

New record of *Distimake ternifoliolus* (Pittier) A.R.Simões & Staples (Convolvulaceae Juss.) from the Brazilian savanna reveals its disjunct distribution pattern

Leonardo de S. Rodrigues¹, Izaías C. de Sousa², Marlene F. Figueiredo¹, Francisco D. S. Santos³

¹ Herbário Prof. Francisco José de Abreu Matos (HUVA), Universidade Estadual Vale do Acaraú, R. Av. Padre Francisco Sadoc de Araújo, 850, Alto da Brasília, 62010-295, Sobral, CE, Brazil

² Programa de Pós-Graduação em Agronomia, Universidade Estadual Paulista, Av. Brasil Sul, 56, Ilha Solteira, 13385-000, São Paulo, SP, Brazil

³ Departamento de Biologia, Laboratório de Sistemática e Ecologia Vegetal (LASEV), Universidade Federal do Ceará, Av. Humberto Monte, s/n, Campus do Pici, Bloco 710, 60455-900, Fortaleza, CE, Brazil

Corresponding author: Francisco D. S. Santos (fdsantosbot@gmail.com)

Abstract. We present the first record of *Distimake ternifoliolus* (Pittier) A.R.Simões & Staples (Convolvulaceae) from the Brazilian savanna (Cerrado). This is a rare species, previously known only from the savannas of the Venezuelan Llanos and the Guianas. We provide a key characters, data on geographic distribution, habitat, conservation status, flowering and fruiting period, updated distribution maps and a key for *Distimake* Raf. species from Ceará.

Key words. Disjoint distribution, Savanna enclaves, Pleistocene, Creepers

Rodrigues LS, Sousa IC, Figueiredo MF, Santos FDS (2024) New record of *Distimake ternifoliolus* (Pittier) A.R.Simões & Staples (Convolvulaceae Juss.) from the Brazilian savanna reveals its disjunct distribution pattern. Check List 20 (3): 570–576. <https://doi.org/10.15560/20.3.570>

INTRODUCTION

Savannas are composed of open vegetation and mostly perennial herbaceous cover associated with woody and sparse vegetation (Walter et al. 2008) and are present in tropical regions in Oceania, Asia, Africa and the Americas (Coutinho 1982). Among the Neotropical biomes, savannas stand out for being the second largest type of vegetation in South America, where they have the greatest diversity of species among savannas in the world (Daly and Mitchell 2000; Ratter et al. 2003). The largest continuous savanna region is represented by the Cerrado (Villarroel et al. 2016), while the second largest region comprises the Colombian-Venezuelan Llanos of western Venezuela and Colombia (Medina and Silva 1990; Sarmiento et al. 2004).

In addition to continuous areas, there are several enclaves of disjunct savannas that occur associated with other vegetation types (Salgado Labouriau 1997; Ratter et al. 2003). In the Caatinga, these enclaves are found, mainly in the northeast region, in areas with higher altitudes, such as Chapada Diamantina, Chapada do Araripe and Cuesta da Ibiapaba (Juncá et al. 2005; Ribeiro-Silva et al. 2012). These disjunct areas influence the evolutionary and biogeographical process of plant lineages occurring within them (Moro et al. 2011; Costa-Coutinho et al. 2019).

The disjunction and origin of the biological diversity of these areas can be explained by the theory of the Pleistocene Arc, which assumes that during this period, climatic fluctuations were responsible for a sequence of expansions and retractions of the humid forests, which gave temporary space to dry vegetation (Andrade-Lima 1982; van der Hammen 1982). Prado and Gibbs (1993) proposed that the current disjunct distribution pattern of savanna areas and associated species is a vestige of a former continuous forest formation, which possibly reached its maximum extent of occurrence during the dry and cold periods of the Last Glacial Maximum (18,000–12,000 years).

The disjunct distribution patterns of many biological groups, such as plants (Prance 1973; Prado and Gibbs 1993), insects (Brown 1982), amphibians (Heyer and Maxon 1982), reptiles (Vanzolini 1970) and birds (Haffer 1969), may support possible connections between the South American savannas. During a floristic survey carried out between 2019 and 2023 in in Cerrado enclave in Chapada da Ibiapaba, we collected *Distimake* specimens (L.S. Rodrigues 200 EAC) and confirmed that these belonged to *D. ternifoliolus* (Pittier)



Academic editor: Guilherme Dubal dos Santos
Seeger

Received: 22 August 2023

Accepted: 18 December 2023

Published: 7 May 2024

Copyright © The authors. This is an open-access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0)

A.R.Simões & Staples (Convolvulaceae), after morphological analysis. After surveying the literature and analyzing herbarium material, we concluded that these specimens are the first record of this species for the Brazilian flora. *Distimake ternifoliolus* was previously known only from the savannas of the Llanos in Venezuela and the Guianese savannas (Ferrer-Pereira et al. 2010).

Distimake Raf. (Convolvulaceae) is characterized by vines (rarely lianas and shrubs), simple leaves, usually with five to seven lobes, or compound, calyx usually with flat sepals, adnate to the base of the corolla tube and additional to the fruit, glabrous corolla, spiral anthers after anthesis, pollen grains 3–(12) zonocolpate and 4-valvular capsule (Simões and Staples 2017). This genus is represented by about 35 species distributed in the tropical region of America and Africa with disjunct species in Asia and northern Australia (Simões and Staples 2017). In Brazil, it is represented by 18 species distributed in all domains and regions (Petrongari and Simões 2022).

We aim to reveal the disjunct distribution pattern of *D. ternifoliolus* between the savannas of Venezuela and the Guianas and the savanna enclaves that occur in the middle of the Caatinga in Brazil using our new record of this species as evidence of possible past connections between the South American savannas.

METHODS

Study area. Ibiapaba plateau is located on the eastern edge of the Parnaíba sedimentary basin (Pires 2003), characterized as a Cuesta with a slope facing Ceará and a slight decline towards the state of Piauí, presenting significant altitudinal variation, reaching up to 1000 m altitude (Moro 2015). In higher altitude areas, there is the presence of tree-like vegetation, dry and humid sedimentary forests, sedimentary Caatinga vegetation associated with sandy soils and savanna enclaves (Figueiredo and Fernandes 1987; Moro et al. 2015). The savanna enclaves have flora structurally formed by an herbaceous-shrub layer with sparse small trees (Figueiredo and Fernandes 1987; Figure 1).

Morphological study. This study was based on morphological analysis, consultation of the bibliographic review (O'Donell 1941; Ferrer-Pereira et al. 2010), analysis of collections of the HUVA, HCDAL and EAC herbaria (acronyms according to Thiers 2023) and images of specimens from virtual platforms (<http://floradobrasil.jbrj.gov.br/reflora/herbarioVirtual>), GBIF (<https://www.gbif.org>), speciesLink (<http://splink.cria.org.br>). The specimens were collected and herborized according to the usual techniques in taxonomy (Mori et al. 1986) and later deposited in the EAC. Identification was based on specialized literature (O'Donell 1941; Ferrer-Pereira et al. 2010) and confirmed with protologue analysis and an image of the type specimen available on JSTOR (<http://plants.jstor.org/>). The morphological description followed the terminology of Harris and Harris (2001). Geographical distribution data were obtained from specialized literature (O'Donell 1941; Ferrer-Pereira et al. 2010) and from the new registry. Species mapping was performed in QGIS. Data on the flowering and fruiting period were based on field observation and the literature (Ferrer-Pereira 2010).

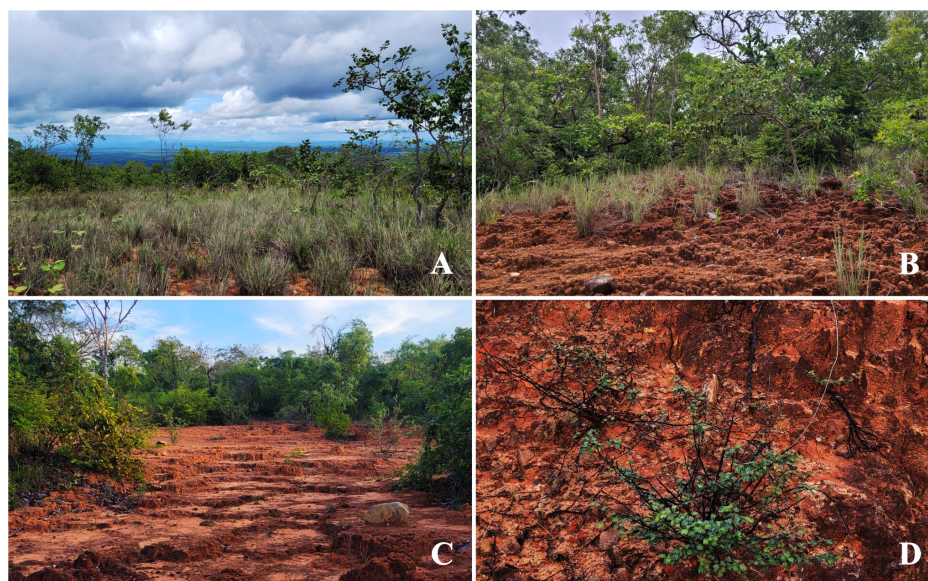


Figure 1. Habitat of *Distimake ternifoliolus*: savanna enclaves on the Ibiapaba plateau, Ceará, Brazil. **A, B.** Coverage of the herbaceous layer with a predominance of Poaceae. **C, D.** Vegetation associated with ferruginous soils. Photographs: L.S. Rodrigues.

RESULTS

Identification key to *Distimake* species in Ceará state

- 1 Leaf compound, 3-foliolate *D. ternifoliolus*
- 1' Leaf compound, 5-foliolate 2
- 2 Branches and leaves with glandular trichomes *D. cissoides*
- 2' Branches and leaves glabrous or with tector trichomes 3
- 3 Branches and leaves with simple or stellate trichomes; capsule ovoid 4
- 3' Branches and leaves glabrous; capsule cuboid *D. macrocalyx*
- 4 Leaf blade elliptical with simple trichomes *D. aegyptius*
- 4' Leaf blade oblanceolate with stellate trichomes *D. digitatus*

Distimake ternifoliolus (Pittier) A.R.Simões & Staples

Figures 2, 3

New record. BRAZIL – CEARÁ • São Benedito, Planalto da Ibiapaba; 04°05'57"S, 078°58'19"W; 899 m alt.; 02.VI.2022; fl.; L.S. Rodrigues 200; EAC 35204.

Figure 2. *Distimake ternifoliolus*. **A.** Branch with trifoliate leaves and flowers. **B.** Details of the corolla, showing the mesopetalic areas. **C.** Details of the stamens and pistil. **D.** Detail of the anther, showing the curved apex of the anther. Photographs: L.S. Rodrigues.





Figure 3. *Distimake ternifoliolus*. **A.** Detail of the trifoliolate leaves. **B.** Lateral view of the corolla. **C, D.** Detail of the corolla. Photographs: L.S. Rodrigues.

Identification. *Distimake ternifoliolus* is characterized by the presence of trifoliolate leaves, ovate bracteoles, and simple trichomes. In Brazil this species is morphologically similar to *D. hoehnei* (Petrongari & Sim.-Bianch.) Petrongari & Sim.-Bianch. and *D. maragniensis* (Choisy) Petrongari & Sim.-Bianch because they share trifoliolate leaves. However, it can be distinguished from *D. hoehnei* by the entire margin (vs. serrated) and ovate bracteole (vs. linear). *Distimake ternifoliolus* differs from *D. maragniensis* by the simple trichomes (vs. stellate) and lanceolate bracteoles (vs. ovate). In Venezuela this species is morphologically similar to *D. nervosus* (Pittier) A.R.Simões & Staples because they share trifoliolate leaves but distinguished by the presence of simple trichomes (vs. stellate).

Updated distribution and habitat. *Distimake ternifoliolus* is known to have a disjunct distribution, divided between the savannas of Venezuela and Guyana and the savanna enclaves in the Caatinga in Brazil. Although the disjunction between these populations is approximately 10,200 km, all populations are near water bodies. In Venezuela, it generally occurs close to the banks of rivers and below 250 m of altitude in vegetation known as the Venezuelan Llanos. The Llanos occupy an area of approximately 240,000 km² on wide plains formed mainly of Quaternary alluvial sediments covered by a mosaic of savannas, gallery forests, and dry to semideciduous forests (Huber et al. 2006). In Brazil, *D. ternifoliolus* occurs in a savanna enclave in the municipality of São Benedito, Planalto da Ibiapaba, where a large population lives close to water at 899 m alt. (Figure 4).

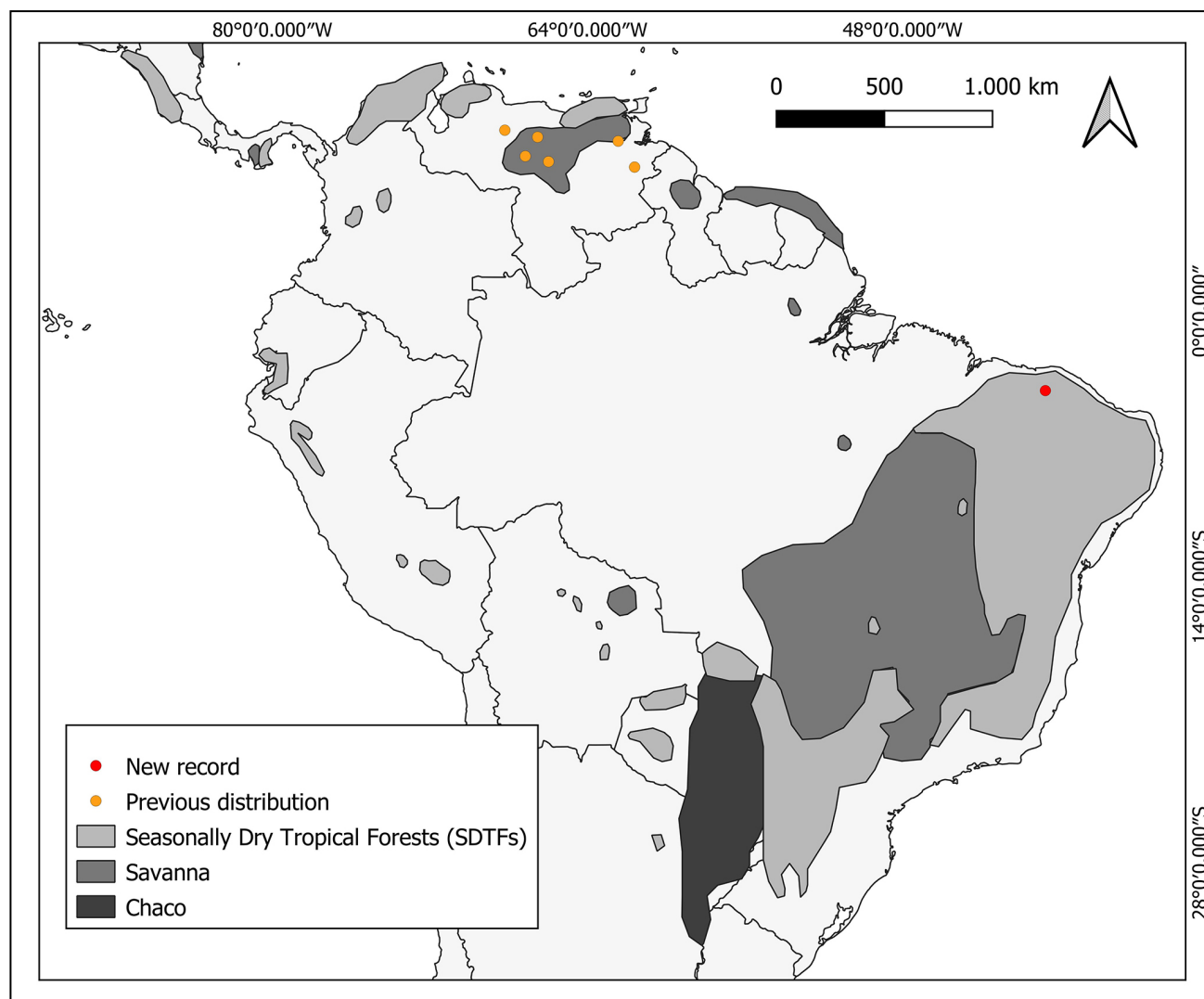


Figure 4. Disjunct distribution pattern of *Distimake ternifoliolus*, shown by the population recorded in a Savanna enclave in the Caatinga.

Flowering and fruiting period. This species was observed with flowers in January, June, July, and December, and with fruits in June.

Preliminary conservation status. The species' large population in Brazil is directly affected by private enterprises and the pasturing cattle, which contribute to the fragmentation of habitat. This restricts the Ceará population to savanna enclaves. According to the International Union for the Conservation of Nature, criteria B2ab(iii) applies, and this species can be considered as Vulnerable (IUCN 2022).

DISCUSSION

The occurrence of a population of *Distimake ternifoliolus* in Ceará state has stimulated studies to substantiate the possible past biogeographical connections between disjunct savannas, such as enclaves in the state of Ceará with others within Brazil and South America. Such knowledge can support hypotheses about the relationship between the South American savannas and the biotic similarity among them. These regions were connected in the recent past (Upper Pleistocene), and the biotic disjunctions observed today may be a result of vicariance rather than long-distance dispersal (Sarmiento 1983).

These patterns are corroborated by several taxonomic groups with disjunct distributions, such as Caryocaraceae (Prance 1973), Anacardiaceae, Bignoniaceae, Fabaceae and Malvaceae (Prado and Gibbs 1993). In Convolvulaceae, many species have this disjunct pattern, such as *Jacquemontia gracillima* (Choisy) Hallier f., *J. nodiflora* (Desr.) G. Don, *J. corymbulosa* Benth (Buriel 2014), *Ipomoea subrevoluta* Choisy, *I. eremnobrocha* D.F. Austin (Wood et al. 2017), and many *Evolvulus* species (Santos and Buriel in press), such as *E. pterocaulon* Moric., have a disjointed distribution in the Seasonally Dry Tropical Forests of South America.

Our new record also highlights the similarity between Brazilian savanna areas, especially the savanna

enclaves in Ceará state, and those in Venezuela. It adds to the knowledge of the Brazilian flora and emphasizes the importance of floristic and taxonomic studies undertaken in underexplored areas. Finally, it contributes to the knowledge of the geographic distribution of *Distimake*, which can be useful information for the conservation of this species.

ADDITIONAL INFORMATION

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Funding

This study was funded by FUNCAPE (Fundação de Apoio ao Desenvolvimento Científico e Tecnológico), process 150120/2023-0.

Author Contributions

Conceptualization: LSR. Data curation: ICS. IS. Visualization: LSR. Writing – original draft: LSR, FDSS. Writing – review and editing: MFF, FDSS.

Author ORCIDs

Leonardo de S. Rodrigues  <https://orcid.org/0000-0001-7541-9429>

Izaías C. de Sousa  <https://orcid.org/0000-0001-9877-2364>

Marlene F. Figueiredo  <http://orcid.org/0000-0002-4087-682X>

Francisco D. S. Santos  <https://orcid.org/0000-0002-0053-1333>

Data availability

All data that support the findings of this study are available in the main text.

REFERENCES

- Andrade-Lima, D** (1981) The caatinga dominium. *Revista Brasileira de Botânica* 4: 149–15.
- Buril MT, Maciel J, Alves M** (2014) Distribution patterns and areas of endemism of Brazilian *Jacquemontia* (Convolvulaceae) species. *Edinburgh Journal of Botany* 72: 13–33. <https://doi.org/10.1017/S0960428614000316>
- Costa-Coutinho JM, Jardim MA, Castro AAJF, Viana-Junior, AB** (2019) Conexões biogeográficas de savanas brasileiras: partição da diversidade marginal e disjunta e conservação do trópico ecotonal setentrional em um hotspot de biodiversidade. *Revista Brasileira de Geografia Física* 12: 2406–2427. <https://doi.org/10.26848/rbgf.v12.7.p2407-2427>
- Coutinho LM** (1982) Ecological effects of fire in Brazilian cerrado. In: Huntley BJ, Walker BH (Eds.) *Ecology of tropical savanas. Ecological studies*, volume 42. Springer-Verlag, Berlin, Germany, 273–291. https://doi.org/10.1007/978-3-642-68786-0_13
- Daly DC, Mitchell JD** (2000) Lowland vegetation of tropical South America—an overview. In: Lentz D (Eds.) *Imperfect balance: landscape transformations in the pre-Columbian Americas*. Columbia University Press, New York, USA, 391–454.
- Ferreira PPA, Miotto STS** (2013) O gênero *Merremia* (Convolvulaceae) na Região Sul do Brasil. *Rodriguésia* 64: 635–646. <https://doi.org/10.1590/s2175-78602013000300014>
- Ferrer-Pereira H, Vivas-Arroyo Y, Hokche O, Nozawa S, Pérez-Cortéz S, Rodríguez L, Mostacero J, Estrada-Sánchez J** (2010) El género *Merremia* (Convolvulaceae) en Venezuela. *Rodriguésia* 61: 639–660. <https://doi.org/10.1590/2175-7860201061406>
- Figueiredo MA, Fernandes A** (1987) Enclaves de cerrado no interior do Ceará. *Ciência Agronômica* 18: 103–106.
- Flora e Funga do Brasil** (2022) Jardim Botânico do Rio de Janeiro, Rio de Janeiro, Brazil. <https://reflora.jbrj.gov.br/reflora/>. Accessed on: 2023-03-17.
- Gonçalves EG, Lorenzi H** (2011) *Morfologia Vegetal*. Instituto Plantarum, São Paulo, Brazil, 512 pp.
- Haffer J, Prance GT** (2001) Impulsos climáticos da evolução na Amazônia durante o Cenozóico: sobre a teoria dos Refúgios da diferenciação biótica. *Estudos Avançados* 16: 175–206. <https://doi.org/10.1590/s0103-40142002000300014>
- Harris JG, Harris MW** (2001) *Plant identification terminology: an illustrated glossary*. Spring Lake Publishing, Payson, USA, 206 pp.
- Heyer WR, Maxon LR** (1982) Distributions, relationships, and zoogeography of lowland frogs: the *Leptodactylus* complex in South America, with special reference to Amazonia. Biological diversification in the tropics. In: Prance GT (Eds.) *Biological diversification in the tropics*. Columbia University Press, New York, USA, 375–402.
- Huber O, Duno de Stefano R, Aymard G, Ricarda Riina R** (2006) Flora and vegetation of the Venezuelan Llanos: a review. In: Pennington RT, Lewis GP, Ratter JA (Eds.) *Neotropical savannas and dry forests: plant diversity, biogeography, and conservation*. CRC Press, Boca Raton, USA, 95–120.

- IUCN (2022) IUCN Red List categories and criteria, version 15.1. International Union for the Conservation of Nature, Cham, Switzerland. <https://www.iucnredlist.org/resources/redlistguidelines>. Accessed on: 23-11-2023.
- Juncá FA, Funch L, Rocha W (2005) Biodiversidade e conservação da Chapada Diamantina. Ministério do Meio Ambiente, Brasília, Brazil, 435 pp.
- Medina E, Silva J (1990) Savannas of northern South America: a steady state regulated by water-fire interaction on a background of low nutrient availability. *Journal of Biogeography* 17: 403–413. <https://doi.org/10.2307/2845370>
- Mori SA, Silva LAM, Lisboa G, Coradin L (1989) Manual de manejo do herbário fanerogâmico. Segunda edição. Centro de Pesquisas do Cacau, Itabuna, Brazil, 104 pp.
- Moro MF, Macedo MB, Moura-Fé MM, Castro ASF, Costa RC (2015) Vegetação, unidades fitoecológicas e diversidade paisagística do estado do Ceará. *Rodriguésia* 66: 717–743. <https://doi.org/10.1590/2175-7860201566305>
- Moro MF, Castro ASF, Araújo FS (2011) Composição florística e estrutura de um fragmento de vegetação savânica sobre os tabuleiros pré-litorâneos na zona urbana de Fortaleza, Ceará. *Rodriguésia* 62: 407–423. <https://doi.org/10.1590/2175-7860201162214>
- Oostroom SJ (1934) A monograph of the genus *Evovulus*. Mededeelingen van het Botanisch Museum en Herbarium van de Rijks Universiteit Utrecht 14: 1–267.
- O'Donnell CA (1941) Revisión de las especies americanas de *Merremia*. *Lilloa* 6: 467–554.
- Pires FRM (2003) Arcabouço geológico. In: Cunha SB, Guerra AJT (Eds.) *Geomorfologia do Brasil*. Bertrand, Rio de Janeiro, Brasil, 188.
- Prance GT (1973) Phytogeographic support for the theory of Pleistocene Forest refuges in the Amazon basin, based on evidence from distribution patterns in Caryocaraceae, Chrysobalanaceae, Dichapetalaceae and Lecythidaceae. *Acta Amazônica* 3: 5–28. <https://doi.org/10.1590/1809-43921973033005>
- Prado DE, Gibbs PE (1993) Patterns of species distributions in the dry seasonal forests of South America. *Annals of the Missouri Botanical Garden* 80: 902–927. <https://doi.org/10.2307/2399937>
- Ratter JA, Bridgewater S, Ribeiro JF (2003) Analysis of the floristic composition of the Brazilian cerrado vegetation III: comparison of the woody vegetation of 376 areas. *Edinburgh Journal of Botany* 60: 57–109. <https://doi.org/10.1017/s0960428603000064>
- Ribeiro-Silva S, Medeiros MB, Gomes BM, Seixas ENC, Silva MAP (2012) Angiosperms from the Araripe National Forest, Ceará, Brazil. *Check List* 8: 744–751. <https://doi.org/10.15560/8.4.744>
- Salgado-labouriau ML (1997) Late Quaternary palaeoclimate in the savannas of South America. *Journal of Quaternary Science* 12: 371–379. [https://doi.org/10.1002/\(sici\)1099-1417](https://doi.org/10.1002/(sici)1099-1417)
- Sarmiento G, Pinillos M, Silva MP, Acevedo D (2004) Effects of soil water regime and grazing on vegetation diversity and production in a hyperseasonal savanna in the Apure Llanos, Venezuela. *Journal of Tropical Ecology* 20: 209–220. <https://doi.org/10.1017/s0266467403001299>
- Sarmiento, G (1983) The savannas of tropical America. In: Bourliere F (Ed.) *Ecosystems of the world XIII. Tropical savannas*. Elsevier, Amsterdam, the Netherlands, 245–288.
- Simões AR, Staples G (2017) Dissolution of Convolvulaceae tribe Merremieae and a new classification of the constituent genera. *Botanical Journal of the Linnean Society* 183: 561–586. <https://doi.org/10.1093/botlinnean/box007>
- Thiers B (2023) Index herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/science/ih/>. Accessed on: 2023-03-26.
- Van der Hammen T (1982) Paleoeecology of Tropical South America. In: Prance GT (Ed.) *Biological diversification in the tropics*. Columbia University Press, New York, USA, 60–66.
- Villarreal D, Munhoz CB, Proença CEB (2016) Campos y sabanas del Cerrado en Bolivia: delimitación, síntesis terminológica y sus características fisionómicas: cerrado grasslands and savanna in Bolivia: delimitation, terminology and physiognomies. *Kempffiana* 12: 47–80.
- Walter BMT, Carvalho AM, Ribeiro JF (2008) O conceito de savana e de seu componente cerrado. In: Sano SM, Almeida SP, Ribeiro JF (Eds.) *Cerrado – Ecologia e Flora*. Embrapa Informação Tecnológica, Brasília, Brazil, 19–46.
- Wood JRI, Buril MT, Scotland, RW (2017) Disjunções notáveis em espécies de *Ipomoea* (Convolvulaceae) no nordeste do Brasil e América Central e suas implicações taxonômicas. *Kew Bulletin* 72: 44. <https://doi.org/10.1007/s12225-017-9710-9>