An Acad Bras Cienc (2022) 94(2): e20200300 DOI 10.1590/0001-3765202220200300
Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences*
Printed ISSN 0001-3765 I Online ISSN 1678-2690
www.scielo.br/aabc | www.fb.com/aabcjournal

ECOSYSTEMS

Advances in knowledge of *Manihot* (Euphorbiaceae) from Brazil

MÁRCIO L.L. MARTINS, PRISCILA ORLANDINI, PAULO C. L. DE CARVALHO & CARLOS A.S. LEDO

Abstract: Herbarium-based studies and extensive field work revealed the existence of a new species in the genus *Manihot* which is restricted to the municipality of Itirapina, in the state of São Paulo, Brazil. Characteristics such as the size and morphology of the leaves and bracts were important to recognize *M. irregularis* as a new taxon. Description, illustration, as well as comments on its morphology, distribution, conservation status, and a key for the identification of *Manihot* species for the state of São Paulo are presented.

Key words: Biodiversity, cerrado, conservation, São Paulo, taxonomy.

INTRODUCTION

The concern for cassava's wild parents is justified once this species is an important food resource in developing countries (FAO 2019) and their most near species show promising results for cassava breading purposes (Boaventura et al. 2015). In addition, many of these are endangered species, especially due to a small extent presence and the degradation of their habitats (Walter & Gillet 1998, Martins et al. 2017a).

Ever since 2010 our team performs expeditions to various Brazilian ecosystems, collecting and identifying accessions of wild relatives of cassava (*Manihot esculenta* Crantz) (Ledo et al. 2010). Since then, diverse new populations were located and therefore expanding the collections of wild parents preserved by the Brazilian Agricultural Research Corporation (EMBRAPA) and by the Federal University of Recôncavo da Bahia (UFRB) and new herbarium vouchers, increasing also the data concerning the Extent of Occurrence (EOO) and Area of Occupation (AOO) from various species of the genus *Manihot*. These data allowed the description of new species (e.g. *M. bellidifolia* P. Carvalho & M. Martins, *M. breviloba* P. Carvalho & M. Martins, *M. macrocarpa* P. Carvalho & M. Martins) and the review of their conservation status (Martins et al. 2011, 2014, Martins & Ledo 2015, Martins et al. 2017a,b).

The highest diversity of *Manihot* in Brazil in concentrate in the Cerrado region (60 spp.), a biome that extends through the central portion of South America (Simon et al. 2018, Murphy et al. 2016). New species are frequently summarized (Mendoza et al. 2015, Silva 2016) and the number of species computed in Brazil has already exceeded 100 (Martins et al. 2020) in contrast with about 80 species registered in the last revision of the genus for the country (Rogers & Appan 1973). In the São Paulo state ten species are known, being the Cerrado the richest biome (7 spp.) (Orlandini & Lima 2014).

Data obtained after extensive field work in the state of São Paulo and analysis of the herbarium collections enabled to identify a new species for the genus *Manihot*.

MATERIALS AND METHODS

Starting from January 2010, we began expeditions to collect species of *Manihot* in the East of Brazil. During these expeditions, a population of this new species has been identified in the municipality of Itirapina, São Paulo. Seeds were collected and seedlings planted in the germplasm bank of Brazilian Agricultural Research Corporation (EMBRAPA) and by the Federal University of Recôncavo da Bahia (UFRB), both in Cruz das Almas, Bahia. We analyzed the collections of the herbaria ALCB, ASE, CEN, CEPEC, CPAP, CVRD, EAC, ESA, F, FLOR, FURB, HAS, HB, HPBR, HPUC*, HRB, HST*, HUEFS, HUFU, HURB, HVASF, IAN, IBGE, ICN, IMA*, IPA, K, JPB, K, MBML, MG, MS, NY, PEUFR, R, RB, SP, SPF, UEC, UFMT, UFP, UFRN, UNB, US, UTPR*, VIC e VIES (acronyms according to Thiers 2021, continuously updated, *no registered).

RESULTS AND DISCUSSION

Manihot irregularis M. Martins & Ledo, *sp. nov.* ––TYPE: BRAZIL. São Paulo: Itirapina, rodovia Itirapina-Brotas, próximo ao pedágio, Trevo Itaqueri, São Pedro, 22º15'51.9''S, 47º53'44.4''W, 743 m, fl. fr., 17 May 2012, *M. Martins et al. SP01* (holotype HURB!, isotypes CEPEC!) (Fig. 1, 2 and 3).

Manihot irregularis resemble *M. anomala* Pohl and *M. tripartita* (Spreng). Müll. Arg. regarding leaf lobes (1 to 3), inflorescences

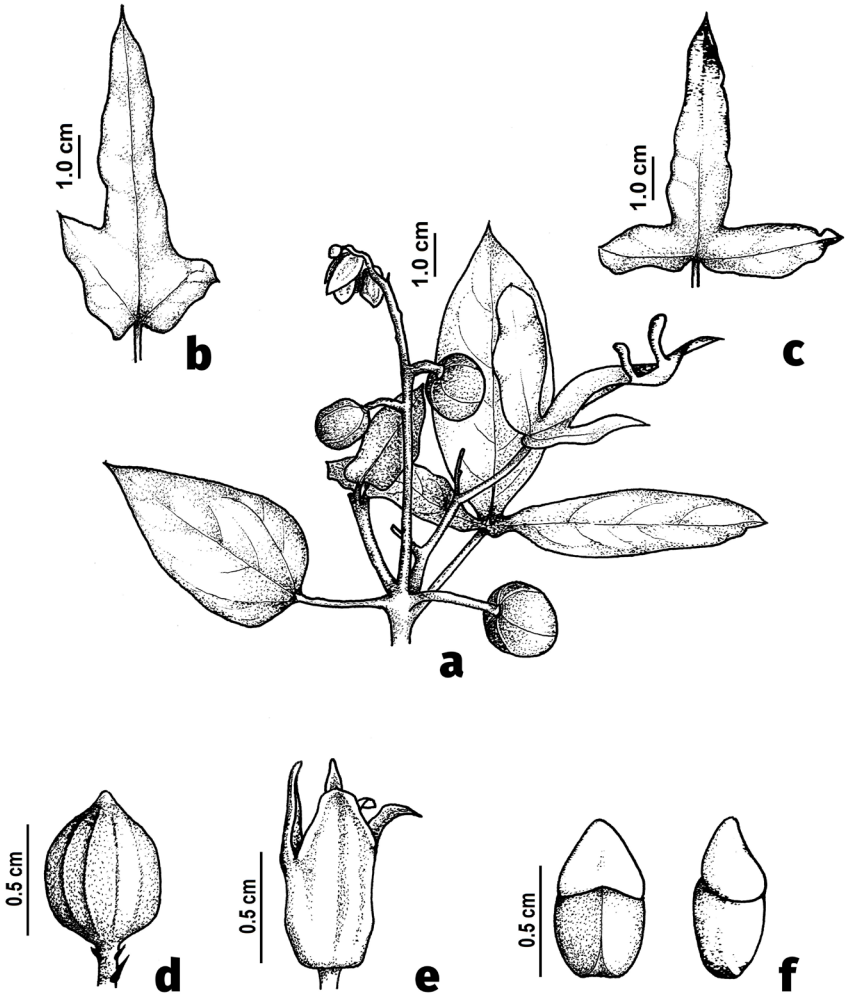

Figure 1. ***Manihot irregularis*** **M. Martins & Ledo. (a) with leaves variably lobed. (b) and (c) Leaves. (d) Staminate bud with bracts and bracteoles. (e) Staminate flower. (f) Seeds in frontal and lateral view. Observe the proportion of caruncle in relation of the size of seed.**

racemoses and orbicular to ovoid capsules. Differs from both species by its subshrub habit (< 0.5 m tall), linear bracts (up to 0.5 mm wide) and caruncle 0.3–0.5 cm long (ca. 1/2 of seed length), while *M. anomala* shows shrub to lianescent habit (1.5-4 m tall), ovate bracts (>2 mm wide) and caruncle with ca. 0.15 cm long (ca. 1/5 seed length), and *M. tripartita* shows subshrub to shrub habit (0.5-4 m tall), ovate bracts (>2 mm wide) and caruncle with ca. 0.2 cm long (1/5 seed length).

Subshrub erect or decumbent, up to 0.5 m tall. **Roots** tuberous. **Stem** glabrous, smooth, Green-purple, cylindrical, little branched, latex white. **Stipules** early caducous, not seen. **Leaf** simple, 3-lobed, sometimes entire or with lateral lobes reduced or asymmetric, glabrous, carthaceous, green or variable purple, abaxial face clearer; central lobe elliptical, oval or oboval, (3–)6–8 × 1.5–3 cm, apex acute or acuminate, margin entire or variable sinuous, nervation camptodromous, petioles 2–4 cm long, cylindrical, basal insertion. **Inflorescence** racemose, 3–6 cm length, erect or slightly pendulum, bracts linear, ca. 2 × 0.5 mm, margin entire, purple, glabrous, bracteoles inconspicuous, ca. 1 × 0.5 mm, margin entire, purple, glabrous. **Staminate bud** 0.4–0.8 × 0.3–0.5 cm, ovoid to orbicular, pedicel ca. 0.3 cm length. **Staminate flower** 0.5–0.9 × 0.3–0.6 cm, sepals 5, fused up to the middle to long, yellow-greenish to purple, glabrous. **Stamens** 10, two cycles, 0.5–0.8 cm length, glabrous; staminal disc yellow. **Pistillate buds** 2, 0.5–0.8 × 0.3–0.5 cm, opposite or subopposite, in the down portion of inflorescence, ovoid or pyramidal, pedicels ca. 1 cm length. **Pistillate flower** 0.6–0.8 × 0.4–0.5 cm, sepals 5, free, yellow-greenish to purple, glabrous. **Capsules** 1–1.5 cm diam., orbicular

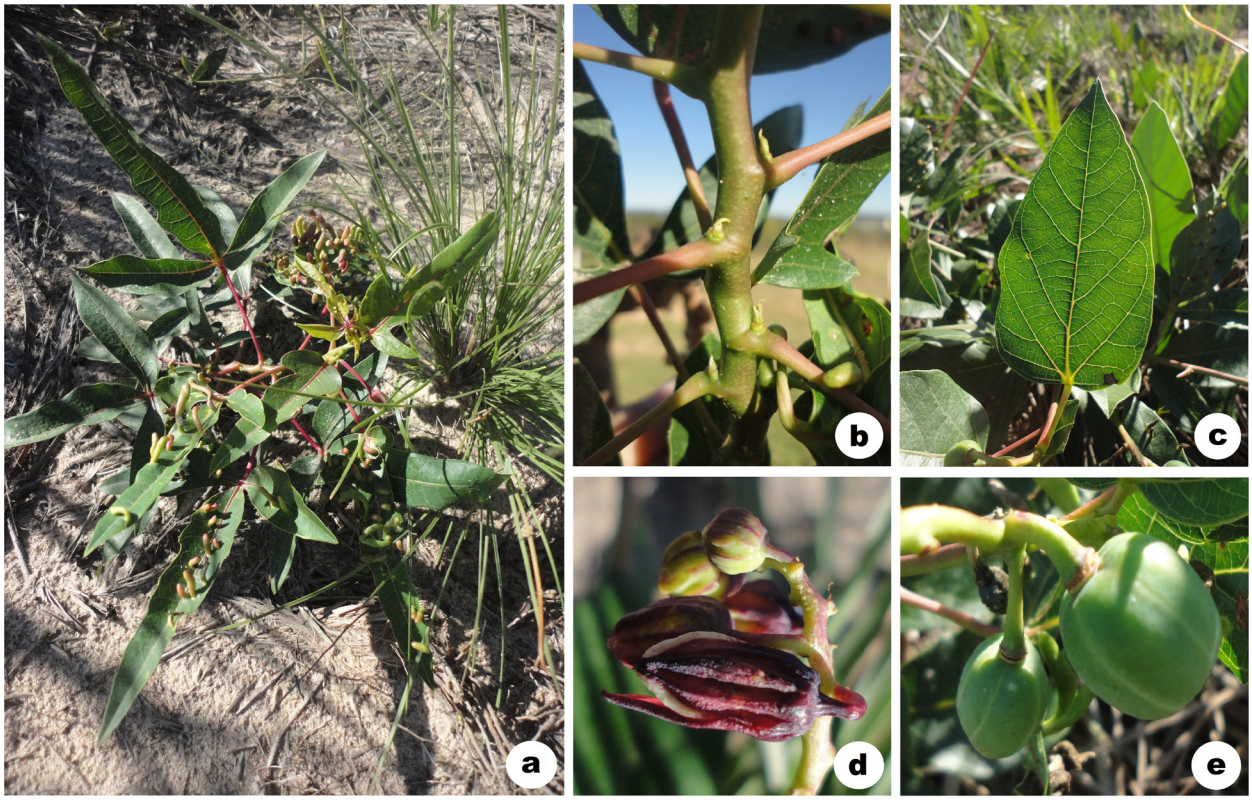

Figure 2. ***Manihot irregularis*** **M. Martins & Ledo. (a) Habit with leaves variably lobed. (b) Stem and petiole insertion. (c) Unlobed leaf. (d) Staminate bud. (e) Capsules.**

to slight ovoid, surface smooth, apex rounded, glabrous, green. **Seeds** 0.7–1.0 cm long, brown-gray, ovoid, margin rounded, caruncle triangular, 0.3–0.5 cm length, yellow to brown.

Commentaries: *Manihot irregularis* M. Martins & Ledo forms vast populations in Cerrado areas in the municipality of Itirapina, State of São Paulo, Brazil, typically in open shrubby vegetation. In most of the analyzed collections, the materials are identified as *M. tripartita* (Spreng.) Müll. Arg. (or *M.* aff. *tripartita*) due to the shrub habit associated with the number of leaf lobes (1-3) and orbicular to ovoid capsules. These species can be easily differentiated by the oval bracts of *M. tripartita* which differ from the linear bracts of *M. irregularis*. The morphological variation of leaves in *M. irregularis* also approximates this species to *M. anomala* characterized by showing leaves with a variable number of lobes and with diverse formats, e.g. elliptical, oval or oboval (Pohl 1827, Rogers & Appan 1973, Flora do Brasil 2020). It can be differentiated from *M. anomala* Pohl, by the smaller subshrub (< 50 cm tall), linear bracts (ca. 0.5 mm wide) and caruncle with 1/2 seed length (3-5 mm), while *M. anomala* shows shrub to lianescent habit (1.5-4 m), ovate semifoliaceous to foliaceous bracts (>2 mm wide) and caruncle with 1/5 seed length (up to 2 mm length). The ratio of the caruncle to the seed length is the largest ever observed in *Manihot* species.

Etimology: The name of this species is related to the morphology of leaves, extremely variable, with lateral lobes reduced or asymmetric and entire or variable sinuous margin (Fig. 2).

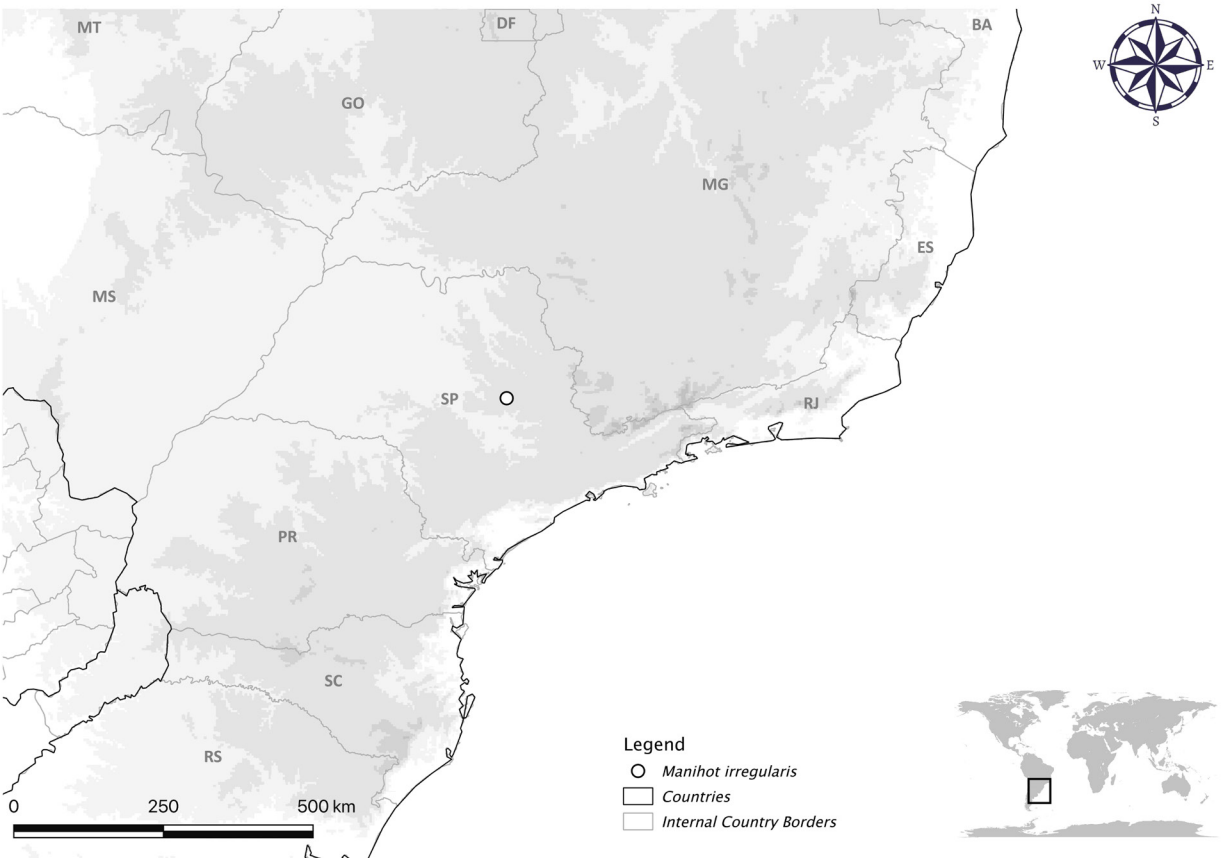

Figure 3. Geographic distribution of *Manihot irregularis* M. Martins & Ledo.

Fenology: Registered with flowers and fruits in January, May and December.

Distribution and habitat: Brazil: São Paulo. Shrub open 'Cerrado' with sand-clayey, flat soil.

Conservation: Population analyses were not performed for *M. irregularis*, preventing the evaluation of criteria A, C and D from the International Union for Conservation of Nature (IUCN 2014). Nevertheless, from distribution data evaluated by the Geospatial Conservation Assessment Tool (GeoCAT) (http://geocat.kew.org/), according to Bachman et al. (2011), the species was considered "Critically Endangered" (CR) due to the extent of occurrence (EOO) with 0.946 km^2 (Fig. 3) and the area of occupation (AOO) with 8 km^2.

Additional specimens examined (Paratypes): BRAZIL. SÃO PAULO: Itirapina, próximo ao pedágio, na Represa de Broa, 22º10'52.3''S, 47º52'48.6''W, fl. fr., 07 Dec 1994, *K.D. Barreto et al. 3353* (HUEFS); *idem*, fl. fr., 20 Jan. 1968, *O. Handro 2004* (SPF), *id.*, Estação Ecológica de Itirapina, fl. fr., Dec 1988, *L.C. Bernacci 20842* (UEC, MBM); *id.* Estação Ecológica de Itirapina, fl. fr., Feb. 1984, *Leitão Filho, H.F. 15966 et al.* (HRCB, UEC, UFMT).

Key to the *Manihot* species in the state of São Paulo, Brazil

1. Plants usually with palmatipartite leaves; lobed leaves with 3-5 lobes; occasionally unilobed at upper branches

2 Leaves unilobed and palmatipartite at the same individual; irregular or asymmetrical formats

3. Adaxial surface variously pubescens to tomentose, never glabrous; bracts with deeply laciniate margin.....*M. tripartita*

3'. Adaxial surface glabrous or with rare trichomes; bracts with entire margin

4. Plants with less than 0,5m tall; linear bracts; proeminet caruncle, up to half the size of the seed.....*M. irregularis*

4'. Plants with more than 0,5m tall; elliptical bracts; caruncle not proeminent, up to 1/5 the size of the seed.....*M. anomala*

2'. Leaves always palmatipartite, without unilobed leaves on the same individual; leaves not irregular.....*M. procumbens*

1'. Plants usually with palmatissect leaves; lobed leaves with (3-)5-7(-11), rarely unilobed at upper branches

5. Treelets, erects, with more than 2m tall; lobed leaves with 7-11 lobes.....*M. grahamii*

5'. Subshrubs to shrubs, erects, semi-prostrates to prostrates, with less than 2m tall; lobed leaves with 3-5 lobes

6. Plants with yellow latex; lobes obovate, apex obtuse or apiculate; fruits indehiscent, bac caceous.....*M. caerulescens*

6'. Plants with white to creamish latex; lobes ovate, elliptical to lanceolate; apex acute, rarely apiculate; fruits dehiscent, capsulate

7. Prostrate subshrubs; leaves 3-lobed; lobes with < 1cm wide

8. Linear to lanceolate estipules, laciniate margin; showy bracts with laciniate margin.....*M. gracilis*

8'. Triangular estipules, entire margin; not showy bracts, with entire margin.....*M. fruticulosa*

7' Erect to suberect shrubs; lobes (3-)4-6; lobes with > 2cm width

9. Pubescents to tomentose plants

10. Staminate buds bifusiforms with base co nstraints.....*M. pilosa*

10'. Staminate buds ovoid, without base constraints .....*M. jolyana*

9'.Glabrous plants.....

.....*M. inflata*

Acknowledgments

The authors would like to thank the Fundação de Amparo à Pesquisa do Estado da Bahia (FAPESB) for their financial support of this research and Embrapa Mandioca e Fruticultura for logistical support. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001", and Fundação and Fundação de Amparo à Pesquisa do Estado de São Paulo, for their financial support to the Projeto Flora Fanerogâmica do Estado de São Paulo: the genus *Manihot* Mill. (Euphorbiaceae) – process 2010/08016-5.

REFERENCES

BACHMAN S, MOAT J, HILL A, DE LA TORRE J & SCOTT B. 2011. Supporting Red List threat assessments with GeoCAT: Geospatial Conservation Assessment Tool. ZooKeys 150: 117-126.

BOAVENTURA VJ, RINGENBERG R & LEDO CAS. 2015. Genetic dissimilarity for resistance to *Mononychellus tanajoa* (bondar) (Acari, Tetranychidae) among domesticated and wild *Manihot* species. Acta Sci-Agron 37(4): 441-446.

FAO. Food and Agriculture Organization of the United Nation. Disponível em: <<http://faostat.fao.org/site/567/default.aspx#ancor>>. Accessed in 10 jun 2019.

IUCN 2014. Guidelines for using the IUCN red list categories and criteria, ver. 11. Disponível em: < www.iucnredlist.org/documents/ RedListGuidelines.pdf > . Accessed in 20 May 2019.

LEDO CAS, SILVEIRA TC, CARVALHO PCL, MARTINS MLL & TAVARES-FILHO LFQ. 2010. Coleta e conservação de germoplasma de espécies silvestres de *Manihot* no estado da Bahia para ampliação da coleção de trabalho da Embrapa Mandioca e Fruticultura, Embrapa Mandioca e Fruticultura, Comunicado Técnico, vol 146, 5 p.

MARTINS MLL & LEDO CAS. 2015. *Manihot cezarii* (Euphorbiaceae), a new species from Central-Western Brazil. Novon 24: 179-181.

MARTINS MLL, CARVALHO PCL & AMORIM AM 2011. A remarkable new *Manihot* (Euphorbiaceae) from the coastal sand plains of Sergipe, Brazil. Phytotaxa 32: 57-60.

MARTINS MLL, CARVALHO PCL & LEDO CAS. 2017b. *Manihot macrocarpa* (Euphorbiaceae), an unusual rain forest species from Brazil. Phytotaxa 309(2): 179-183.

MARTINS MLL, CARVALHO PCL, LEDO CAS & AMORIM AM. 2014. What's New in *Manihot* (Euphorbiaceae)? Syst Bot 39(2): 485-489.

MARTINS MLL, LEDO CAS, CARVALHO PCL, AMORIM AM & SILVA DCS. 2017. *Wild Relatives of Cassava: Conservation and Use*. In: Handbook of Cassava, *Nova Science Publishers*, Inc, p. 373-405

MARTINS MLL, ORLANDINI P, MENDOZA FJM & SILVEIRA TC. 2020. *Manihot in* Flora do Brasil 2020. Jardim Botânico do Rio de Janeiro. Disponível em: <https://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB17591>. Acesso em: 20 dez. 2021

MENDOZA JM, SIMON MF & CAVALCANTI TB. 2015. Three new endemic species of *Manihot* (Euphorbiaceae) from the Chapada dos Veadeiros, Brazil. Arnaldoa 22: 297-312.

MURPHY BP, ALAN AN & PARR CL. 2016. The underestimated biodiversity of tropical grassy biomes. Philos Trans R Soc B 371: 1-12.

ORLANDINI P & LIMA LR. 2014. Sinopse do gênero *Manihot* Mill. (Euphorbiaceae) no Estado de São Paulo. Hoehnea 41: 51-60.

POHL J. 1827. *Plantarum Brasiliae Icones et Descriptiones*. vol 1, p. 17-56.

ROGERS DJ & APPAN SG. *Manihot, Manihotoides (Euphorbiaceae)*. 1973. Flora Neotrop 13: 1-272.

SILVA MS. 2016. *Manihot gratiosa* and *M. lourdesii* spp. nov. (Manihoteae, Euphorbiaceae) from the Brazilian Cerrado. Nord J Bot 34(1): 66-74.

SIMON MF ET AL. 2018. Conservation assessment of cassava wild relatives in central Brazil. Biodivers Conserv 29: 1589-1612.

THIERS B. 2021. *Index Herbariorum*: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/ Assessed 20 Dez 2021.

WALTER KS & GILLET HJ. 1997. *IUCN Red List of threatened plants*. IUCN, Cambridge, UK.

How to cite
MARTINS MLL, ORLANDINI P, DE CARVALHO PCL & LEDO CAS. 2022. Advances in knowledge of *Manihot* (Euphorbiaceae) from Brazil. An Acad Bras Cienc 94: e20200300. DOI 10.1590/0001-3765202220200300.

Manuscript received on March 13, 2020;
accepted for publication on August 15, 2021

MÁRCIO L.L. MARTINS[1]
https://orcid.org/0000-0002-7714-4980

PRISCILA ORLANDINI[2]
https://orcid.org/0000-0002-1609-6452

PAULO C.L. DE CARVALHO[1]
https://orcid.org/0000-0001-6714-1551

CARLOS A.S. LEDO[3]
https://orcid.org/0000-0001-9578-4167

[1]Universidade Federal do Recôncavo da Bahia, Centro de Ciências Agrárias, Ambientais e Biológicas, Rua Ruy Barbosa, 710, Centro, 44380-000 Cruz das Almas, BA, Brazil

[2]Universidade Estadual de Campinas, Instituto de Biologia, Rua Monteiro Lobato, 255, Cidade Universitária, 13083-862 Campinas, SP, Brazil

[3]Embrapa Mandioca e Fruticultura, Rua Embrapa, s/n, 44380-000 Cruz das Almas, BA, Brazil

Correspondence to: **Márcio Lacerda Lopes Martins**
E-mail: marciollm@ufrb.edu.br

Author contributions

Márcio Lacerda Lopes Martins: taxonomic analysis from collections and fieldwork, description, illustration and comments about the species. Priscila Orlandini: taxonomic analysis from collections and fieldwork, review of the description and comments on the species. Paulo Cezar Lemos de Carvalho: taxonomic analysis from visualization of material in the field. Carlos Alberto da Silva Ledo: fundraising and logistical support.