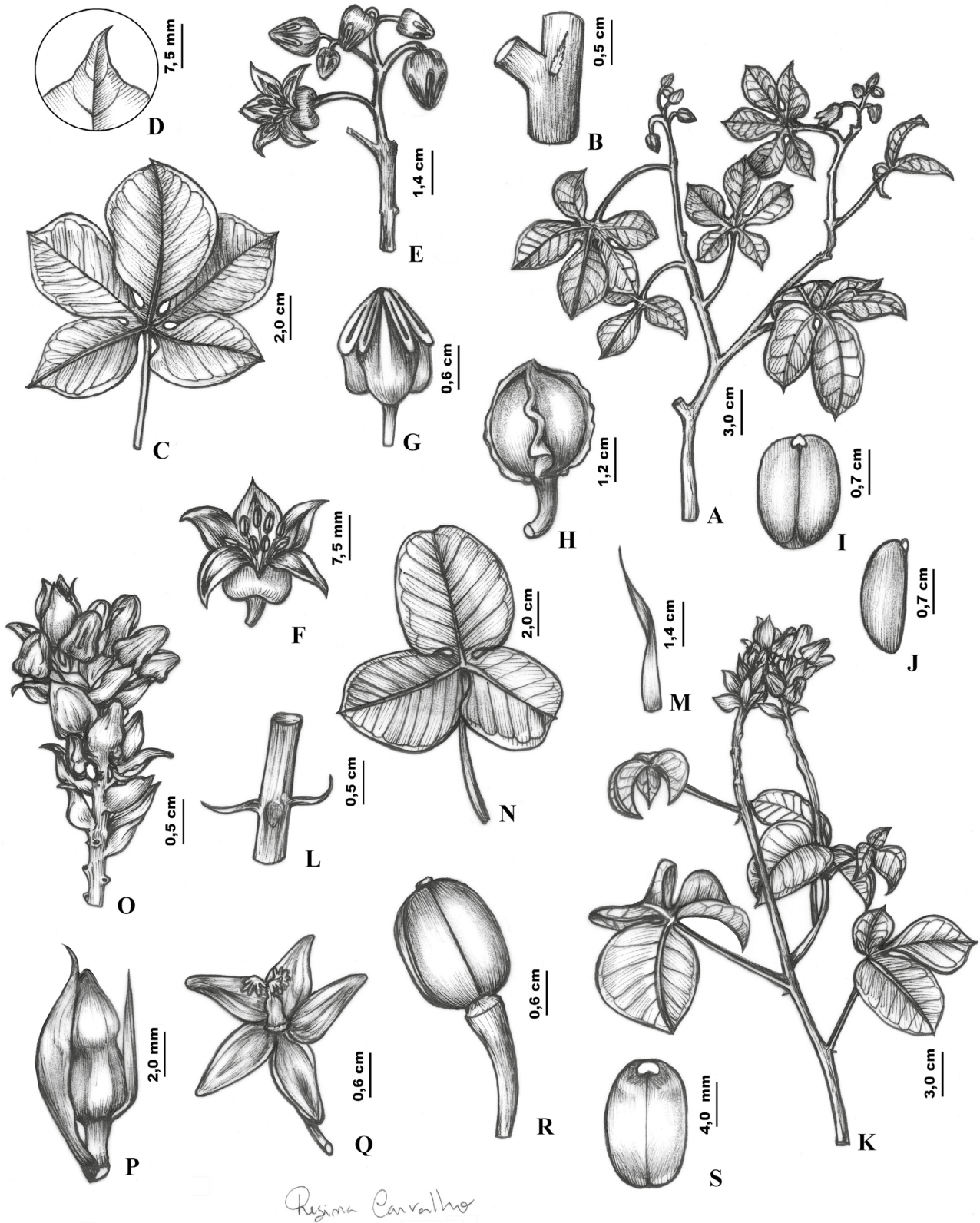
**Taxonomic comments**: *Manihot dichotoma* was described based on an unnumbered Ule collection by Ule (1907) which did not mention or bring information about the location or depositary herbarium of the type. Ule (1908a) cited the same specimen and included the *Bahia, Bei Calderao* and the collection number 7045. Rogers and Appan (1973) and Allem (2001) commented on the existence of syntypes deposited in the herbaria G, L, MG and a photo of the same in K. Despite this, none of them clarified which herbarium is the depositary. In fact, only Martins (2013) indicated the MG herbarium as lectotype, however this decision was not published. We decided to follow Martins' (2013) suggestion and selected the collection of MG (MG023959) as a lectotype because this specimen is in conformity with the protologue, presenting flowers and one fruit, and it is also in good condition. Another specimen deposited in

this herbarium (MG023962) has information compatible with the protologue, but the sample does not correspond to *M. dichotoma*.

**Specimens examined**: BRAZIL. Bahia: Barra da Estiva, 15 Dec 2011, *M. L. L. Martins 1837* (HURB); Barra da Estiva, 31 Jul 2012, *M. L. L. Martins 1870* (HURB); Barra do Mendes, Road to Canarina, Carretão locality, 15 Dec 2009, *E. Melo 7512* (HUEFS); Boa nova, BR-116, Km 75, 7 Jun 1996, *W. L. Werneck 853* (CEN); Boa Nova, 28.7 km to SW of Manoel Vitorino, 8 Feb 1995, *C. Allem 4525* (CEN); Brumado, 5 km to Rodovia Brumado–Caetitê, 27 Dec 1989, *Carvalho et al., 2634* (SP); Brumado, about 76 km SE of Caetitê, 6 Dec 1987, *C. Allem 3719* (HUEFS); Brumado, about 77 km SE of Caetitê, 22 May 1993, *C. Allem 4071* (CEN); Cruz das almas, Embrapa, Germplasm Bank, 8 Mar 2012, *M. L. L. Martins 1422* (HURB); Itapetinga, Matinha Park, 3 Feb 1994, *W. Thomas et al., 10252* (SP); Jequiê, 7 Oct 1965, *N. D. Cruz 109, 110* (US, SP); Jequiê, southeast, 2 Nov 2001, *D. L. Santana et al., 494* (ALCB); Jequiê, Morro da Torre, 13 Apr 2007, *Queiroz 12904* (HUEFS); Livramento, on the way to Itanagé, 20 Apr 2010, *M. L. L. Martins 56* (CEPEC); Manoel Vitorino, km 8, 16 Feb 1979, *L. A. Mattos-Silva 279* (CEPEC); Manoel Vitorino, 107 km N of Vitória da Conquista, 11 Nov 1984, *C. Allem 2941* (CEN); Manoel Vitorino, Rodovia BR-116, 11 Nov 1984, *C. Allem 3724* (CEN); Manoel Vitorino, 100 m ahead of the intersection of the highway BR - 116 with the road to Catingal, 8 Feb 1995, *C. Allem 4520, 4521, 4522* (CEN); Manoel vitorino, 107 Km N from Vitória da Conquista, 11 Nov 1984, *C. Allem et al 2934* (SP); Milagres, Serra do Jatobá, 3 Dec 1993, *R. M. Harley 22025* (CEPEC); Manoel Vitorino 3 km road to Catingal, 5 Jun 2022, *K. Suarez 15* (PEUFR); Rio de Contas, Boa Sentença, road to Jataí, 21 Apr 2003, *A. M. Giulietti et al. 2434* (HUEFS); Rio de Contas, 17.4 km from Rio de Contas, 5 Feb 1999, *M. Silva et al 39* (SP).

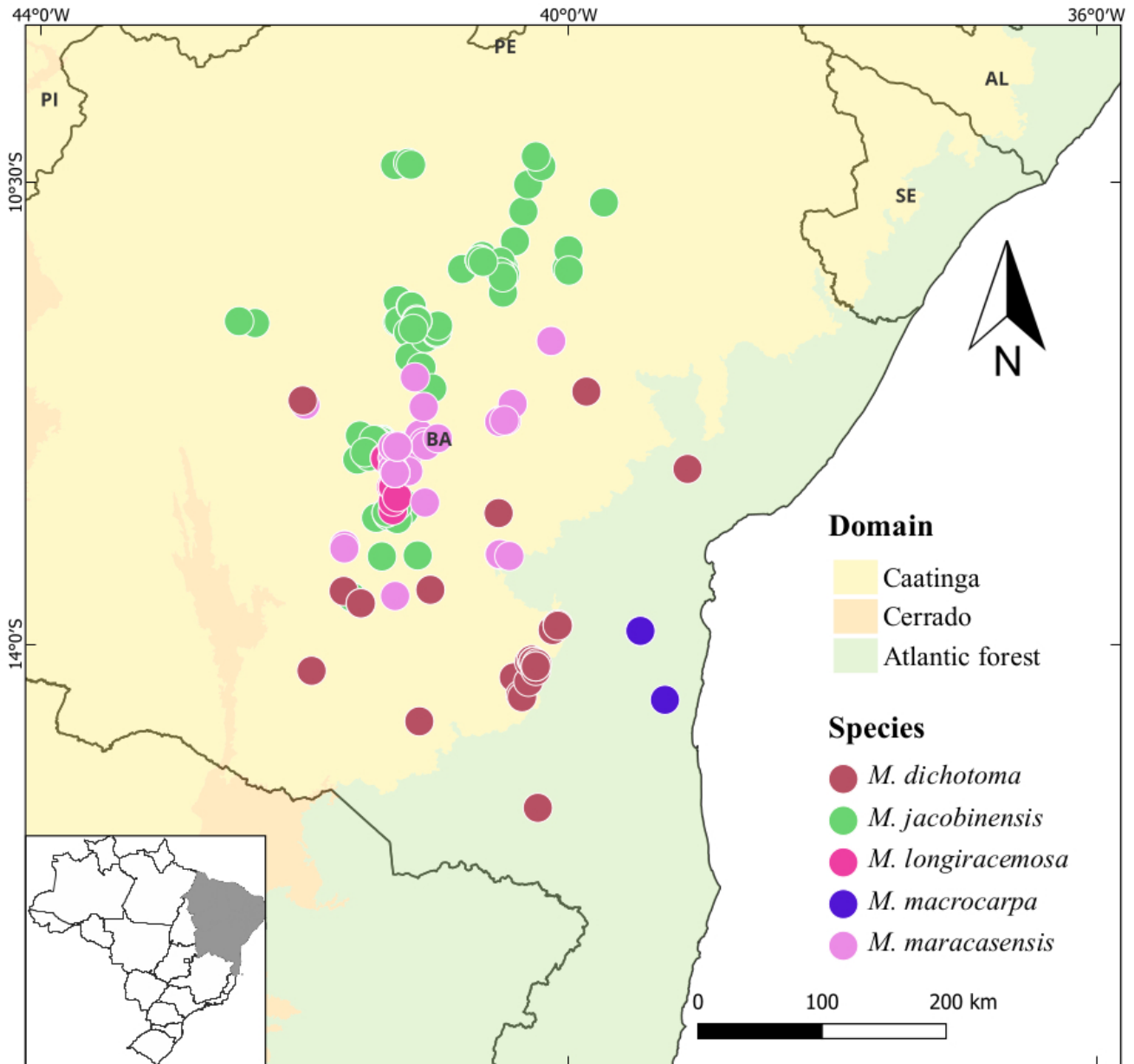
**7. *Manihot jacobinensis*** Mull. Arg., Linnaea 34: 205.1865. Type:—Brazil, Bahia, Mun. Jacobina, Serra da Jacobina, 1836, *Blanchet 2553*. Lectotype **designated here**: G (G00441885 [Image!]). Isolectotypes: F (F0056893F! [Image]); MA (MA251074! [Image]); NY (NY00263633!); P (P00648621! [Image]); K (000600349!). Fig. 6 K-S and Fig. 11 A-H.

**Shrub** 0.7–2(–3) m tall, erect. **Roots** not tuberous. **Stem** glabrous, smooth, branches cylindrical, latex white, abundant. **Stipules** semifoliateous, deciduous, margin entire. **Petioles** dorsiventrally flattened, (1–)6–10 cm long, purple, glabrous, basally inserted to the lamina. **Leaves** 3–5 lobed, deeply divided, glabrous, lobes normally suborbicular, occasionally elliptic or ovate, median lobe (2.5–)6–8 × (1.5–)3–4.5 cm, margin entire, apex acuminate, venation camptodromous. **Inflorescence** terminal, erect, (6–)10–15 cm long; bracts foliaceous, ovate, apex acute semi-reflexed, margin entire, yellowish-green at the basal portion and purplish at the apex, glabrous; bracteoles semifoliateous, margin entire, glabrous, yellowish-green to purple.



**Figure 6.** *Manihot dichotoma* Ule, A. Fertile branch, B. Stipules, C. Leaf, D. Detail of the apex, E. Inflorescence, F. Staminate flower, G. Staminate flower bud, H. capsule, I-J. Seed (Suarez et al. 15). *Manihot jacobinensis* Mull.Arg., K. Fertile branch, L-M. Stipule, N. Leaf, O. Inflorescence, P. Staminate flower bud, Q. Pistillate flower, R. Capsule, S. Seed (Suarez et al. 2, 3).





**Figure 7.** Distribution map of *M. dichotoma* Ule, *M. jacobinensis* Müll. Arg., *M. longiracemosa* P. Carvalho & M. Martins and *M. macrocarpa* P. Carvalho & M. Martins and *M. maracasensis* Ule, species endemic to Northeast Brazil.

**Staminate buds** bifusiform, 0.5–2 cm. **Staminate flowers** sympetalous, fused to 2/3 of the length, yellowish, glabrous, staminal disk yellow. **Pistillate buds** 2, bifusiform, 1.2–1.8 × ca. 0.5 cm long, opposite to subopposite; pedicel 1 cm long. **Pistillate flowers** apopetalous, greenish yellow to purple, glabrous. **Capsules** globose to ovoid, ca. 1 cm in diameter, smooth, green with purplish lines, apex acuminate. **Seeds** oblongoid, ca. 1.5 × 0.6 cm, grey with small dark spots. **Caruncle** triangular, ca 0.3 mm long, white.

**Phenology:** Flowering and fruiting all year round.

**Distribution and habitat:** Found in Bahia, in Cerrado and Caatinga, growing in a rupestrian field and sandy soil (Fig. 7).

**Conservation status:** Least concern, with an extent of occurrence of 108,946.587 km<sup>2</sup>

**Notes:** The dorsiventrally flattened petioles is also shared with other species such as *M. bellidifolia* and *M. reniformis*. However, *M. jacobinensis* has suborbicular lobes, stipules semifoliaceous, capsules with acuminate apex and caruncle white (vs. flat leaves with short-lanceolate lobes, stipules setaceous, capsules with rounded apex and caruncle yellow in *M. bellidifolia* and entire, not lobed and reniform leaves, stipules setaceous, capsules with rounded apex and caruncle yellow in *M. reniformis*).

*Manihot jacobinensis* can be confused with *M. violacea* (which occurs in the Central-West region of Brazil) by

the racemose inflorescences, semifoliate bracts and bracteoles, and leaves lobes less than 8 cm long. *Manihot jacobinensis*, however, has suborbicular leaf lobes, erect shrubby habit, and erect and longer (between 10.0 and 15.0 cm) inflorescences (vs. recurved and oblanceolate lateral leaf lobes, prostrate subshrubby habit, and pendulous and short inflorescences < 5.0 cm in *M. violacea*).

**Taxonomic comments:** The type information in the protologue of *M. jacobinensis* was “*In Brasilia Bahiensis in montibus Jacobina (Blanchet n. 2553!)*” without mentioning the depositary herbaria. Rogers and Appan (1973) mentioned the same collection stored at F, G, BM, K, NY, P and W, but they did not propose the lectotypification. Since the main herbarium of Müller Argoviensis is G, we choose the collection G00441885 as lectotype.

**Specimens examined:** BRAZIL. Bahia: Andaraí, Road from Mucugê to Igatu, 28 Jan 2015, T. Carnero 1277 (HUEFS); Andaraí, south of the city heading to Mucugê, near Xique-Xique, 14 Feb 1977, R. M. Harley 18674 (CEPEC); Andaraí, Old Andaraí/Mucugê road via Igatu, 2 km south of Igatu, 23 Dec, S. A. Mori 13196, (CEPEC); Bela Vista, 25 Mar 2004, M. V. Moraes 641 (HUEFS); Bonito, 24 Feb 2012, M. L. L. Martins. 2044 (HURB); Campo Formoso, Morro do Cruzeiro, 15 May 1999, F. França, 2936 (HUEFS); Conde, north coast way to Cavalo Russo, 27 Apr 2014, M. L. Guedes et al., 21600 (ALCB); Feira da Mata, Medium São Francisco, 1 km from the Caririnha River bank, 20 Jul 2007, M. L. Guedes 13660 (HUEFS); Ibicoara, Chapada Diamantina, 13 Oct 2007, M. L. Guedes et al., 13924 (ALCB); Igatu, 17 Feb 2012, A. K. A. Santos 1277 (HUEFS); Jacobina, Jacobina road/Morro do Chapéu, ca. 24 km from the seat of the municipality of Serra do Tombador, 28 Oct 1995, A. M. Amorim 1804 (CEPEC); Jacobina, 2 km road to Feira de Santana, 03 Nov 1987, A. M. de Carvalho 2386 (CEPEC); Jacobina, Serra do Tombador - 10 km East Jacobina, 02 Mar 1978, C. Allem 1751 (CEN); Jacobina, Itaitú village, 16 Nov 2014, B. L. R. Barbosa 7 (HUEFS); Jacobina, Serra of Brite, 05 Jul 1996, H. P. Bautista 3417 (ALCB); Jacobina, 24 Jun 1999, França, F. 3093 (HUEFS); Jacobina, 23 Oct 1990, Freire-Fierro, A 2051 (SPF); Jacobina, On the road to Pico Jacaraguá, 09 Apr 2015, R. M. Harley 57231 (HUEFS); Jacobina, 12 Jun 1996, W. Werneck 889 (CEN); Jacobina, road to Santo Toca Fole, 21 Oct 2021, K. Suarez 03 (PEUFR); Lençóis, Along the BA-850 highway, 25 May 1993, A. Allem 4081 (CEN); Lençóis, access road to the municipality, 26 Jan 1998, A. M. Amorim 2158 (CEPEC); Lençóis, Serra da Chapadinha, Serra do Brejão, 28 Sep 1994, A. M. Giuliatti 882 (CEPEC); Lençóis, Chapada Diamantina, 10 Jul 2004, s/n, (CEPEC); Lençóis, near the city cemetery, 26 Aug 2005, S. F. Conceição, 242 (HUEFS); Lençóis, BR 242, ca. 15 km West of Lençóis, 04 Oct 2007, L. P. Queiroz, 13085 (HUEFS); Morro do Chapéu, Piemonte da Diamantina, 01 May 2006, P. H. Cardoso et al., 72 (ALCB); Morro do Chapéu, Alto do Cruzeiro, 09 Apr 2000, I. Cordeiro 2228 (HUEFS); Morro do

Chapéu, Guariba, 04 May 2007, F. França 5663 (HUEFS); Morro do Chapéu, road to Bonito, 24 Feb 2012, M. L. L. Martins 2041 (HURB); Morro do Chapéu, Guariba Farm, 02 Jul 2007, E. Melo. 498 (HUEFS); Morro do Chapéu, 15 km from the city towards Jacobina, 11 Mar 1996, R. Lima 2240 (CEPEC); Morro do Chapéu, road to ferro doido, 22 Oct 2021, K. Suarez 05 (UFRPE); Mucugê, Poço do Padre Trail, 26 Nov 2016, D. S. Carneiro-Torres 1501 (HUEFS); Mucugê, 21 Jul 1981, J. R. Pirani 1640 (CEPEC); Mucugê, 1 km east to town, 09 Aug 2007, D. S. Pastore 2119 (HUEFS); Mucugê, 30 Oct 2003, C. S. Santana 9 (HUEFS); Palmeiras, 22 Aug 2009, J. C. Brito 121 (HUEFS); Palmeiras, 13 Dec 2016, G. Costa et al., 2332 (HURB); Palmeiras, 12 Mar 1997, P. Gasson PCD6190 (HUEFS); Palmeiras, Chapada Diamantina, 25 Sep 1994, Guedes, ML et al., s/n (ALCB); Palmeiras, BR-242 Highway, 12 Oct 1987, L.P. Queiróz, et al., 1975 (MBM).

**8. *Manihot longiracemosa*** P. Carvalho & M. Martins, Syst. Bot. 39:(2) 487. 2014. Type: —Brazil, Bahia, Municipality of Igatu, Labirinto, 12°53'81" S, 41°19'31.9" W, 16 Nov 2011, M. Martins & P.C.L. Carvalho 1840. Holotype: HUEFS (224331!). Isotypes: CEN (CEN00094334!); HURB (5156!); RB (RB01160799!); SP (488266!). Fig. 8 A-J and Fig. 11 I-K.

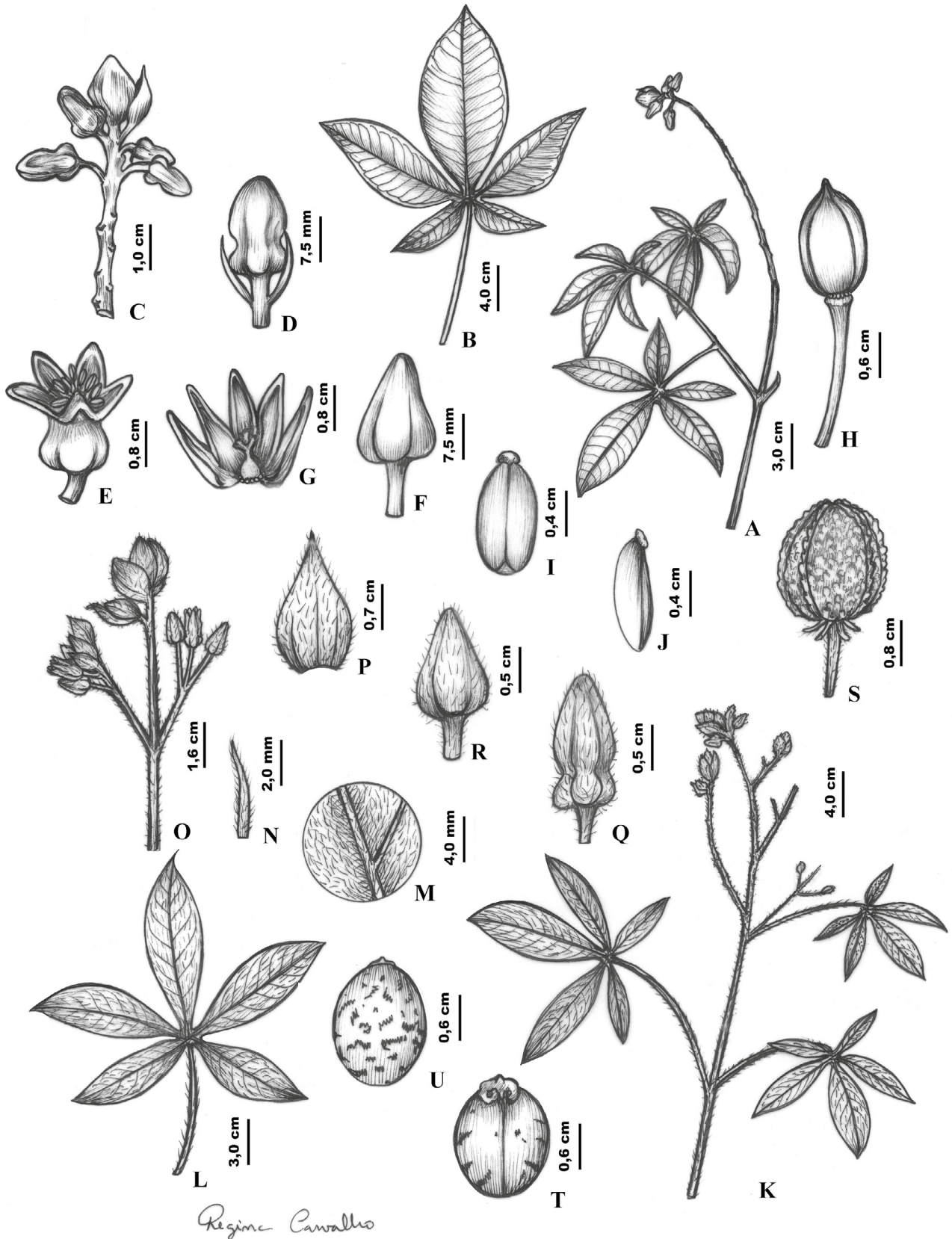
**Shrub** 1–7 m tall, erect. **Roots** not tuberous. **Stem** glabrous, smooth, branches cylindrical, latex white, abundant. **Stipules** setaceous, deciduous, ca. 0.1 mm long, margin entire. **Petioles** cylindrical, (1–) 10–15 cm long, purple, short in apical leaves, glabrous, basally inserted to the lamina. **Leaves** 3–5-lobed, glabrous, lobes lanceolate, adaxial surface green with slightly purplish veins, median lobe (10–)15–21 × 4–8.5 cm, margin entire, apex acuminate, venation camptodromous. **Inflorescence** a single terminal raceme, erect, (15–)20–25(–38) cm long; bracts foliaceous, arched over the floral buds, ovate, apex obtuse, margin entire, greenish-yellow at base and purplish at the apex, pubescent; bracteoles setaceous, apex obtuse, margin entire, greenish-yellow, pubescent along the margins. **Staminate buds** bifusiform, 1.5–2 cm; pedicel 1 cm long. **Staminate flowers** sympetalous, fused to halfway, greenish-yellow, glabrous, staminal disk yellow. **Pistillate buds** 2, pyramidal, 1.5–2 cm long, opposite; pedicel 1 cm long. **Pistillate flowers** apopetalous, greenish-yellow, glabrous. **Capsules** ovoid to elliptic, 1–1.5 cm in diameter, smooth, green with purplish lines, apex acuminate. **Seeds** oblongoid, 1 cm, light grey. **Caruncle** triangular, ca. 0.2 mm long, white.

**Phenology:** Flowering and fruiting all year round.

**Distribution and habitat:** This species is endemic to the Chapada Diamantina Range in Bahia, in rupestrian field vegetation with rock outcrops (Fig. 7).

**Conservation status:** According to IUCN criteria, this species is considered Endangered (EN B1a), with an extent of occurrence less than 5000 km<sup>2</sup>.





**Figure 8.** *Manihot longiracemosa* P. Carvalho & M. Martins, A. Fertile branch, B. Leaf, C. Inflorescence, D. Staminate flower bud, E. Staminate flower, F. Pistillate flower bud, G. Pistillate flower, H. Capsule, I-J. Seed (Suarez et al. 17). *Manihot maracasensis* Ule, K. Fertile branch, L. Leaf, M. Leaf detail, N. Stipule. O. Inflorescence, P. Bract, Q-R. Staminate flower bud, S. Capsule, T-U. Seed (C. Allem 141148).



**Notes:** *Manihot longiracemosa* is similar to *M. jacobinensis* and *M. reflexifolia* in the shrubby habit and racemose inflorescences with foliaceous bracts, but differs from them by the larger leaves with reflexed and short-lanceolate lobes (10–)15–21 × 4–8.5 cm, longer inflorescences (ca. 15 cm), bracts with obtuse apex arching over the bifusiform staminate buds (vs. suborbicular leaf lobes, (2.5–)6–8 × (1.5–)3–4.5 cm, inflorescences less than 15 cm long, bracts with acute semi-reflexed apex in *M. jacobinensis* and short-lanceolate lobes, (3–)5–8(–10) × 1–3 cm inflorescences less than 15 cm long, bracts reflexed with acute apex in *M. reflexifolia*).

**Specimens examined:** BRAZIL. Bahia: Mun. Andaraí, trail Andaraí/Lençóis, 03 Jun 1995, *F. França et al.* 1200 (HUEFS); Mun. Andaraí, Serra do Cornelius, 13 Oct 1942, *R. de Lemos* 12647 (NY); District Igatu, 16 Nov 2011, *M. L. L. Martins* 1840 (CEN, HUEFS, HURB); District Igatu, 29 Sep. 2017, *T. Vieira* 306 (HUEFS); District Igatu, Labirinto, 04 Mar 2009, *N. S. Brito* 20 (HUEFS); road between Vale da Fumacã and Vale da Sucupira, 22 Jan 2010, *B. Russ* 36 (HUEFS); Serra do Sincorá, 05 Oct 2001, *Nonato et al.* 998 (HUEFS); Chapada Diamantina National Park, Ribeirão do Meio, 22 Jan 1996, *E. Ramos* 1266 (CEN); climbing the trail to Pati, 10 May 2003, *Anjos et al. s/n* (ALCB, CEPEC); Mun. Cruz das Almas, Embrapa Mandioca e Fruticultura, Banco Ativo de Germoplasma, 05 Jun 2009, *M. L. L. Martins* 1423 (HURB); Mun. Cruz das Almas, Federal University of the Recôncavo of Bahia, 9 Jun 2022, *K. Suarez* 17 (PEUFR); Embrapa Mandioca e Fruticultura, Banco Ativo de Germoplasma, 17 Mar 2011, *M. L. L. Martins* 1789 (HURB, CEPEC); Mun. Lençóis, Afloramento do Veneno, 02 Oct 2005, *S. Neves et al.*, 51 (HUEFS). Ribeirão Meio, 03 Apr 1996, *L. Werneck* 814 (CEN); trail to Veneno, 05 Jun 2013, *M. L. L. Martins* 2148 (HURB); Mun. Mucugê, 28 km south of Andaraí towards Mucugê, 14 Nov 1984, *C. Allem* 2970 (CEN); Semper-Viva Municipal Park, 31 Oct 2011, *P. Oliveira* 1906 (HUEFS).

**9. *Manihot macrocarpa*** P. Carvalho & M. Martins, Phytotaxa 309(2): 179. 2017. Type:—Brazil, Bahia, Municipality of Ibirapitanga, administrative head office of Área de Proteção Ambiental do Pratigi, near the restaurant, 13°53'51.2" S, 39°27'25.9" W, 691 m. 27 Mar 2013, *M. Martins & C. Ledo* 1928. Holotype: HURB (5202!). Isotypes: CEN (108611!); CEPEC (95603!); HUEFS (108611!); SP (515140!). See Fig. 1 (Martins *et al.* 2017, p. 181).

**Vine**, 10–15 m tall. **Roots** not tuberous. **Stem** glabrous, cylindrical, with evident nodes along the basal portion, latex white. **Stipules** setaceous, deciduous, filiform, ca. 3 mm long, margin entire. **Petioles** cylindrical, voluble, 1–8 cm long, green, glabrous, basally inserted to the lamina. **Leaves** not lobed, glabrous, blade elliptic to oval, base obtuse, blade (5–)10(–12) × 2–5 cm, margin entire, apex acute, venation camptodromous. **Inflorescence** paniculate or rarely racemose, erect to pendulous, 7–11(–15) cm long; bracts and bracteoles setaceous, margin entire, blackened. **Staminate**

**buds** ovoid, 0.8–1.5 × 0.5–0.7 cm, greenish yellow with purple inner spots. **Staminate flowers** sympetalous, fused to 1/3 of the length, glabrous, staminal disk yellowish. **Pistillate buds** 2, pyramidal, 2 × 0.5 cm long, opposite to subopposite; pedicel 1–2 cm long, greenish yellow with purplish spots. **Pistillate flowers** apopetalous, greenish-yellow, glabrous, nectary disk light yellow. **Capsules** globose, (3–)4–5(–5.3) cm in diameter, indehiscent, smooth, green, rarely ribbed, ribs ca. 1 mm long, tenuous. **Seeds** ellipsoid to oblongoid, (2.5–)3.5–4 × 2–2.5 cm, smooth, dark brown, sometimes with small dark spots. **Caruncle** triangular, ca. 1 × 5 mm long, yellowish white.

**Phenology:** Flowering during March and October and fruiting during March, May and June.

**Distribution and habitat:** The species occur in southern Bahia, in montane rain forest, in the Serra do Papuã (Fig. 7). It was found at forest edges, profusely branched, near disturbed areas. Individuals can measure up to 15 m tall.

**Conservation status:** According to IUCN criteria, this species is considered Critically Endangered (CR B1a), with an extent of occurrence less than 100 km<sup>2</sup>.

**Notes:** This species resembles *M. compositifolia* in its vine habit and indehiscent fruits, but it is distinguished by having leaves not lobed, and orbicular fruits (vs. (3–)5(–7) lobed deeply lobed leaves and ellipsoid fruits in *M. compositifolia*).

**Specimens examined:** BRAZIL. Bahia: Ibirapitanga, Serra do Papuã, APA de Pratigi; wood behind the bungalow 1, 15 Mar 2013, *L. Y. S. Aona et al.*, 2516 (HURB); Ibirapitanga, Serra do Papuã, APA de Pratigi, in front of the restaurant, 08 Jun 2022, *K. Suarez* 16 (PEUFR); Itacaré, road between Embratel Tower and highway BR-101/Itacaré, 21 Dec 1979, *S. A. Mori & F. Benton* 12851 (CEPEC).

**10. *Manihot maracasensis*** Ule, Bot. Jahrb. Syst. 42: 221. 1908. Type:—Brazil, Bahia, Municipality of Maracás, Oct 1906, *Ule* 7003. Lectotype **designated here:** HBG (HBG515957! [Image]). Isolectotypes: F (F0BN005457! [Image]); G (G00441862! [Image]); L (L0020819!); NY. Fig. 8 K–U.

**Vine**, 1.5–8 m tall. **Roots** not tuberous. **Stem** glabrous or pubescent, cylindrical, latex pale white, abundant. **Stipules** setaceous, deciduous, filiform, 0.5 mm long, margin entire. **Petioles** cylindrical, 6–12 cm long, pubescent, basally inserted to the lamina. **Leaves** 3–5-lobed, pubescent, lobes elliptic to oblong, median lobe 10–13 × 3–5 cm, margin entire, apex acute, venation camptodromous. **Inflorescence** paniculate erect or pendulous, 8–12 cm long; bracts foliaceous, ovate, apex obtuse, margin entire, greenish to purple, pubescent; bracteoles semifoliaceous, short lanceolate, margin entire, greenish to purple, pubescent. **Staminate buds** ovoid to bifusiform, 1–1.5 × ca. 0.7 cm, greenish to purple. **Staminate flowers** sympetalous, fused to halfway, pubescent, staminal disk yellowish. **Pistillate buds** 2, ovoid to bifusiform, 1–1.5 × 0.6–0.9 cm long, opposite. **Pistillate flowers** apopetalous, greenish-yellow



to purple, pubescent. **Capsules** globose to ovoid, 1.5–2.5 cm in diameter, smooth, with ribs ca. 2 mm long. **Seeds** oblongoid, 1.6 cm, smooth, light brown with small brown spots. **Caruncle** triangular, 3 mm long, yellowish brown.

**Phenology:** Flowering and fruiting from January to May.

**Distribution and habitat:** Bahia, in Caatinga and semideciduous seasonal forest (Fig. 7). It is usually found at forest edges in red clayey soil.

**Conservation status:** According to IUCN criteria, this species is considered Endangered (EN B2a), with an area of occurrence less than 500 km<sup>2</sup>.

**Notes:** Distinguishable by generalized pubescence, paniculate inflorescences with foliaceous bracts and slightly ribbed capsular fruits. *Manihot maracasensis* resembles *M. caerulescens* Pohl because of its stipules, bracts and fruits, but differs by having vine habit, white latex and paniculate inflorescences (vs. shrubby to arboreal habit, yellow latex and racemose inflorescences in *M. caerulescens*). It also resembles *M. brachyandra* Pax & K. Hoffm. by having vine habit, pubescent leaves and paniculate inflorescences, but differs by having foliaceous bracts, lobes elliptic to oblong, 10–13 × 3–5 cm, apex acute and seeds oblong (vs. setaceous bracts, lobes oval 5.0–10.0 × 2.0–5.0 cm, apex acuminate and seeds elliptic), respectively. *Manihot maracasensis* is used as an ornamental plant in the municipality of Rui Barbosa, Bahia. It is locally known as “Maniçoba” (Rogers & Appan 1973).

**Taxonomic comments:** Ule (1908b) cited in the protologue the collection *Ule 7003* from Maracas, in Bahia, without mentioning the depositary herbaria. Rogers and Appan (1973) recognized this specimen as a syntype, but they did not specify the herbarium where it was deposited. Martins (2013) chose the specimen deposited in L, but this choice was not officially published. We choose HBG515957 as lectotype because it is in conformity with the protologue by presenting flowers and leaves and because it is in good condition.

**Specimens examined:** BRAZIL. Bahia: Abaíra, s/n, R.M. Harley, 50515 (NY), Abaíra, 13 Dec 2013, M. L. L. Martins. 2116, (CEPEC); Abaíra, 28 Dec 1992, R.M. Harley et al. 50515 (SP); Andaraí, Km 39 of the Andaraí highway - BR-242, 04 Mar 1978, A.C. Allem 1799 (CEN); Andaraí, Km 39 of the Andaraí highway - BR-242, 04 Mar 1978, A.C. Allem 1800 (CEN); Andaraí, Km 39 of the Andaraí highway - BR-242, 04 Mar 1978, A.C. Allem 1803 (CEN); Andaraí, 14 km from the junction of BR - 242, towards Andaraí, 14 Nov 1984, A.C. Allem 2956 (CEN); Andaraí, 3 km southeast of the junction of highway BR - 242 with the highway that leads to Andaraí, 25 May 1993, A.C. Allem 4083 (CEN); Andaraí, 25 km southeast of the junction of highway BR - 242 with the highway that leads to Andaraí, 25 May 1993, A. C. Allem 4084 (CEN); Andaraí, 25.2 km southeast of the junction of highway BR - 242 with the highway that leads to Andaraí, 06 Feb 1995, A.C. Allem 4512 (CEN); Andaraí, 25.2 km southeast of the junction of highway BR - 242 with

the highway that leads to Andaraí, 06 Feb 1995, A.C. Allem 4513 (CEN); Andaraí, 25.5 km southeast of the junction of highway BR - 242 with the highway that leads to Andaraí, 06 Feb 1995, A.C. Allem 4515 (CEN); Andaraí, 29.1 km from BR-324 to Andaraí, 18 Mar 2010, M. L. L. Martins 2162 (CEPEC); Andaraí, 8 km from the junction of the BR - 242, towards Andaraí, 14 Nov 1984, A.C. Allem .2655 (HUEFS); Andaraí, 15 Nov 1992, M.M. Arbo et al. 5782 (SP); Barra da Estiva, 31 Jul 2012, M. L. L. Martins. 1871 (HURB); Boa Vista do Tupim, Paraguaçu, Fazenda Esperança, 27 Mar 2016, M. Casaes & M. L. Guedes 59 (ALCB); Itaberaba, 25 Sep 2018, M. L. L. Martins. et al. 2233 (HURB); Itaetê, border of the Mucugê/Itaetê highway, right side, 25 Apr 2013, M. L. L. Martins et al. 1970 (HURB); Itaete, 13 Apr 2001, M.L. Guedes et al. 8291 (ALCB); Lajedinho, Chapada Diamantina, 24 Aug 2014, R.S. Souza 78 (HST); Lajedinho, 26 Nov 2014, G.E.L. Macedo 2298 (HUESB); Lençóis, 06 Feb 1995, A.C. Allem 4511 (CEN); Maracás, road to Marcionílio Souza, ca. 12.6 km from the city, 03 Nov 2011, E. Melo 10556 (HUEFS); Marcionílio Souza, 07 Jun 1996, W.L. Werneck 855 (CEN); Ruy Barbosa, 27 Mar 2005, D. Cardoso 385 (HUEFS); Ruy Barbosa, 18 Dec 2004, L.P. de Queiroz 9904 (HUEFS); Ruy Barbosa, 20 Sep 2005, D. Cardoso 782 (CEPEC); Ruy Barbosa, 07 Jun 1996, W.L. Werneck 857 (CEN); Ubiraitá, 3.4 km from BR 324 to Andaraí-Ubiraitá, 18 Apr 2010, M. L. L. Martins 2146 (HURB); Wagner, Road from Morro do Chapéu to Wagner, 107 km from Morro de Chapéu (section between Utinga and Wagner), 16 Apr 1988, R.S. Costa 73 (CEN); Wagner, 2 km from the junction of the BR-242, towards Andaraí, 15 Nov 1984, R.S. Costa 2978 (CEN); Wagner, 11 Mar 2016, M.L. Guedes 24294 (ALCB); Wagner, 11 Mar 2016, M.L. Guedes et al. BIOC05 24318 (ALCB).

**11. *Manihot pandurata*** M. Martins & M. Mend., Novon 26(1): 61, f. 2. 2018. Type:— Brazil, Bahia, Municipality of Cocos, Fazenda Trijunção, road to Guará, 14°40'55" S, 45°50'39" W, 825 m, 12 Dec 2001, M. Fonseca, R.C. Mendonça, B.M.T. Walter & E. Cardoso, 3088. Holotype: CEN (45424!). Isotypes: HUEFS (233766!); SP (361361!). See Fig. 2 (Mendoza & Martins 2018, p. 3).

**Subshrub** 15–25 cm tall, erect to decumbent. **Roots** not seen. **Stem** suberect to decumbent, glabrous, smooth, 2 or 3 arising from a woody base giving the appearance of a reduced caespitose plant, latex white. **Stipules** setaceous, deciduous, linear to linear-lanceolate, margin usually entire sometimes dentate. **Petioles** reduced and slightly canaliculate on the adaxial face, 0.5 mm long. **Leaves** not lobed, sessile to subsessile, spirally alternate and regularly distributed along the stem, glabrous, blade oblong, lanceolate to linear-lanceolate, (5–) 9–11(–12) × (0.5–)1–2.5(–3.5) cm, margin strongly to slightly pandurate, apex acuminate to acuminate-attenuate, base acute to slightly decurrent, venation camptodromous. **Inflorescence** terminal, racemose, 1.5–2.5 cm long; bracts foliaceous, ovate-lanceolate, apex attenuate, margin strongly lacinate, glabrous; bracteoles setaceous and linear. **Staminate buds**

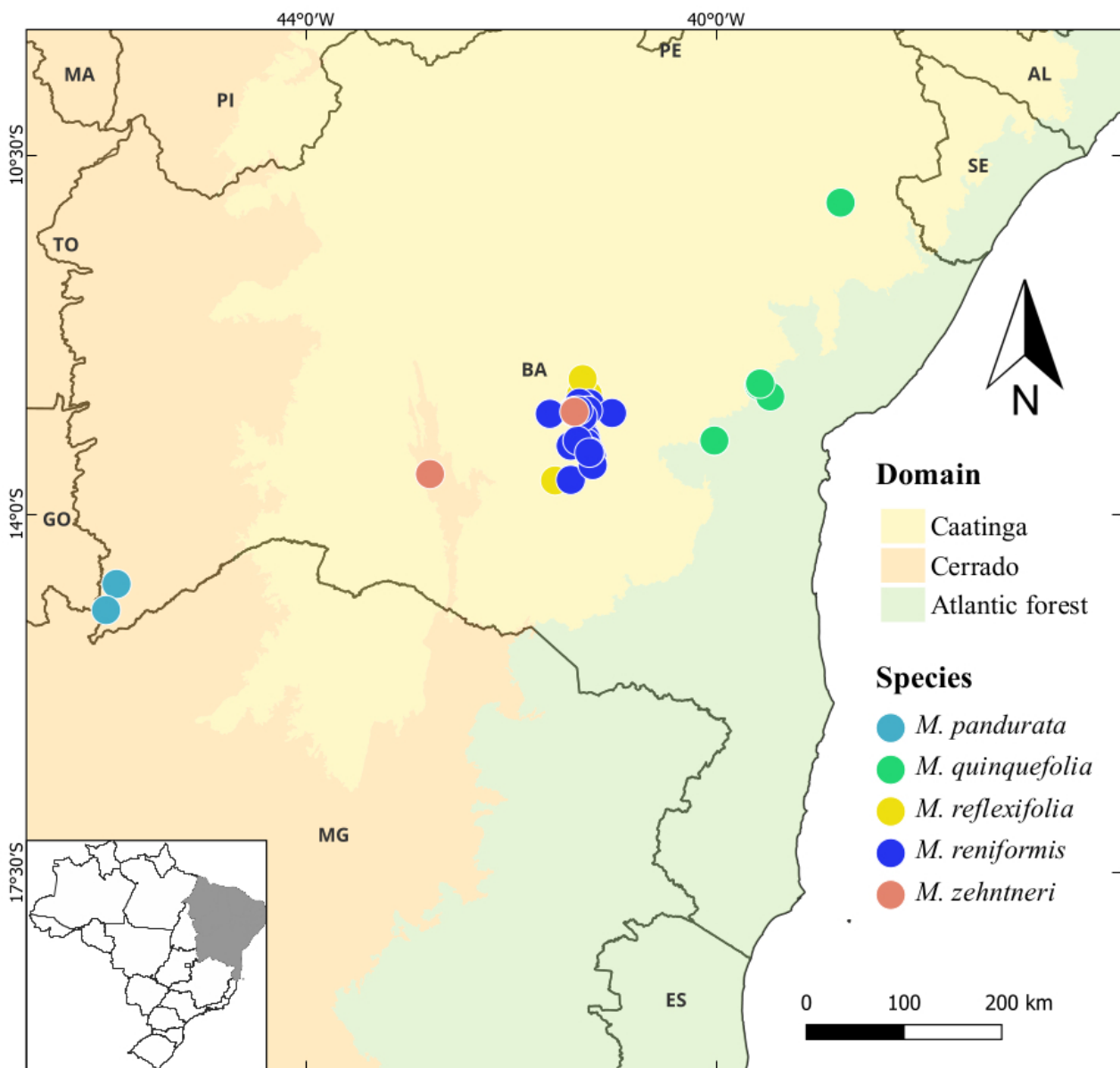
conical, 10–12 × 7–8 mm, greenish to purplish. **Staminate flowers** sympetalous, fused to halfway. **Pistillate buds and pistillate flowers** not seen. **Capsules** short-cylindrical, 1.2–1.3 cm in diameter, pale green, with fine white lines, apex rounded. **Seeds** ellipsoid, 7–8 × 4–5 mm **Caruncle** triangular, slightly prominent.

**Phenology:** Flowering and fruiting in December.

**Distribution and habitat:** This species is restricted to the municipality of Cocos in Bahia, where it grows in sandy soil and in well-preserved fragments of “campo sujo” (cerrado) vegetation, preferentially in shady places (Fig. 9).

**Conservation status:** According to IUCN criteria, this species is considered Critically Endangered (CR B1a), with an extent of occurrence less than 100 km<sup>2</sup>, known only from 2 collections.

**Notes:** *Manihot pandurata* is similar to *M. weddelliana* Baill. in the presence of sessile to subsessile leaves which are neither peltate neither with entire margins, deciduous stipules, inflorescences with lacinate margins and pedicellate flowers, but differs from *M. weddelliana* by having subshrubby habit with two or three suberect to decumbent stems arising from the base, oblong-lanceolate and strongly pandurate leaves (vs. erect habit, 40 to 60 cm tall, with a single erect stem, and linear-lanceolate leaves with irregularly serrate to serrate-toothed margins in *M. weddelliana*). *Manihot pandurata* also resembles *M. salicifolia* Pohl (distributed in the Midwest and North of Brazil) in the presence of sessile to subsessile leaves but differs by presenting pandurate leaf margins (vs. entire margins in *M. salicifolia*).



**Figure 9.** Distribution map of *M. pandurata* M. Martins & M. Mend. and *M. quinquefolia* Pohl, *M. reflexifolia* P. Carvalho & M. Martins, *M. reniformis* Pohl and *M. zehntneri* Ule. species endemic to Northeast Brazil.



**Specimens examined:** BRAZIL. Bahia: Cocos, Trijunção farm, 12 Dec 2001, *M.L. Fonseca et al.* 3088 (HUEFS); Cocos, Santa Luzia farm, campo sujo, 13 Dec 2001, *M. C. Mendonça* 4632 (HUEFS); Cocos, Fazenda Trijunção, 10 Dec. 2001, *M. L. Fonseca et al.* 3027 (HUEFS).

**12. *Manihot quinquefolia*** Pohl, Pl. Bras. Icon. Descr. 1: 56. 1827. Type:—Brazil, Bahia, near Sincorá, *Martius s.n.* Lectotype: M (M0233289!). Isolectotype: G (G00441834!). See Fig. 4 (Martins et al. 2018, p. 6).

**Shrub** 1.5–4 m tall, erect. **Roots** not tuberous. **Stem** glabrous, smooth, cylindrical, with evident nodes on upper branches, latex creamy with light consistency. **Stipules** setaceous, deciduous, filiform, 1.5 mm long, margin entire, greenish. **Petioles** cylindrical, 5–7 cm long, greenish, glabrous, basally inserted to the lamina. **Leaves** 5 (3) deeply lobed, with a large constriction at the base of the lobes, rarely spontaneously deciduous, abaxial surface glaucous, adaxial surface green, glabrous, lobe elliptic, median lobe (3–)4(–5) × ca. 1.5 cm, margin slightly pandurate, apex acuminate, venation camptodromous. **Inflorescence** racemose, pendulous, 6–14 cm long; bracts semifoliateous, linear, yellowish, glabrous; bracteoles setaceous, linear, yellowish, glabrous. **Staminate buds** ovoid, 5–7 × 3–5 mm. **Staminate flowers** sympetalous, fused to halfway, greenish, glabrous, staminal disk yellowish. **Pistillate buds** 2, ovoid, 6 × 5 mm long, opposite. **Pistillate flowers** apopetalous, with vinaceous lines on the outside, glabrous, nectary disk slightly yellowish. **Capsules** globose to slightly ovoid, 1–1.5 cm in diameter, smooth, green with white lines on septa, apex rounded. **Seeds** oblongoid, 1 × 0.5 cm, brown, with small dark spots. **Caruncle** triangular, ca. 2 mm long, yellowish.

**Phenology:** Flowering and fruiting in January, August, October, November and December.

**Distribution and habitat:** Bahia. Shrubby Caatinga vegetation, in rocky and sandy clayey soil (Fig. 9).

**Conservation status:** According to IUCN criteria, this species is considered Endangered (EN B1a), with an extent of occurrence less than 5000 km<sup>2</sup>.

**Notes:** Martins (2013) proposed that *M. quinquefolia* was probably extinct, because the species was known from only a single collection made by Pohl in 1827. However, Martins et al. (2018) rediscovered the species in the Municipality of Santa Terezinha, in Caatinga vegetation. *Manihot quinquefolia* resembles *M. compositifolia*, but differs by its erect habit, semifoliateous bracts and capsular fruits (vs. vine habit, inconspicuous bracts, and baccaceous fruits in *M. compositifolia*).

**Specimens examined** BRAZIL. Bahia: Santa Teresinha, 15 Aug 2010, *M. L. L. Martins et al.* 1661 (HURB); Santa Teresinha, 14 Oct 2010, *M. L. L. Martins et al.* 1706 (HURB); Santa Teresinha, 16 Nov 2011, *M. L. L. Martins* 1847 (FLOR); Santa Teresinha, 15 Feb 2018, *G. Costa* 3251 (HUEFS); Tucano, 01 Jun 2013, *G. Costa* 852 (HURB).

**13. *Manihot reflexifolia*** P. Carvalho & M. Martins, Pl. Syst. Evol., 305, p 671. 2019. Type:—Brazil, Bahia, Municipality of Mucugê, rock field ca. 3.0 km from the Byzantine cemetery, next to Escola Agrotécnica, 13°53'51.2" S, 39°27'25.9" W, 691 m. 24 Apr 2013, *M.L.L. Martins, P.C.L. Carvalho, C.A.S. Ledo, L. Reis, L. Pimentel*, 1965. Holotype: HURB (5476!). Isotypes: CEN; CEPEC (1965!); MBM (435052!). See Fig. 7 (Santos et al. 2019, p. 10) and Fig. 11 L–N.

**Shrub** 1–3 m tall, erect. **Roots** not tuberous. **Stem** glabrous, smooth, branches cylindrical, latex white to lightly cream, translucent, abundant. **Stipules** setaceous, deciduous, margin entire. **Petioles** cylindrical, (2–) 6–9 (–11) cm long, purple, glabrous, basally inserted to the lamina. **Leaves** 3–5-lobed, glabrous, green, abaxial surface lighter, lobes elliptic to lanceolate, reflexed to semi-reflexed, median lobe (3–)5–8(–10) × 1–3 cm, margin revolute, apex acuminate, venation camptodromous. **Inflorescence** terminal, racemose, 6–15(–25) cm long; bracts foliaceous, ovate lanceolate, apex acute semi-reflexed, margin entire, cream to purple; bracteoles semifoliateous, ovate to lanceolate, apex acute semi-reflexed, cream to purple, glabrous. **Staminate buds** bifusiform, 0.8–1.2 × ca. 0.7 cm; pedicel 0.5–0.8 cm long, purple, glabrous. **Staminate flowers** sympetalous, fused to halfway, purple, glabrous, staminal disk yellowish. **Pistillate buds** 1 or 2, pyramidal, 1–1.5 × ca. 0.5, purple; pedicel 5–10 cm long. **Pistillate flowers** apopetalous, purple, glabrous, nectary disk light yellow. **Capsules** globose to ovoid, 1–1.5 cm in diameter, smooth, green with purple lines, apex rounded or apiculate. **Seeds** ovoid, 1 cm long, grayish brown with dark brown spots. **Caruncle** slightly triangular, ca. 2 mm long, yellowish.

**Phenology:** Flowering and fruiting all year round.

**Distribution and habitat:** Bahia, Municipality of Mucugê, restricted to the Chapada Diamantina, in the municipality of Mucugê, on rocky outcrops with open shrub vegetation and sandy soil (Fig. 9).

**Conservation status:** According to IUCN criteria, this species is considered Endangered (EN B1a), with an extent of occurrence less than 5000 km<sup>2</sup>. Fires constantly affect the areas where the species lives.

**Notes:** *Manihot reflexifolia* is similar to other species occurring in the Chapada Diamantina, such as *M. jacobinensis* and *M. longiracemosa*, sharing with them characteristics such as the foliaceous bracts, racemose inflorescences and bifusiform staminate buds (Rogers & Appan 1973; Martins et al. 2014), but *M. reflexifolia* differs by the reflexed and lanceolate leaves, (3–)5–8(–10) × 1–3 cm, setaceous stipules, cylindrical petioles, and bracts with semi-reflexed and acute apices (vs. elliptic-round leaves, (10–)15–21 × 4–8.5 cm, semifoliateous stipules, dorsiventrally flattened petioles in *M. jacobinensis* and long-lanceolate leaves and bracts with obtuse apices arching over the floral buds in *M. longiracemosa*).

**Specimens examined:** BRAZIL. Bahia: Andaraí, Road from Andaraí to Mucugê at 28 km, 16 Apr 1988, *R. Costa* 74 (CEN); Andaraí, Bank of the Paraguaçu River, 16 Dec 2006, *F. França* 5594 (HUEFS); Mucugê, 4 km on Mucugê Andaraí Road, s/n, *A. M. V. de Carvalho* 3081 (NY); Mucugê, 2 km north of Mucugê, on the way to Andaraí, s/n, *M. M. Arbo* 75 (NY); Mucugê, Semper Viva Park - Trail to the Andorinhas waterfall, 16 Jun 2018; *Gama, H. et al.*, 38 (ALCB); Mucugê, Sustainable Management Unit, 03 Jan 1997, *H. P. Bautista et al.*, 45 (MBM); Mucugê, trail to Siberia, 26 Jun 1993, *M. C. Ferreira* 488 (MBM); Mucugê, km 5 Mucugê-Andaraí, 04 Mar 1978, *A. Allem & G. Vieira* 1978 (MNHN); Mucugê, 09 Aug 2007, *J.F.B. Pastore* 2197 (HUEFS); Mucugê, highway to Andaraí, 16 Aug 1984, *G. Hatschbach* 47974 (MBM); Mucugê, close to the Cumbuca River, 3 km North in the city, Rodoviária to Andaraí, 06 Jan 1982, *R. M. Harley* 15987 (CEPEC); Mucugê, about BA-245, 7.1 km to Andaraí from Mucugê, 25 Oct 2021, *K. Suarez* 9 (PEUFR).

**14. *Manihot reniformis*** Pohl, Pl. Bras. Icon. Descr. 1: 56, 1827. Type:— Brazil, Bahia, Serra de Sincorá, 1818. *Martius* 1935. Lectotype **designated here:** M (M0233293 Image!). Isolectotypes: G (G00441908! [Image]); K (K000600414!); L (L0020821!); M (M0233290! [Image]); MO (MO260659! [Image]). Fig. 10 A-I and Fig. 11 O-T.

**Shrub** 0.8-2 m tall, erect. **Roots** not tuberous. **Stem** glabrous, smooth, cylindrical, latex white. **Stipules** setaceous, deciduous, margin entire. **Petioles** dorsiventrally flattened, 2.0-5 cm long, glabrous, peltate insertion to the lamina. **Leaves** not lobed, glabrous, green with purple ribs, abaxial face lighter, blade reniform to cordate, leaves arranged parallel to the stem axis, blade (4)5–8 × 3–6 cm, margin entire, apex acuminate, base cordate, venation camptodromous. **Inflorescence** terminal, racemose, 6–15(–25) cm long, bracts foliaceous, ovate, pink to purple along the margin and at the apex, margin entire to serrate, glabrous, bracteoles 2, semifoliaceous, ovate, white-pink, margin entire, apex acute, glabrous. **Staminate buds** bifusiform, 0.8–1.2 × 0.5 cm; pedicel 1.0 cm long. **Staminate flowers** sympetalous, fused to 2/3 of the length, greenish yellow with purple margin, glabrous, staminal disk white. **Pistillate buds** 2, bifusiform, 1–1.5 × 0.5–0.7 cm, opposite to subopposite; pedicel 1 cm long. **Pistillate flowers** apopetalous, green to purple with purple lines. **Capsules** globose to oval, ca. 1 cm in diameter, smooth, green from base to apex with purplish dehiscence lines, apex rounded or slightly pointed. **Seeds** oblongoid, 0.5–0.8 cm long, greyish-brown. **Caruncle** triangular, ca. 2 mm long, yellowish.

**Phenology:** Flowering and fruiting all year round.

**Distribution and habitat:** Bahia, endemic to areas of rupestrian field vegetation in the southern region of the Chapada Diamantina. There is a large population that can be found on the edges of the road BA-142 growing on rocky and sandy soil (Fig. 9).

**Conservation status:** According to IUCN criteria, this species is considered Endangered (EN B1a), with an extent of occurrence less than 5000 km<sup>2</sup>.

**Notes:** *Manihot reniformis* is recognized by having petioles dorsiventrally flattened, reniform leaves with a chordate base and oriented parallel to the stem axis.

**Taxonomic comments:** Pohl (1827) mentioned in the protologue “*Habitat in locis petrosis aridis in adscensu orientali Serra de Sincora, capitania Bahiensis. Lecta mensi Novembri a Celeb. Dni. Eqn. de Martius*”. Johann Baptist von Spix and Carl Friedrich Martius traveled through Brazil from 1817 to 1820 (see Spix & Martius 1817-1820) collecting specimens of the fauna and flora, and according to the diary of this expedition, Martius passed through the place (Sincorá mountain range) indicated in the original description of *M. reniformis* in 1818.

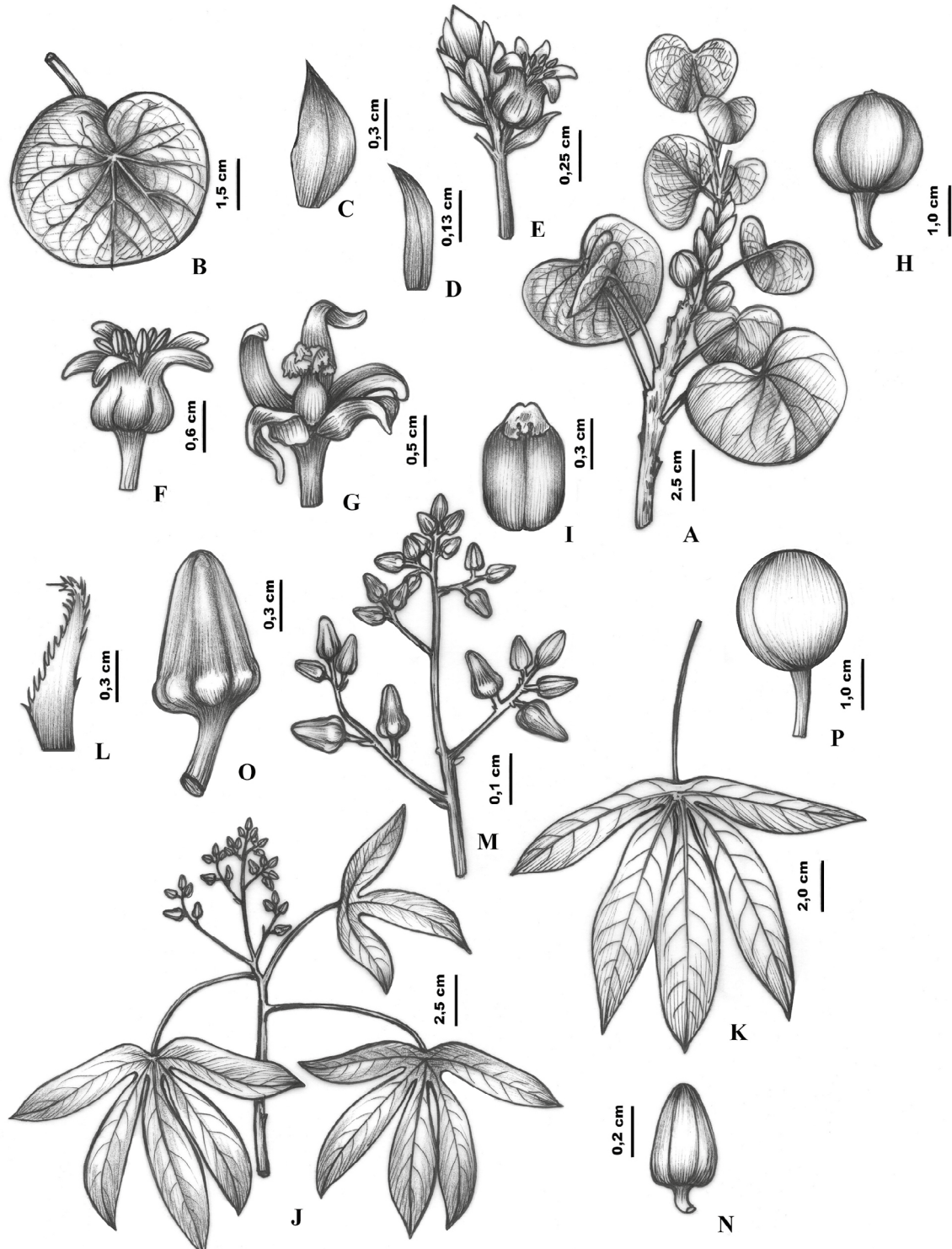
Based on the indicated location and date, Müller (1866), Pax (1910) and Rogers and Appan (1973) recognized the specimen *Martius n. 1935* as the collection type, which corresponds to the date of the trip. However, they did not specify the herbarium where it was deposited. Specimens of this collection were found in G, K, L, M and MO. The herbarium M was chosen as depositary of the lectotype because most of the collections made by Martius in Brazil are found in this institution. However, two specimens of *Martius n. 1935* were located in M. In this sense, we selected M0233293 as the lectotype because it is in conformity with the protologue by presenting flowers and because it is in good condition.

**Specimens examined:** BRAZIL. Bahia: Andaraí, road to Mucugê, 02 Mar 2008, *E. Melo* 5492 (HUEFS); Andaraí, right bank road towards Mucugê/Andaraí, 14 Sep 2018, *J.E.Q. Faria & T. N. Vasconcelos* 5918 (HEPH); Barra da Estiva, Serra do Sincorá Chapada Diamantina 23 Mar 1980, *R.M. Harley* 20806 (CEPEC); Barra da Estiva, Serra do Sincorá Chapada Diamantina, 07 Mar 1996, *F.R. Salimena-Pires et al.*, PCD2142 (ALCB); Cascavel, Western edge of the PNCD, 24 Mar 2005, *R. Funch* 753 (HUEFS); Ibicoara, Gerais do Licuri, Chapada Diamantina, 25 Jun 2012, *H.A. Ogasawara & G.B. Siqueira* 230 (ALCB); Ibicoara, Pau Ferrada Batava/Baixão, 12 Jan 2005, *R. Funch*, 466 (HUEFS); Ibicoara, Machombongo, Chapada Diamantina area around the Toca, 20 Sep 2012, *K.M. Pimenta*, 479 (HUEFS); Ibicoara, way to Brejão Campo Redondo, 23 Apr 2013, *M.L.L. Martins et al.*, 1963 (HURB); Ibicoara, surroundings of Licuri waterfall, 28 Jan 2018, *C.S. Santana*, 8 (HUEFS); Ibicoara, 06 Mar 2005, *P.D. Carvalho*, 79 (HUEFS); Iramaia, road from Iramaia to Ibicoara, 08 Oct 2014, *M.L.L. Martins* 2152 (CEPEC); Mucugê, Right side of the Piabas River bridge, 04 Apr 1996, *W.L. Werneck*, 815 (CEN); Mucugê, Km 4 of the Mucugê - Andaraí highway (Serra do Sincorá), 04 Apr 1978, *A. C. Allem*. 1784 (CEN); Mucugê, Km 14 of the Mucugê - Andaraí highway (Serra do Sincorá), 04 Apr 1978, *A. C. Allem*. 1790 (CEN); Mucugê, 28 km south of Andaraí towards Mucugê, 14 Nov 1984, *A. C. Allem*. 2969 (CEN); Mucugê, about BA-245, 5.2

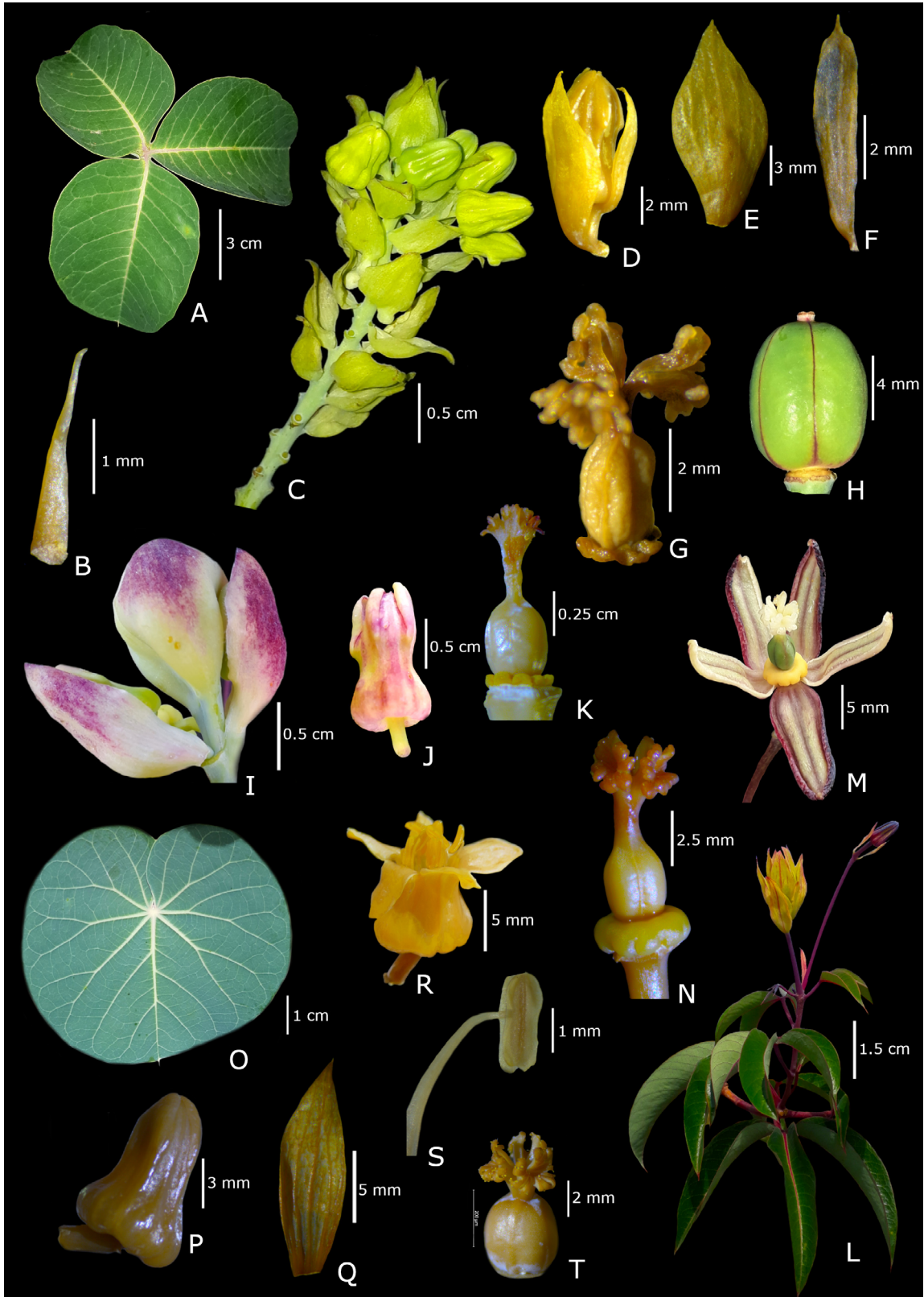


km to Andaraí from Mucugê, 25 Oct 2021, *K. Suarez*. 10, 1 (PEUFR); Mucugê, Exactly 26 km ahead of the bridge over the Paraguaçu River (Andaraí), along the road, 06 Feb 1995, *A. C. Allem*. 4515 (CEN); Mucugê, Chapada Diamantina, 15 Feb 2003, *Barbosa, et al.* 04 (ALCB); Mucugê, 17 Feb 2016,

, *E.S. Chaves* 97 (HUEFS); Mucugê, Chapada Diamantina, 11 Oct 1998, *S. B. Silva* 103 (ALCB); Mucugê, Chapada Diamantina, Boiadeiro stream, 29 Apr 2011, *F. Hurbath*, 128 (ALCB); Mucugê, Chapada Diamantina, Semper Viva project area, 27 Sep 2002, *M. J. Andrade*, 145 (HUEFS).



**Figure 10.** *Manihot reniformis* Pohl, A. Fertile branch, B. Leaf, C. Bract, D. Bracteole, E. Inflorescence, F. Staminate flower, G. Pistillate flower, H. Capsule, I. Seed (*Suarez K. 10, 1*). *Manihot zehntneri* Ule, J. Fertile branch, K. Leaf, L. Stipule, M. Inflorescence, N. Staminate flower bud, O. Pistillate flower bud, P. Capsule (*Martins M.L.L. 2114, Zehntner 598*).



**Figure 11.** *Manihot jacobinensis* Mull.Arg., A. Leaf, B. Stipule, C. Inflorescence, D. Staminate flower bud with bract and bracteole, E. Detail of bract, F. Detail of bracteole, G. Detail of pistillate flower, H. Capsule. *Manihot longiracemosa* P. Carvalho & M. Martins, I. Inflorescence, J. Staminate flower bud, K. Detail of pistillate flower. *Manihot reflexifolia* P. Carvalho & M. Martins, L. Fertile branch, M. Pistillate flower, N. Detail of pistillate flower. *Manihot reniformis* Pohl, O. Leaf, P. Staminate flower bud, Q. Bract, R. Staminate flower, S. Detail of anther, T. detail of pistillate flower.



**15. *Manihot zehntneri*** Ule, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 114: 10. 1914. Type:— Brazil, Bahia, Riacho de Santa Anna, 21 Nov 1912, *Zehntner 598*. Lectotype **designated here**: R (R000006811). Isolectotypes: IAN (6225! [Image]); F; M [M0233303! [Image]]. Fig 10 J-P.

Shrub **or tree** 1–3(4) m tall, erect. **Roots** tuberous and elongate. **Stem** glabrous, smooth, cylindrical, with swollen knots, latex white. **Stipules** foliaceous, persistent, triangular, margin lacinate. **Petioles** cylindrical, 5–15 cm long, greenish, peltate insertion to the lamina. **Leaves** 3–5–7-lobed, glabrous, green, lobes oblong, median lobe 10–18 × 3–7 cm, margin entire, apex acute, venation camptodromous, leaves close to inflorescences simple (not lobed). **Inflorescence** terminal, paniculate, 6–9 cm long, bracts and bracteoles setaceous and filiform. **Staminate buds** ovoid, 0.2–0.5 cm; pedicel 0.1 mm long. **Staminate flowers** sympetalous, fused to halfway, light green with purple base. **Pistillate buds** pyramidal, 0.5–1 cm long; pedicel 0.5–0.8 cm long. **Pistillate flowers** apopetalous, creamy green, glabrous. **Capsules** globose, 1.5 × 2 cm in diameter, smooth, green, apex rounded. **Seeds** ovoid, smooth. **Caruncle** triangular.

**Phenology:** Flowering and fruiting from September to December.

**Distribution and habitat:** Bahia, in Caatinga, found in anthropic areas of Riacho de Santana and Mucugê (Fig. 9).

**Conservation status:** According to IUCN criteria, this species is considered Critically Endangered (CR B1a), with an extent of occurrence less than 100 km<sup>2</sup>. Known only from 2 localities.

**Notes:** *Manihot zehntneri* resembles *M. esculenta* in the shrubby habit and stems with swollen knots. For this reason, Martins (2013) suggested *M. zehntneri* as a probable synonym of *M. esculenta*. However, *M. zehntneri* differs from *M. esculenta* by having a shrubby or arboreal habit, stipules with lacinate margins, oblong leaf lobes and more than 10 cm long (vs. shrubby habit, stipules with entire margins and oval to elliptic leaf lobes less than 10 cm long in *M. esculenta*). *Manihot zehntneri* was described as a weed capable of invading newly created urban spaces, and it is frequently found on limestone-derived and well-drained soils (Nassar et al. 2008).

**Taxonomic comments:** The collection “*Wildwachsend bei Riacho de Sant Anna, 21 November 1912 (L. Zehntner n. 598)*” was mentioned in the protologue of *M. zehntneri* without giving any information about the depositary herbaria. Rogers and Appan (1973) mentioned the same collection stored at F and NY as the type of *M. zehntneri*, but they did not clearly indicate in which herbarium the lectotype was deposited. We chose the specimen deposited in R (R000006811) because it has flowers and fruits, it is in conformity with the protologue, and it is in good condition.

**Specimens examined:** BRAZIL. Bahia: Riacho de Santana, 12 Nov 2013, *M.L.L Martins 2114* (CEPEC); Riacho

de Santa Anna, 21 Nov 1912, *Zehntner 598* (R); Mucugê, In front of the gas station, next to the Byzantine cemetery, 26 Sep 2018. *M.L.L Martins et al. 2231* (HURB).

## Discussion

Rogers and Appan (1973) reported 10 species distributed exclusively in Northeast Brazil, five of which remain with this endemic distribution until the present day. The catalog *Flora e Funga do Brasil* (2020) reports 17 endemic species to the Northeast, but in this work, we consider 15 of them. *Manihot fortalezensis* Nassar, Ribeiro, D. G., Bomfim & P.T.C. Gomes, is originating from a hybridization process between *M. esculenta* and *M. glaziovii* Müll. Arg (Nassar et al. 2011) and is known only by one collection with six duplicates, without reproductive organs, that were obtained from a living collection of the experimental station of the University of Brasilia. Because of this we don't include in this treatment.

*Manihot pohliana* was also not included in this treatment. This species was described by Müller (1874) based on one specimen, which is currently quite deteriorated and do not allow the observation of the main characteristics of the species. Pax (1910) renamed this entity to *M. johaniis* considering that the epithet was preempted by *M. pohlli* Wavra. Rogers and Appan (1973) were unable to make an adequate classification based on the state of the material and treated it as a “dubia species”. Allem (2001) suggested the synonymization of *M. johannis* under *Manihot carthagenensis* subsp. *glaziovii* (Müll.Arg.) Allem. Recently, this subspecies was synonymized to *Manihot glaziovii* Müll. Arg. by Da Silveira et al. (2019) which does not have an endemic distribution for Northeast Brazil, for this reason, we do not consider the species in the present study.

The conservation status proposed by other authors is confirmed in this study for 13 species (Martins 2013; Martins et al. 2017; Martins et al. 2018; Santos et al. 2019). The only two modifications concern the status of *M. quinquefolia*, which is being changed from Least Concern, proposed by Martins et al. (2018), to Endangered, and of *M. maracasensis*, which is being changed from Vulnerable, proposed by Martins (2013), to Endangered. Currently, only *M. dichotoma* is included in the IUCN list of threatened species (Fernandez et al. 2021; IUCN 2022) in the category of Least Concern. Although the distribution range of this species increased, its conservation status remains the same. None of the species reported here as endemic are included in any category of threat in the National Center for the Conservation of Flora (CNC Flora 2012).

In Northeast Brazil, *M. dichotoma* occupies small areas in Caatinga and Cerrado, which are, therefore, biomes biogeographically relevant for the study of this taxon (Nassar et al. 2008; Duputié et al. 2011). Caatinga, Cerrado and Atlantic Forest are recognized as biodiversity hotspots for their high richness and endemism levels of different



biological groups (Klink & Machado 2005). These biomes are considered seriously threatened mainly due to habitat loss and fragmentation, introduction of exotic species, environmental pollution, and climate change (Newbold *et al.* 2015). Despite a restricted and irregular rainfall regime and a semi-arid climate with predominance of seasonally dry forests, Caatinga is an important center of diversity and endemism in Brazil (Werneck *et al.* 2011; Simões *et al.* 2020). *Manihot* species from the Caatinga were predominantly trees to subshrubs, those from Cerrado were predominantly shrubs, and those from Atlantic Forest were exclusively vines. This pattern of predominance of habits in each domain has already been identified in other studies and is related to the nutrient availability and environmental conditions (Rogers & Appan 1973; Nassar *et al.* 2008; Simon *et al.* 2022).

The areas with the highest species richness are associated with the Espinhaço Range which is a mountain chain extending from the state of Minas Gerais to the state of Bahia recognized as an important center diversity (Bitencourt & Rapini 2013; Campos *et al.* 2017), housing approximately 10% of the plant diversity recorded in Brazil (Rapini 2010). Our results showed that the Espinhaço Range, specifically the Chapada Diamantina, has a great richness of *Manihot* species endemic to Cerrado, with two species restricted to the Chapada Diamantina park, which is characterized by rupestrian field vegetation and presents one of the highest levels of plant endemism in Brazil (Giulietti & Pirani 1987; Rapini *et al.* 2008; Bitencourt & Rapini 2013). However, despite their ecological importance, these ecosystems are greatly underestimated and are being threatened by exploitation processes (Fernandes *et al.* 2020).

The remarkable presence of endemic *Manihot* species in the Chapada Diamantina has been reported in other studies (Duputié *et al.* 2011; Martins 2013; Simon *et al.* 2022) and is explained by a combination of several factors such as the large altitude range provided by the mountainous topography and the intersections between Caatinga, Cerrado and Atlantic Forest. This scenery provides conditions for the establishment of plant lineages with different requirements, leading to high levels of endemism and diversity.

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## Authors' contributions

KYSC designed the study, reviewed herbarium specimen, performed data curation, analyzed and interpreted the data and wrote the manuscript. MLLM data curation, reviewed herbarium specimen and wrote the manuscript. SADS designed the study, analyzed and interpreted the data, wrote the manuscript and research funding.

## Conflict of interest

The authors declare that there is no conflict of interest.

## Supplementary material

The following online material is available for this article:

**Figure S1.** Altitude range of *Manihot* species endemic to Northeast Brazil.

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