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Research

Manihot alterniflora and *M. elongata* spp. nov. (Euphorbiaceae) and the rediscovery of *M. quinquefolia* in Caatinga (semiarid) vegetation in Brazil

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We describe and illustrate two species of *Manihot* that occur in Caatinga (semiarid) vegetation in Brazil and redescribe and lectotypify *M. quinquefolia* Pohl, which was only known from a single collection made by J. E. B. Pohl in 1827. *Manihot elongata* P.Carvalho & M.Martins is widely distributed and *Manihot alterniflora* P.Carvalho & M.Martins is endangered because of its small populations and restricted area of occurrence. We establish *M. quinquefolia* as the only species of *Manihot* in the Caatinga with compound leaves. An identification key is provided for the 13 species of *Manihot* present in the Caatinga.

Introduction

Manihot Mill. (1754) is a neotropical genus with about 90 species that occur in Brazil (Rogers and Appan 1973, Flora do Brasil 2020). Cassava (*Manihot esculenta* Crantz) is a major source of starch in the world and is an important component of the human diet in many developing countries (FAO 2009). The taxonomy of *Manihot* has received considerable attention in recent years with the publication of new species, identification keys, and illustrations of many wild species (Martins et al. 2011, 2014, Carmo et al. 2013, Neves et al. 2014, Mendoza 2016, Silva 2016, Silva et al. 2016).

Researchers at the National Research Center for Manioc and Fruticulture (CNPMPF/EMBRAPA) and the Federal University of Recôncavo of Bahia (UFRB) have been collecting and conserving *Manihot* species since 2010 to better understand the distribution and conservation status of the taxa (Ledo et al. 2010, Martins 2013). These species have been collected in the Atlantic Forest, savannas and Caatinga. The latter biome is typically semiarid, shrubby vegetation that is widely distributed in northeastern Brazil.



During this work, two new species of *Manihot* from the Caatinga were found. Of these, *Manihot elongata* is widely distributed in different vegetation types in Caatinga in Bahia State, Brazil while *Manihot alterniflora* is considered endangered, based on IUCN (2001) criteria, because of its small populations and restricted area of occurrence in Bahia. *Manihot quinquefolia* Pohl (1827), previously known only from the type material and described as early as in 1827 (Pohl 1827), is redescribed based on collections from the municipalities of Santa Terezinha and Tucano, Bahia. Descriptions of these species and estimates of their conservation status are based on field observations, plants maintained in the wild species collections of *Manihot* at CNPMF/EMBRAPA and UFRB, and analyses of herbarium collections at ALCB, ASE, CEN, CEPEC, EAC, ESA, F, HB, HPBR, HRB, HST, HUEFS, HURB, HVASE, IAN, IBGE, ICN, IMA, IPA, K, JPB, K, MBML, MG, NY, PEUFR, R, RB, SP, SPF, UPF, UFRN, UNB and US.

***Manihot alterniflora* P. Carvalho & M. Martins sp. nov.**
(Fig. 1)

A species resembling *M. carthagenensis* Müll.Arg. (1866) by its obovate leaf lobes, persistent stipules ca 4×3 mm, and orbicular fruits, but differing by its subshrub habit (< 0.5 m), racemose inflorescences with alternate, pistillate flowers, and caruncle that extends beyond the apex of the seed (ca 4 mm long). (*M. carthagenensis* has a shrub or arboreal habit (> 1.5 m), paniculate inflorescences with opposite, pistillate flowers, and caruncle restricted to the ventral part of the seed (< 2 mm long)).

Type: Brazil. Bahia, Municipality of Jussara, $10^{\circ}44'7.8''S$, $41^{\circ}14'50.9''W$, 475 m a.s.l., 13 Mar 2010, M. Martins, Carvalho, P. C. L. and Ledo, C. A. S. 1740 (holotype: HURB!, isotypes: CEN!, CEPEC!, HUEFS!, K!, NY!, P!, RB!).

Description

Subshrub, up to 50 cm tall, erect or prostrate. Roots not tuberous. Stem glabrous, smooth, cylindrical. Stipules ovate, ca 4×3 mm, persistent, with lacinate margin. Leaves simple, 3–5-lobed, rarely entire, glaucous green, slightly bluish, their median lobe obovate, $6.5\text{--}9.0 \times 2.5\text{--}4.0$ cm, entire to pandurate along margin; venation camptodromous; petioles $4.5\text{--}8.5$ cm long, cylindrical, greenish, basally inserted. Inflorescence a single pseudoterminal raceme, $9.5\text{--}12.5$ cm long; bracts semifoliaceous, entire, ca 3 mm long; bracteoles semifoliaceous, entire or lacinate, ca 2 mm long. Staminate buds $0.9\text{--}1.2 \times 0.6\text{--}0.8$ cm, orbicular to ovoid; pedicel $2.5\text{--}4.2$ cm long; staminate flowers ca $1.2 \times 0.4\text{--}0.6$ cm, ovoid; sepals 5, fused up to halfway, green with purplish lines, glabrous. Stamens 10, in two whorls; staminal disc white. Pistillate buds 2, alternate, ovoid, $0.7\text{--}1.0 \times 0.5$ cm; pistillate flowers ovoid, ca 1.0×0.5 cm; sepals 5, creamy green, glabrous, free; disc light yellow. Capsules ca 2 cm in diameter, orbicular, green; sepals caducous. Seeds ca 1.5×0.6 cm, ellipsoid, with

flattened inner face, gray, with small, dark spots, caruncle ca 4 mm long, light yellow, at apex with slight central recess, extending beyond the apex of the seed.

Phenology

Plants were observed at flowering and fruiting reproductive stages in February and March, and while under cultivation at UFRB from October to May.

Distribution and habitat

There are records of *Manihot alterniflora* from only three localities in northwestern Bahia State, including relatively large populations in the understory of shrubby Caatinga vegetation at 475–600 m a.s.l. (Fig. 2).

Etymology

The name of this species refers to the position of the pistillate flowers on the inflorescence.

Conservation status

Considered 'Critically Endangered' (CR B1a; IUCN, 2001) due to its small extent of occurrence (less than 100 km²).

Additional specimens examined (paratypes)

Brazil. Bahia, Municipality of Jussara, Baixão dos Honoratos, $11^{\circ}05'S$, $41^{\circ}49'W$, 600 m a.s.l., 3 Apr 1984, fl. and fr., O. A. Salgado and H. P. Bautista 342 (CEPEC); Municipality of Sento Sé, road Jussara-Sanharó, km 42, $10^{\circ}44'7.8''S$, $41^{\circ}14'50.9''W$, 475 m a.s.l., 13 Mar 2010, fl. and fr., M. Martins et al. 1740 (HURB); ibidem, km 42, $10^{\circ}44'7.8''S$, $41^{\circ}14'50.9''W$, 475 m a.s.l., 9 Mar 2013, fl. and fr., M. Martins et al. 1940 (HURB).

***Manihot elongata* P. Carvalho & M. Martins sp. nov.**
(Fig. 3)

A species resembling *M. dichotoma* Ule by its arborescent habit and leaves commonly with 3 to 5 lobes, but differing by its stipules with an entire margin and oblongoid or ovoid, usually purplish capsules with discrete, straight ribs (vs stipules with a lacinate margin and capsules orbicular, green, with undulating ribs).

Type: Brazil. Bahia, Municipality of Sento Sé, village Volta da Serra, $10^{\circ}06'17.5''S$, $42^{\circ}05'59.1''W$, 400 m a.s.l., 12 Mar 2010, M. Martins, Carvalho, P. C. L. and Ledo, C. A. S. 1738 (holotype: HURB!, isotypes: CEN!, CEPEC!, HUEFS!, K!, P!, RB!, SP!).

Etymology

The name of this species refers to the elongated shape of the fruits, which is unique in the genus.

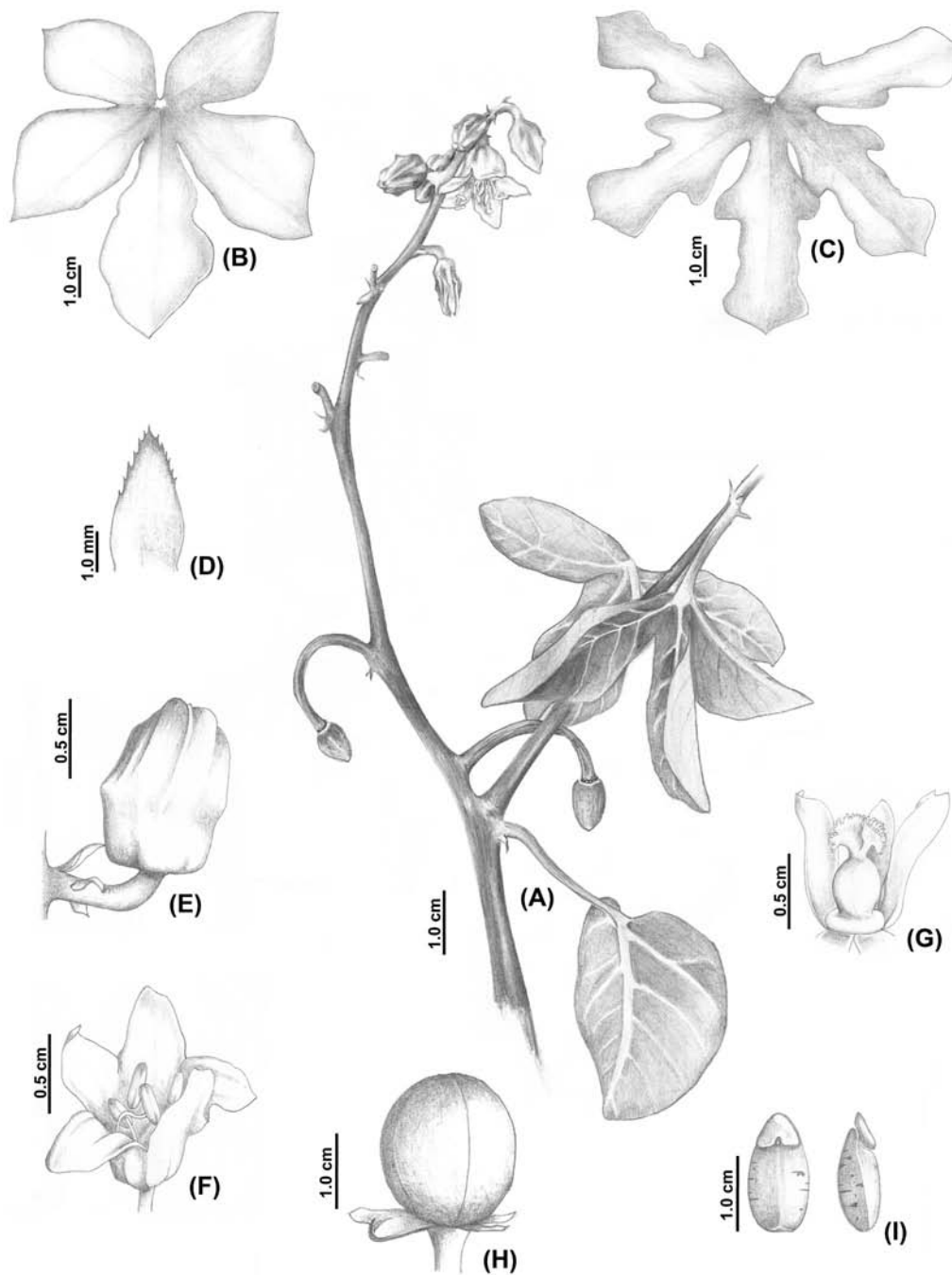


Figure 1. *Manibot alterniflora* sp. nov. (A) flowering branch, (B) leaf with entire margin, (C) leaf with pandurate margin. (D) stipule, (E) staminate bud with bract and bracteoles, (F) staminate flower, (G) pistillate flower, (H) capsule, (I) seeds. From the holotype.

Description

Trees or treelets, 2–5 m tall. Roots not tuberous. Stem glabrous, smooth; branches cylindrical. Latex white. Stipules caducous, setaceous, ca 1 mm long, with entire margins. Leaves simple, 3–5-lobed, glabrous, chartaceous to membranaceous, the median lobe 3–8 × 1–2 cm, elliptic, ovate, or obovate, acute at apex, entire or pandurate; venation campodromous, glabrous, with purplish veins; petioles 3–7 cm long, cylindrical, glabrous, basally inserted. Inflorescence a

single terminal raceme, ca 7 cm long, glabrous, sometimes with isolated pistillate flowers at base; bracts and bracteoles inconspicuous, ca 0.1 cm long, with entire margin, green. Staminate buds 0.8–1.0 cm, orbicular, green; pedicel 5–12 mm long, staminate flowers 1.2–2.0 × 0.4–0.7 cm, pyramidal, sepals 5, cleft after 1/3 of their length into five lobes, greenish to purplish at base, glabrous. Stamens 10, in two whorls; staminal disc yellow. Pistillate buds 2, opposite or subopposite, 0.8–1.0 × 0.5–0.7 cm, ovoid to pyramidal;

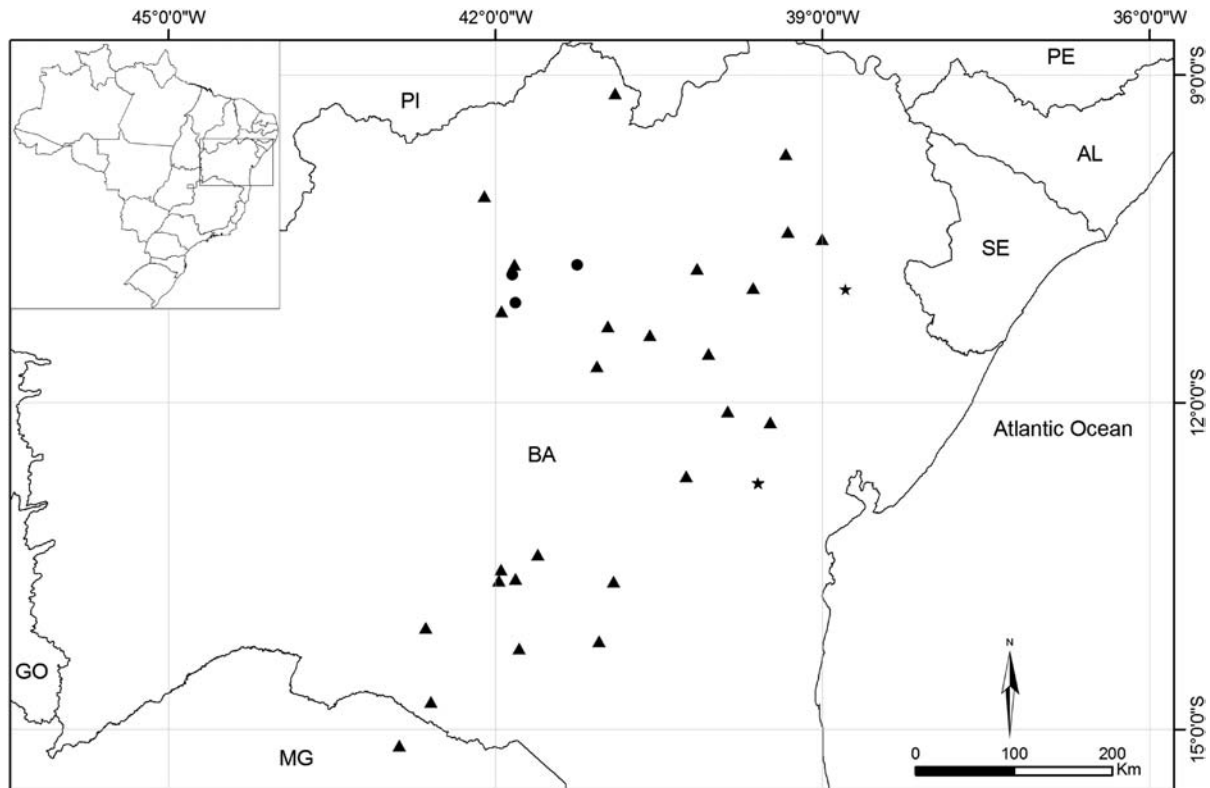


Figure 2. Distribution map of *Manihot alterniflora* sp. nov. (●), *Manihot elongata* sp. nov. (▲) and *Manihot quinquefolia* (★).

pedicel 2.0–3.5 cm long, pistillate flowers ca 1.0×0.5 cm; sepals 5, greenish to slightly purplish, glabrous, free. Capsules 2–3 cm long, commonly purplish, oblongoid or ovoid, acute or truncate at apex, smooth, slightly ribbed with straight ribs. Seeds ca 1.7×0.6 cm, oblongoid, their ventral surface convex, brown, with small, dark spots; caruncle ca 0.15 cm long, white.

Phenology

Plants have been found at all reproductive stages throughout most of the year.

Distribution and habitat

Bahia and Minas Gerais states, Brazil (Fig. 1). Wooded Caatinga vegetation, in sandy clay soil at 300–825 m a.s.l. (Fig. 1).

Conservation status

The wide distribution and large population size indicate that there is no immediate threat to this species (IUCN 2001).

Notes

Manihot elongata has been collected many times, always in Caatinga, and it commonly forms large populations. It has often been identified as *M. dichotoma* Ule (1907), a caatinga tree species (Rogers and Appan 1973) with a globular fruit that typically has undulating ribs. In addition, the margins of the stipules (lacinate in *M. dichotoma* and entire

in *M. elongata*) and the shape of the pedicel (swollen in *M. dichotoma* but not in *M. elongata*) may help distinguish these species.

Additional specimens examined (paratypes)

Brazil. Bahia, Municipality of Abaíra, $13^{\circ}23'50.5''S$, $41^{\circ}36'39.3''W$, 550 m a.s.l., 20 Apr 2010, M. Martins et al. 1644 (HURB); Municipality of Caetité, $14^{\circ}04'03''S$, $42^{\circ}38'12''W$, 825 m a.s.l., 9 Feb 1997, E. Saar et al. PCD 5290 (HUEFS); Municipality of Euclides da Cunha, $10^{\circ}30'S$, $39^{\circ}00'W$, 21 Mar 2004, M. L. Guedes et al. 10845 (ALCB); Municipality of Filadélfia, $10^{\circ}46'20''S$, $40^{\circ}08'55''W$, 350 m a.s.l., 28 Feb 2000, A. M. Giulietti 1879 and R. M. Harley (HUEFS); Municipality of Iaçú, $12^{\circ}40'40.8''S$, $40^{\circ}14'53.8''W$, 300 m a.s.l., 18 Apr 2010, M. Martins et al. 1640 (HURB); Municipality of Jeremoabo, Raso da Catarina, 15 May 1981, L. M. C. Gonçalves 58 (CEPEC); Municipality of Livramento do Brumado, $13^{\circ}38'S$, $41^{\circ}58'W$, 600 m a.s.l., 12 Dec 1988, R. M. Harley 27144 (CEPEC); Municipality of Miguel Calmon, Parque Sete Passagens, $11^{\circ}22'52''S$, $40^{\circ}34'59''W$, 550 m a.s.l., 23 Dec 2006, M. L. Guedes et al. 13196 (ALCB); Municipality of Milagres, Serra do Jatobá, $12^{\circ}05'S$, $39^{\circ}52'W$, 500 m a.s.l., 3 May 1980, R. M. Harley 22025 (CEPEC); Municipality of Monte Santo, $10^{\circ}26'S$, $39^{\circ}19'W$, 11 Jan 2006, M. L. Guedes et al. 12031 (ALCB); Municipality of Morro do Chapéu, $11^{\circ}40'S$, $41^{\circ}04'W$, 9 Dec 2006, M. L. Guedes et al. 13005 (ALCB); Municipality of Poções, 5 Mar 1978, S. A. Mori et al. s.n. (CEPEC 13392);

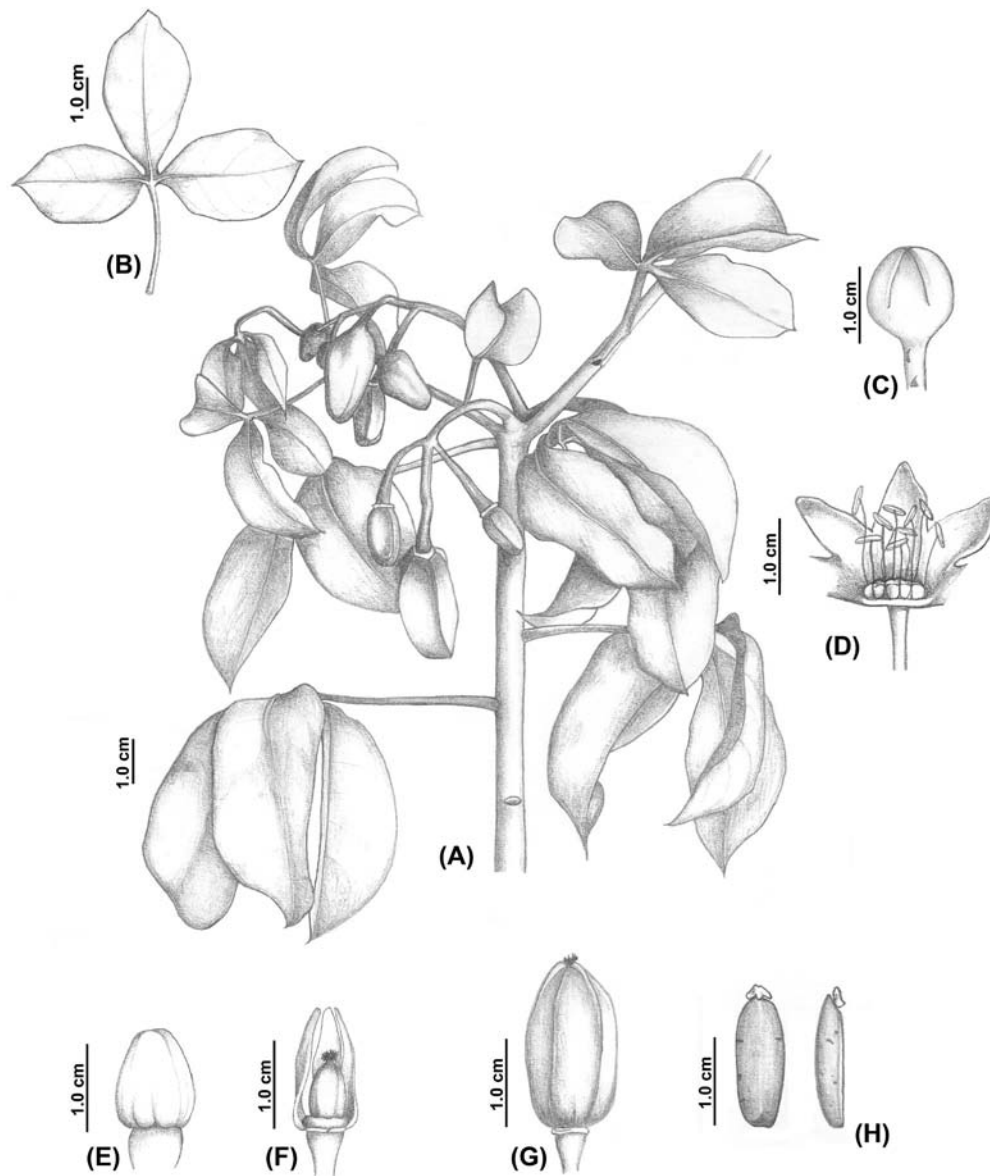


Figure 3. *Manihot elongata* sp. nov. (A) flowering branch, (B) leaf, (C) staminate bud with bracteoles, (D) staminate flower, (E) pistillate bud, (F) pistillate flower, (G) capsule, (H) seeds. From the holotype.

Municipality of Queimadas, 10°57'S, 39°38'W, 400 m a.s.l., 17 Nov 1986, G. Webster et al. 12031 (HUEFS); Municipality of Rio de Contas, 13°32'S, 41°57'W, 1 Jan 2000, A. M. Giuliatti 1614 and R. M. Harley (HUEFS); Municipality of São Gabriel, 11°09'54"S, 41°56'34"W, 775 m a.s.l., 25 Oct 2009, E. Melo et al. 6932 (HUEFS); Municipality of Saúde, Cachoeira do Paulista, 23 Feb 1993, A. M. A. Amorim et al. 1061 (CEPEC); Municipality of Sento Sé, 10°06'17.5"S, 42°05'59.1"W, 400 m a.s.l., 12 Mar 2010, M. Martins et al. 1738 (HURB); Municipality of Uauá, Serra do Jerônimo, 09°43'23"S, 39°19'56"W, 30 Mar 2000, M. R. Fonseca et al. 1356 (ALCB); Municipality of Valente, Fazenda São Barnabé, 15 Jan 1979, Döbereiner and Tokarnia (CEPEC 15208); Municipality of Várzea Nova, 11°18'00"S, 40°58'00"W, 650 m a.s.l., 5 Feb 1995, A. C. Allem and V.

S. Silva 6498 (CEN). Minas Gerais, Municipality of Mato Verde, 15°09'S, 42°53'W, 550 m a.s.l., 14 Feb 1995, A. C. Allem and V. S. Silva 4566 (CEN).

***Manihot quinquefolia* Pohl (1827, p. 56) (Fig. 4)**

Type: Brazil, Bahia, near Sincorá, Martius s.n. (lectotype designated here: M!, isolectotype: G!).

Lectotypification

The material deposited at G and M does not have reproductive structures (only leaves). The Munich herbarium (M) specimen was chosen to be the lectotype because it is the best preserved, with intact leaves and well-defined leaflets.

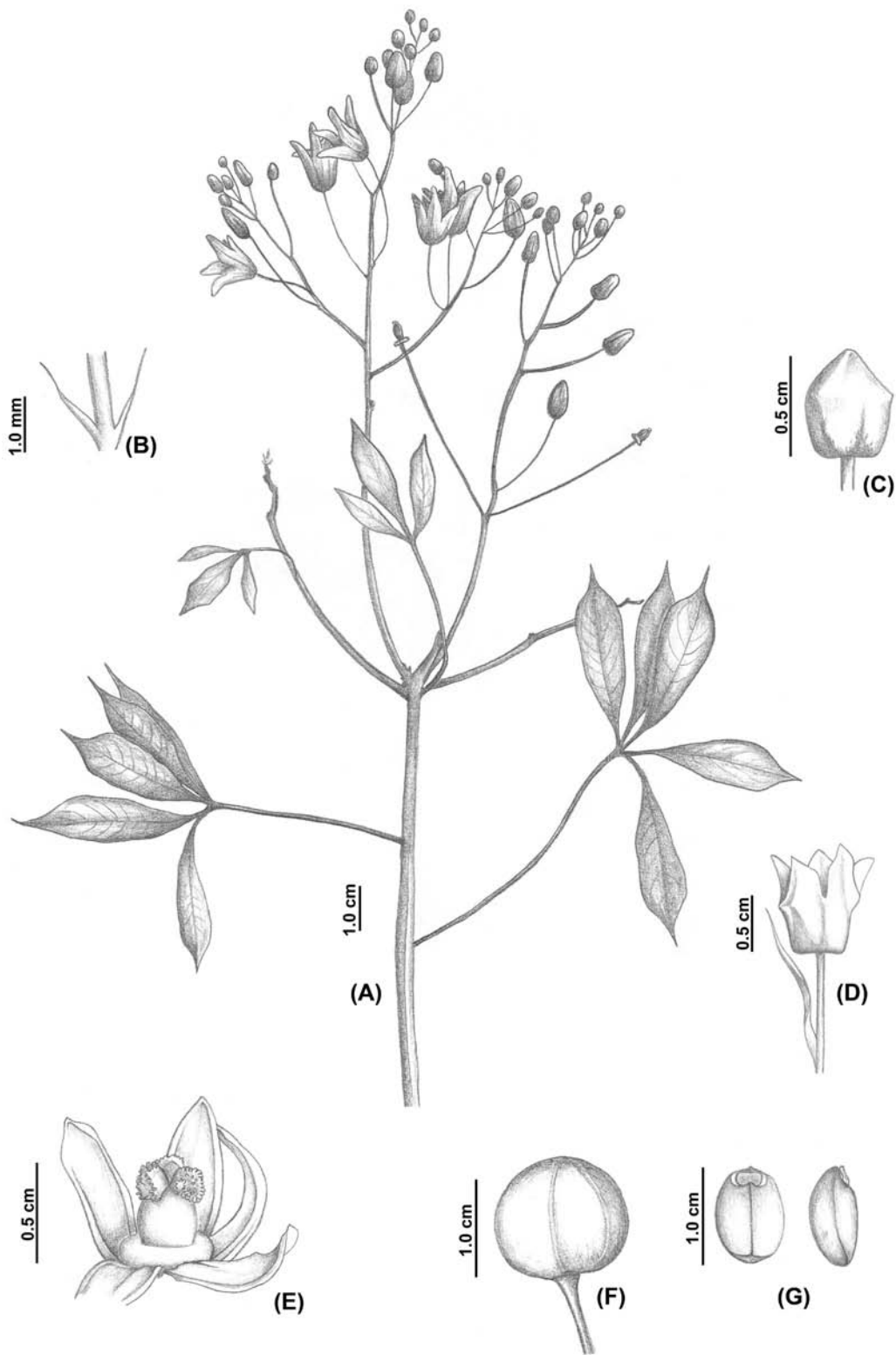


Figure 4. *Manihot quinquefolia*. (A) flowering branch, (B) stipules, (C) staminate bud, (D) staminate flower with bracteoles, (E) pistillate flower, (F) capsule, (G) seeds. Martins 1847.

Description

Shrubs, 1.5–4.0 m tall, erect. Roots dilated, with spongy consistency. Stem glabrous, smooth, cylindrical, little ramified at base, with evident nodes on upper branches. Latex creamy, with light consistency. Stipules setaceous, caducous, ca 1.5 mm long, greenish. Leaves compound, glabrous, chartaceous, their abaxial surface glaucous and adaxial surface green, with evident veins; leaflets 5, rarely spontaneously deciduous, the median elliptic, acuminate at apex, (3–)4(–5) × ca 1.5 cm, generally pandurate, the lateral often not pandurate; venation camptodromous; petioles (2)5–7 cm long, cylindrical, glabrous, basally inserted, greenish. Inflorescences as 3–4 racemes, pendulous, terminal, 6–14 cm long, glabrous; bracts semifoliaceous, 1.0–1.5 × 0.2–0.3 cm, glabrous, yellowish, linear; bracteoles setaceous, glabrous, yellowish, ca 1.5 mm long, linear. Staminate buds 5–7 × 3–5 mm, ovoid; pedicel 1.0–2.5 cm long; staminate flowers ca 1.0 × 0.3–0.5 cm, ovoid; sepals 5, cleft at their midpoint into five lobes, greenish, glabrous. Stamens 10, in two whorls, 8–9 mm, glabrous; staminal disc yellow. Pistillate buds 2, opposite, at base of inflorescence, ca 6 × 5 mm, greenish, ovoid; pedicel 2.9–4.5 mm long; pistillate flowers 0.8–1.0 cm, ovoid; sepals 5, glabrous, yellowish, with vinaceous lines on the outside, sometimes persistent, free; nectary slightly yellowish. Capsules 1.0–1.5 cm in diameter, green, orbicular to slightly ovoid, smooth, with white lines on septa, rounded at apex. Seeds ca 1.0 × 0.5 cm, oblongoid, ventral surface convex, brown, with small, dark spots, caruncle ca 2 mm long, yellowish.

Phenology

Plants were found at different reproductive stages in January, August, October, and November, and from October to June while under cultivation.

Distribution and habitat

Bahia State, Brazil (Fig. 1). Shrubby Caatinga vegetation, in sandy clay soil at 300 m a.s.l. (Fig. 1).

Conservation status

‘Least Concern’ (LC, IUCN 2001).

Notes

This is the second report in the literature of *Manihot quinquefolia* (Fig. 4), which was previously collected only in 1827. Until recently, the lack of collections suggested this species might be extinct, according to IUCN criteria (IUCN 2001), as proposed by Martins (2013). The lectotype at M lacks reproductive structures but has elliptical leaflets with narrow petiolules, as reported by Pohl (1827) and verified in individuals collected by us. This characteristic leaves no doubt about the identity of the species. Although other authors (Rogers and Appan 1973, Allem 1989, 1999) report the occurrence of compound leaves in at least five species of *Manihot* (e.g. *M. baccata* Allem, *M. brachyloba* Müll. Arg. and *M. quinquepartita* Huber ex D.J. Rogers & Appan), our experience from natural populations of these species indicates that only *M. quinquefolia* and *M. compositifolia* Allem

have this characteristic. *Manihot quinquefolia* differs from *M. compositifolia* by its erect habit, semifoliaceous bracts (1.0–1.5 × 0.2–0.3 cm), and capsular fruits (vs lianescent habit, inconspicuous bracts, and bacaceous fruits in *M. compositifolia*). The division of the blade into leaflets can be confirmed by observing the lack of fusion of the leaflets at the petiole apex. The leaflets easily detach at the joining point, or fall off when senescent.

Additional specimens examined

Brazil. Bahia, Municipality of Santa Terezinha, 12°44'46.4"S, 39°34'46.0"W, 300 m a.s.l., 16 Nov 2011, fl. and fr., M. Martins and P. Carvalho 1847 (HURB); ibidem, 14 Oct 2010, fl. and fr., M. Martins 1706 et al. (HURB); ibidem, 5 Aug 2010, fl. and fr., M. Martins and P. Carvalho 1661 (HURB); ibidem, 2 Jan 2010, fl. and fr., M. Martins 1606 and P. Carvalho (HURB); Municipality of Tucano, Torre do Quererá, 10°57'47.2"S, 38°47'12.1"W, 1 Jun 2013, fl. and fr., G. M. Costa 852 (HURB).

Key to the species of *Manihot* in Brazilian Caatinga vegetation

1. Bracts foliaceous or semifoliaceous, > 2 mm wide 2
 - Bracts setaceous, up to 1 mm wide 6
2. Bracts foliaceous, > 5 mm wide 3
 - Bracts semifoliaceous, 2–4 mm wide 5
3. Latex yellowish; fruits bacaceous *M. caerulescens*
 - Latex white; fruits capsular 4
4. Plants pubescent; inflorescence branched
 - *M. maracasensis*
 - Plants glabrous; inflorescence unbranched
 - *M. jacobinensis*
5. Leaves compound *M. quinquefolia*
 - Leaves simple *M. anomala*
6. Plants pubescent 7
 - Plants glabrous 8
7. Leaf lobes obovate *M. brachyandra*
 - Leaf lobes elliptical *M. janiphoides*
8. Subshrubs, < 0.5 m tall 9
 - Trees, treelets or shrubs, > 1.5 m tall 10
9. Stipules inconspicuous, < 1 mm wide
 - *M. diamantinensis*
 - Stipules conspicuous, semifoliaceous, ca 4 mm wide
 - *M. alterniflora*
10. Stipules foliaceous to semifoliaceous, > 2 mm wide 11
 - Stipules setaceous, up to 1 mm wide 12
11. Stipules foliaceous, > 8 mm wide *M. zehntneri*
 - Stipules semifoliaceous, < 5 mm wide
 - *M. carthagenensis*
12. Capsules orbicular, with undulating ribs
 - *M. dichotoma*
 - Capsules oblongoid or ovoid, with straight ribs
 - *M. elongata*

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