



# Revista Brasileira de Geografia Física

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## New insights from *Solanum fernandesii* (Solanaceae)

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Artigo recebido em 18/02/2023 e aceito em 20/06/2023

### ABSTRACT

*Solanum fernandesii* is an unusual and important species of the genus *Solanum*, and it is the only known species within *Solanum* that has a petiolar gland. We provide new insights for this species endemic to Brazil, including a new record for the state of Piauí, Northeastern Brazil. *Solanum fernandesii* is distributed in the states of Piauí, Ceará, Bahia, Alagoas, Minas Gerais, and Pernambuco. Based on the use of online tools and field observations, its conservation status is classified as Least Concern for the Extension of Occurrence (754.583,610 km<sup>2</sup>) and Endangered for the Area of Occupancy (68.000 km<sup>2</sup>). We emphasize that serrated leaf margins, the presence of a petiole gland, and the shape of the calyx of fruits and seeds are important characteristics for the delimitation of this species. Taxonomic notes, field images, comments, and identification key for species of the genus *Solanum* in the study area are presented.

Keywords: Caatinga, Flora of Piauí, Gardneri Clade, Petiolar glands.

## Novos insights sobre *Solanum fernandesii* (Solanaceae)

### RESUMO

*Solanum fernandesii* é uma inusual e importante espécie do gênero *Solanum*. Esta é a única espécie conhecida dentro de *Solanum* que apresenta glândula peciolar. Fornecemos novos insights para esta espécie endêmica do Brasil, incluindo um novo registro para o estado do Piauí, Nordeste do Brasil. *Solanum fernandesii* tem distribuição nos estados do Piauí, Ceará, Bahia, Alagoas, Minas Gerais e Pernambuco. A partir do uso de ferramentas *on-line* e observações em campo, seu *status* de conservação é tido como Menos Preocupante para a Extensão de Ocorrência (754.583,610 km<sup>2</sup>) e Em Perigo para a Área de Ocupação (68.000 km<sup>2</sup>). Reforçamos que as margens da lâmina foliar serreadas, presença de glândula peciolar, forma do cálice dos frutos e sementes são importantes características para delimitação desta espécie. Notas taxonômicas, imagens de campo, comentários e uma chave de identificação para espécies do gênero *Solanum* na área de estudo são apresentadas.

Palavras-chave: Caatinga, Clado Gardneri, Flora do Piauí, Glândula peciolar.

## Introduction

Solanaceae is an important botanical family with a wide range morphological diversity, habits, and habitats. It is one of the most economically important angiosperm families, used for a variety purposes including food (e.g., *Solanum lycopersicum* L., tomato; *S. tuberosum* L., batata; *S. melongena* L., beringela), medicinal or source of medicinal compounds (e.g., *Nicotiana tabacum* L. and *N. rustica* L., fumo or tabaco; *Atropa belladonna* L., beladona), ornamental (e.g., *Petunia hybrida* Hort., petúnia; *Salpiglossis sinuata* Ruiz & Pav., flor-de-trombeta, see Knapp et al., 2004), among others, ensuring an essential role in the sustainability of local communities around the world (Poczai et al., 2022). In this way, species of this family are used as important and different human adaptation strategies, especially to deal with illness events (Kutal et al., 2021; Hankiso et al., 2023; Liu et al., 2023).

Solanaceae comprises 99 genera and approximately 2.700 species (Poczai et al., 2022), with a cosmopolitan distribution, concentrating the highest rates of diversity and endemism for the family in the Neotropics (Hunziker, 2001; Olmstead, 2013). South America is its center of origin and diversification, with subsequent dispersion to other parts of the world (Olmstead, 2013).

In Brazil, there are 506 species distributed in 36 genera, with 236 species and four endemic genera (Solanaceae in Flora e Funga do Brasil, 2023). Among the genera that constitute the family, *Solanum* stands out for its great diversity in number of species, high morphological variation, and great economic importance (Knapp, 2008). There are 291 species for the genus in Brazil, with 143 of them being endemic, found in the most diverse types of vegetation, mainly in the Atlantic Forest (Solanaceae in Flora e Funga do Brasil, 2023).

Among the species of this genus, there is *Solanum fernandesii* V.S. Sampaio & R. Moura. It species is native and endemic to Brazilian territory, and has been recently published for science, and belongs to the Gardneri clade (Sampaio et al., 2016), which is still constituted by some species, which include *S. agrarium* Sendtn., *S. gardneri* Sendtn., *S. polytrichum* Moric, *S. schomburghii* Sendtn., and *S. stenandrum* Sendtn. (Stern et al., 2011). Members of this clade are species native to Brazil, the Caribbean, and one species from northern Peru. The delimitation of this clade is complex. However, the possible characteristics that unite these species are the slender stem, herbaceous

to shrubby habit, straight spines, commonly acicular, small leaves in many species; inflorescences simple, lateral pauciflorous; accrescent fruit calyxes, and a preference for arid environments (Silva, 2014).

*Solanum fernandesii* is characterized by having resin glands on the petiole, the first record for the genus, and uncommon, which secrete a mixture containing phenolic compounds, polysaccharides, pectins, mucilage, proteins, lipids, oils, and resins (Sampaio et al., 2021).

The first collection of the species was carried out in 1954 by Andrade-Lima, in the locality of Barreiras, municipality of Petrolândia, Pernambuco, Northeastern Brazil. Due to being like other species, it was often confused with *S. flagellare* Sendtn., *S. stenandrum*, and, mainly, *S. agrarium* (SpeciesLink, 2023). Only in 2016, Sampaio and collaborators recognized it as a new species, presenting a set of characteristics that define *S. fernandesii* as a unique species (see Sampaio et al., 2016), and that separated it from the others hitherto confused, occurring in the states of Ceará, Pernambuco, Bahia, Alagoas, and Minas Gerais (SpeciesLink, 2023). Since then, the knowledge about the species has advanced with morphological and anatomical studies (Sampaio et al., 2019, 2021).

Despite advances in knowledge about the species, we need to advance in many aspects involving its biology, especially in its current geographic distribution and conservation status. In this way, according to Poczai et al. (2022), the decrease in the resilience of ecosystems that suffer biodiversity loss increased the urgency of promoting the conservation and sustainable use of species of this family.

Considering what has been reported, we seek to answer the following questions: What characteristics allow the identification of *S. fernandesii*? In what diversity of habitats or landscapes does it occur? What is its geographic distribution in Brazil? What is your conservation status? By answering these questions, we hope to contribute to the knowledge of *S. fernandesii*, an important and unusual species of the genus *Solanum*.

Therefore, based on the status of knowledge regarding the species, in the present study, we report for the first time the occurrence of *S. fernandesii* for the Piauí state, Northeastern Brazil, thus expanding its geographic distribution area, in addition to providing general comments and information about its conservation status and

the different types of landscapes in which it occurs. In addition, field images of *S. fernandesii* and an

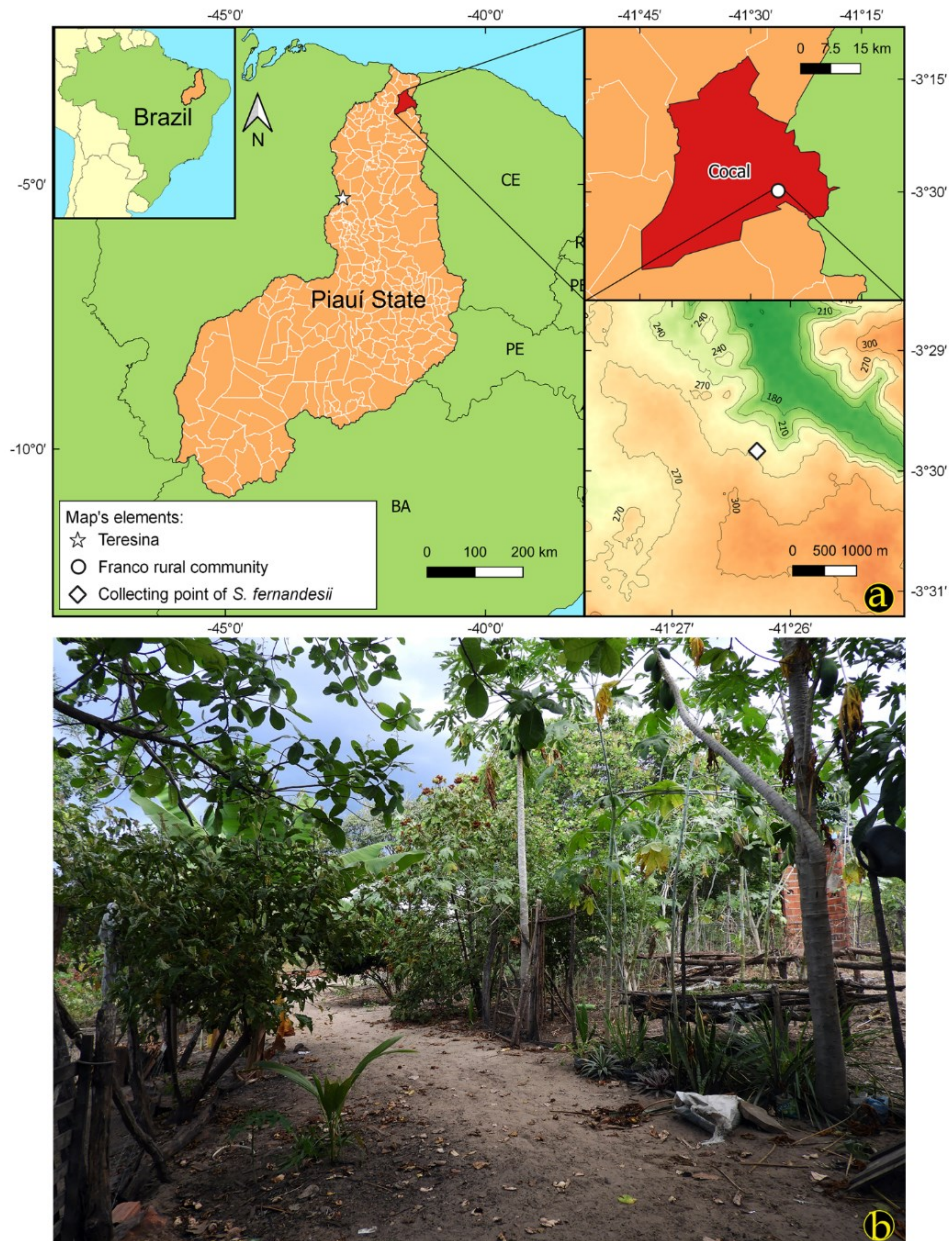
identification key of *Solanum* species for the municipality of Cocal/PI are presented.

## Material and methods

### Study area

In Piauí state, *Solanum fernandesii* was collected in the Franco rural community (3°29'49.7"S and 41°26'17.0"W), municipality of

Cocal, north of Piauí (Fig. 1). The municipality is 268 km from the state capital, Teresina. The collection site of the species is within the limits of the Environmental Protection Area (EPA) of Serra da Ibiapaba (Brasil, 1996).



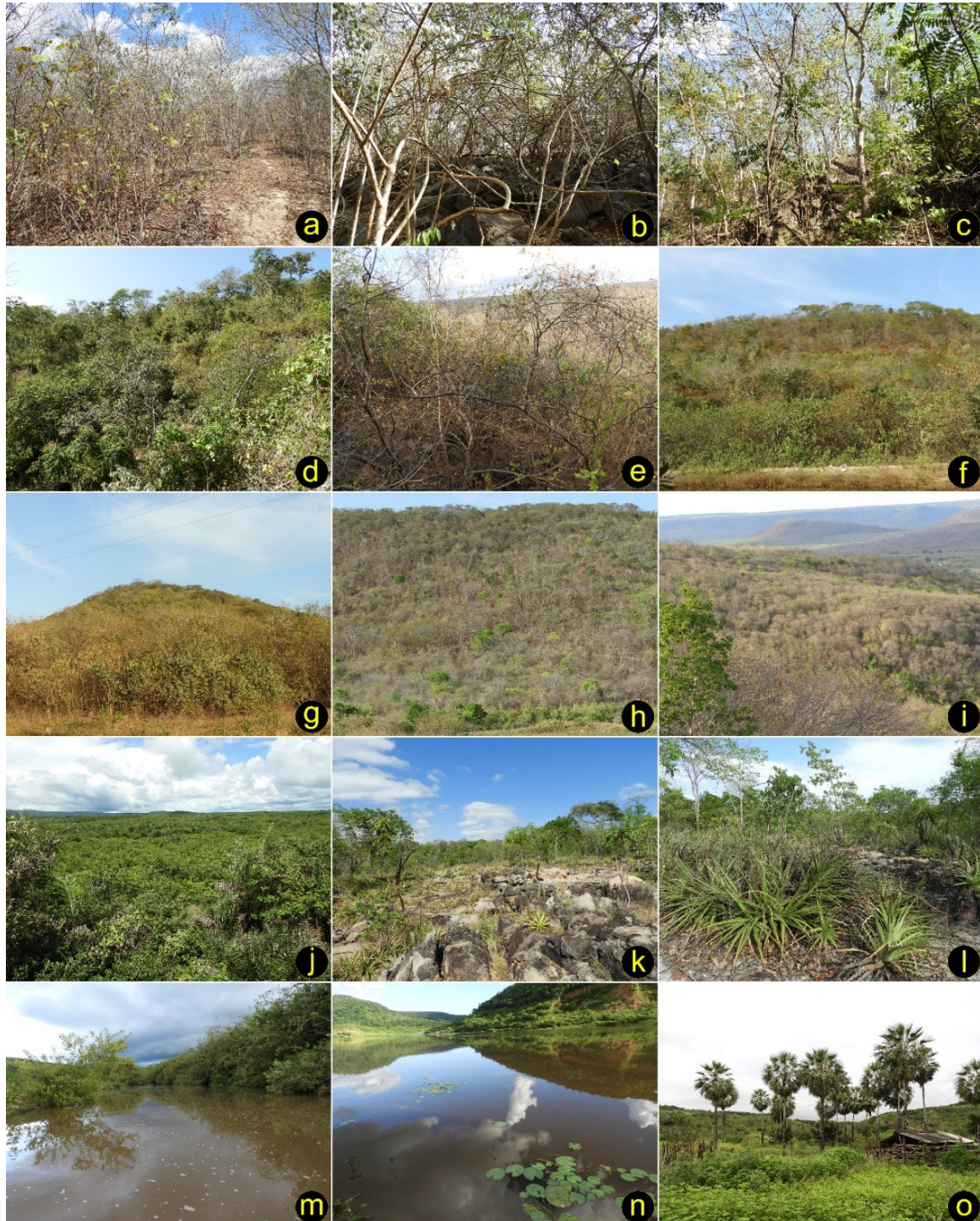
**Figure 1.** The *Solanum fernandesii* collection's location map (a) detailing the landscape (b) where it was discovered in the Franco rural community, Cocal, Piauí, Northeastern Brazil.

The area of the municipality is located under the Aw' - Tropical climate domains, with two well-marked seasons: rainy summer and hot

winter, with temperatures ranging between 25 and 35 °C. The average annual rainfall is 900 mm (Medeiros, 2004). The vegetation is described as

Carrasco. This type of deciduous vegetation is characterized by the predominance of woody, shrubby, branched plants and by the strong presence of vines, with great emphasis on species of the Asteraceae, Bignoniaceae, Euphorbiaceae, Fabaceae, Malpighiaceae, and Rubiaceae botanical

families (Chaves, 2005). Vegetation transitions such as hyperxerophilous Caatinga and Cerrado also occur in the study area (Jacomine, 1986). Figure 2 shows some landscapes in the Cocal municipality.



**Figure 2.** Landscapes and vegetation details recorded in Cocal, PI: a. area of local vegetation in the dry season; b-c. detail of vegetation on top of flattened surfaces, dissected in tabular interfluves; d-j. details of the municipality's vegetation in different areas; k-l. typical vegetation in areas of lajeiros; m. Piranji River; n. view of the Algodões I Dam; o. area of carnaubas (Carnaubal). (Photos: JIA Siqueira).

## Collection and identification of botanical material

*Solanum fernandesii* was collected according to usual techniques for the collection and herborization of botanical materials (Mori et al., 1989), between February and March 2020, in the Franco rural community, during the conduct of an ethnobotanical investigation by the first author. The material was identified using a dichotomous key for the genus *Solanum* occurring in Ceará state (Sampaio et al., 2019) and confirmed by an expert. The samples were incorporated into the collection of the HDELTA Herbarium at the Federal University of Delta do Parnaíba (UFDPAr), Piauí, Brazil, under voucher numbers 7236-7238. The results of this research were registered in the *Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado* (SisGen, acronyms in Portuguese, <https://sisgen.gov.br/>) under registration number A38ED40.

The morphological description and terminology followed the delineations proposed by Radford (1974), Agra et al. (2009), Gonçalves and Lorenzi (2011), and Sampaio et al. (2016, 2019). The confirmation of the names of the taxa presented here was consulted in the International Plant Names Index - IPNI (2023).

## Geographic distribution and conservation status

To obtain data on the occurrence of the species in Brazil, the resources of the online tools SpeciesLink (<https://specieslink.net/search/>), and the Re flora Virtual Herbarium ([reflora.jbrj.gov.br](http://reflora.jbrj.gov.br)) were used. In this sense, we organized a spreadsheet in Excel® with data on the genus of the species, scientific epithet, state of collection, municipality, and information on latitude and longitude. Data from scanned labels and exsiccates (when available) was carefully reviewed so that the selected material was correctly identified.

For records with general or imprecise geographic coordinates, searches were carried out in the Google Earth tool (<https://earth.google.com/web/>) using the information on the herbarium labels to more accurately locate the areas of occurrence of the species. For records collected in the same area or at

geographically close points, it was decided to select only the coordinates of one of them as an instrument for analyzing the geographic distribution of the species.

During the study of sorting the occurrence points, 30 records were reported in SpeciesLink, while 11 were located in the Re flora Virtual Herbarium, the latter being duplicated and previously sorted in SpeciesLink, in addition to three occurrence records for the municipality of Cocal (PI) from fieldwork and botanical excursions that were added to the list, totaling 33 records. Excluding duplicate points or very close populations, 17 records were selected for the delimitation of the Extent of Occurrence and Area of Occupation of the species, according to subsequent descriptions.

From the geographic coordinates data, the points were plotted on maps of geographic distribution running the software QGIS version 3.22 (<https://www.qgis.org/es/site/>), and Geospatial Conservation Assessment Tool, GeoCAT (<http://geocat.kew.org/>). In the latter, the Extent of Occurrence and Area of Occupancy of the species were traced to determine its conservation status (Bachman et al., 2011).

## Results

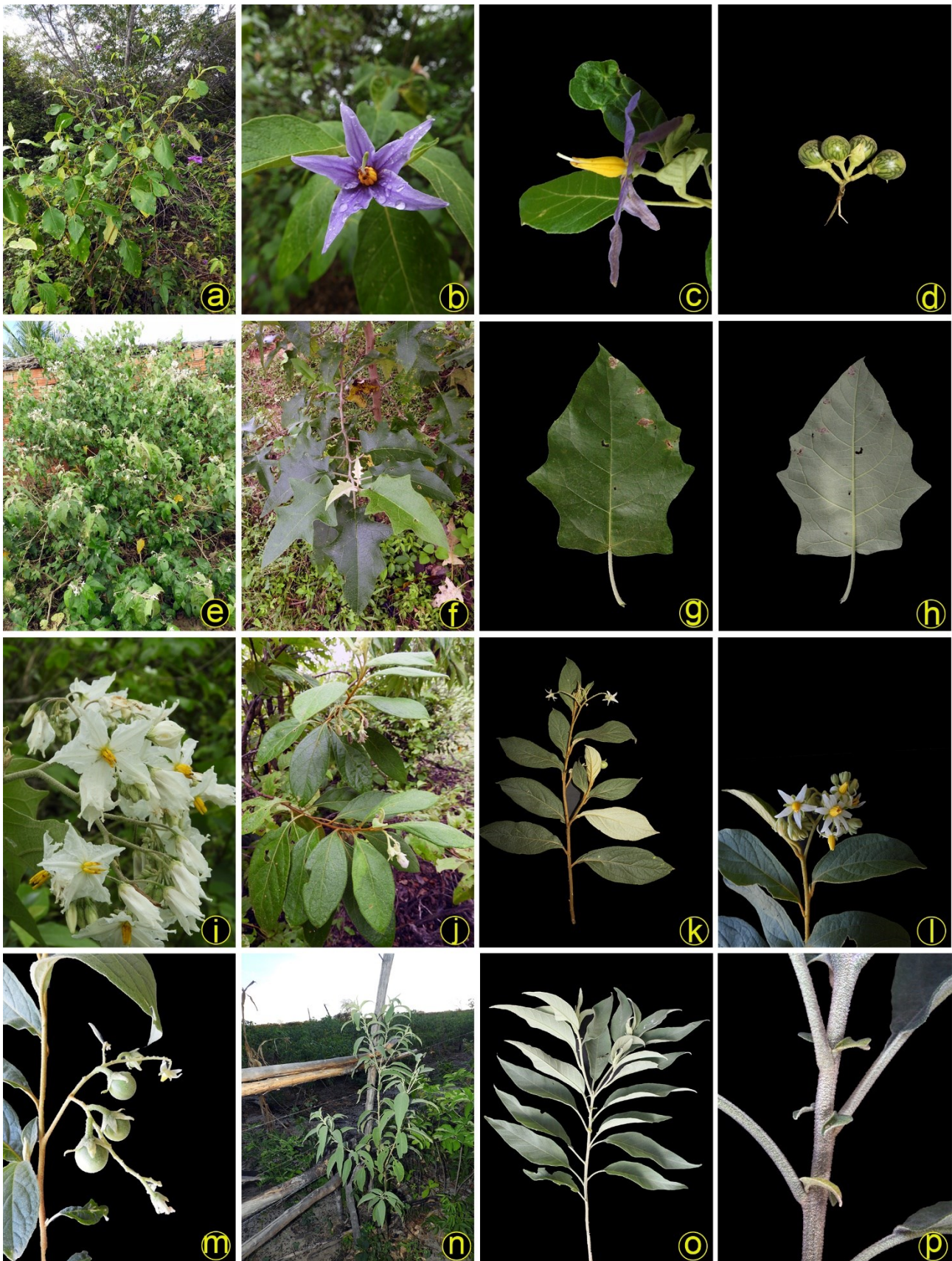
New occurrence of *Solanum fernandesii* from Piauí and *Solanum* of the municipality of Cocal

*Solanum fernandesii* V.S. Sampaio & R. Moura occurs in the state of Piauí in Northeastern Brazil, thus expanding its distribution area and current knowledge about the species. It has an herbaceous to subshrub habit, is found in ruderal areas, and has great biocultural importance for the Franco rural community in the municipality of Cocal, in the north of Piauí.

The number of *Solanum* in Cocal (Figs. 3-4) has increased to nine as a result of this new record: *S. agrarium*, *S. americanum* Mill., *S. asperum*, *S. crinitum* Lam., *S. fernandesii*, *S. paludosum* Moric., *S. paniculatum* L., *S. rhytidoandrum* Sendtn., and *S. stipulaceum* Willd. ex Roem. & Schult., recognized by morphological characters, according to the identification key of *Solanum* for the municipality of Cocal, Piauí, presented below.



**Figure 3.** Field details of *Solanum* species of the municipality of Cocal: *S. agrarium*: a. habit; b. flower; c-d. fruit; *S. americanum*: e. flowers; f. fruits; *S. asperum*: g. habit; h. flower; i. fruits; *S. crinitum*: j. habit; k. details of branch; l. flower; m. flower calyx; *S. fernandesii*: n. habit; o. flowers; p. fruit. (Photos: JIA Siqueira).



**Figure 4.** Field details of *Solanum* species of the municipality of Cocal: *S. paludosum*: a. habit; b-c. flower; d-d. fruit; *S. paniculatum*: e. habit; f. details of branch; g. leaf blade adaxial surface; h. leaf blade abaxial surface habit; i. inflorescences; *S. rhytidoandrum*: j. habit; k. details of branch; l. details of inflorescence; m. details of fruits; *S. stipulaceum*: n. habit; o. details of branch; p. details of pseudoestipules. (Photos: JIA Siqueira).

**Identification key of *Solanum* species in the municipality of Cocal, Piauí, Northeastern Brazil**

1. Plants without spines; blade with entire or wavy margin; anthers oblong or attenuated towards the apex, if attenuated it has a prominent connective.
  2. Herb; trifoliate or bifoliate sympodial unit, unbranched inflorescence.....1. *Solanum americanum*
  - 2'. Shrubs; plurifoliate sympodial unit, branched inflorescence.
    3. Adaxial surface of leaves with multiangulate stellate, porrecto-stellate, sessile and pedicellate trichomes; subreniform seeds; bushes with pseudostipules.....2. *Solanum stipulaceum*
    - 3'. Adaxial surface of leaves with sessile porrecto-stellate trichomes; oval seeds; bush without pseudostipules.....3. *Solanum asperum*
- 1'. Plants with spines; blade with serrated or lobed margin; anthers attenuated towards the apex, without connective.
  4. Petioles with petiolar gland; blades with serrated margins.....4. *Solanum fernandesii*
  - 4'. Petioles without petiolar gland; blades with lobed margins
    5. Greenish corolla..... 5. *Solanum agrarium*
    - 5'. White, lilac or violet corolla.
      6. Tomentose epicarp, with porrecto-stellate trichomes.....6. *Solanum crinitum*
      - 6'. Epicarp glabrous, sparse-pubescent, with glandular and stellate-glandular or glandular trichomes.
        7. Branched inflorescence; reniform seeds.
          8. Tomentose adaxial surface, scabra.....7. *Solanum rhytidoandrum*
          - 8'. Adaxial surface glabrous to sparse-pubescent, powdery.....8. *Solanum paniculatum*
        - 7'. Unbranched inflorescence; subreniform seeds.....9. *Solanum paludosum*

Description of the new record of *Solanum fernandesii* from Piauí, Northeastern Brazil

***Solanum fernandesii*** V.S. Sampaio & R. Moura, Phytotaxa 270: 33. 2016. Figs. 5-6.

Plant herbaceous to subshrub, prostrate, less often erect, ca. 13-36 cm tall, aculeate; stems cylindrical, greenish, brownish to vinaceous, moderately to densely hirsute, covered by glandular and simple hyaline uniseriate trichomes, spines 1-3 mm long, conical and slightly recurved. Sympodial unit trifoliate, less frequently bifoliate. Leaves simple, 4.9-12.2 cm long, petiole 0.8-4.1 x 0.1-0.3 cm, greenish, pubescent, with glandular or simple uniseriate trichomes, spines 1-3 mm long, conical and acicular, adaxial petiolar gland proximal to the base of the petiole; blade 3.2-8.1 x 2.3-5.2 cm, ovate, concolor, apex rounded, truncated or acute, base truncate or asymmetrical, membranous, margin serrated, venation craspedodromous, adaxial surface sparse-pubescent to pubescent, trichomes glandular, simple, uniseriates; abaxial surface sparse-pubescent, with glandular and porrect-stellate sessile trichomes. Inflorescences extra-axillary, simple monocasial cyme. Peduncle 0.1-0.2 cm long, sessile; pedicel 0.09-0.1 x 0.9-1.9 cm, pubescent, with glandular, and rare simple uniseriate trichomes. Oblong buds, 0.2-1.9 cm

long; Flowers perfect, pentamerous, monoclines; calyx 2.3-5.3 mm diam., greenish triangular lobes, acute, with glandular, simple uniseriate and stellate trichomes; corolla 1.3-1.9 cm diam., stellate, white, lobes lanceolate; stamens equal, anthers 0.4-0.5 cm long, yellow to yellowish-green, lanceolate; style 0.6-0.7 cm long, cylindrical, yellowish-green, extending beyond the length of the anthers, stigma clavate. Fruit a berry ovoid, globose to subglobose, 1.5-2.5 x 2.1-3.6 cm, epicarp glabrous, variegated, green when immature, purple/vinaceous at maturity; pedicel 1.6-3.9 cm long, not lenticated and not accrescent on the fruit, vinaceous lobes, aculeate. Seeds 0.3-0.4 x 0.5-0.6 cm, suborbicular, white to slightly brownish or beige, winged.

Material examined: BRASIL. PIAUÍ: Cocal, comunidade rural Franco, 3°29'49.9"S, 41°26'16.8"W, 25.II.2020, fl. and fr., *J.I.A. de Siqueira* (HDELTA 7236); 28.II.2020, fl. and fr., *J.I.A. de Siqueira* (HDELTA 7237); 10.III.2020, fl. and fr., *J.I.A. de Siqueira* (HDELTA 7238).

**Species comments**

*Solanum fernandesii* (Figs. 5-6) occurs in the states of Alagoas, Bahia, Ceará, Minas Gerais, and Pernambuco (*Solanaceae in Flora e Funga do Brasil, 2023; SpeciesLink, 2023*).

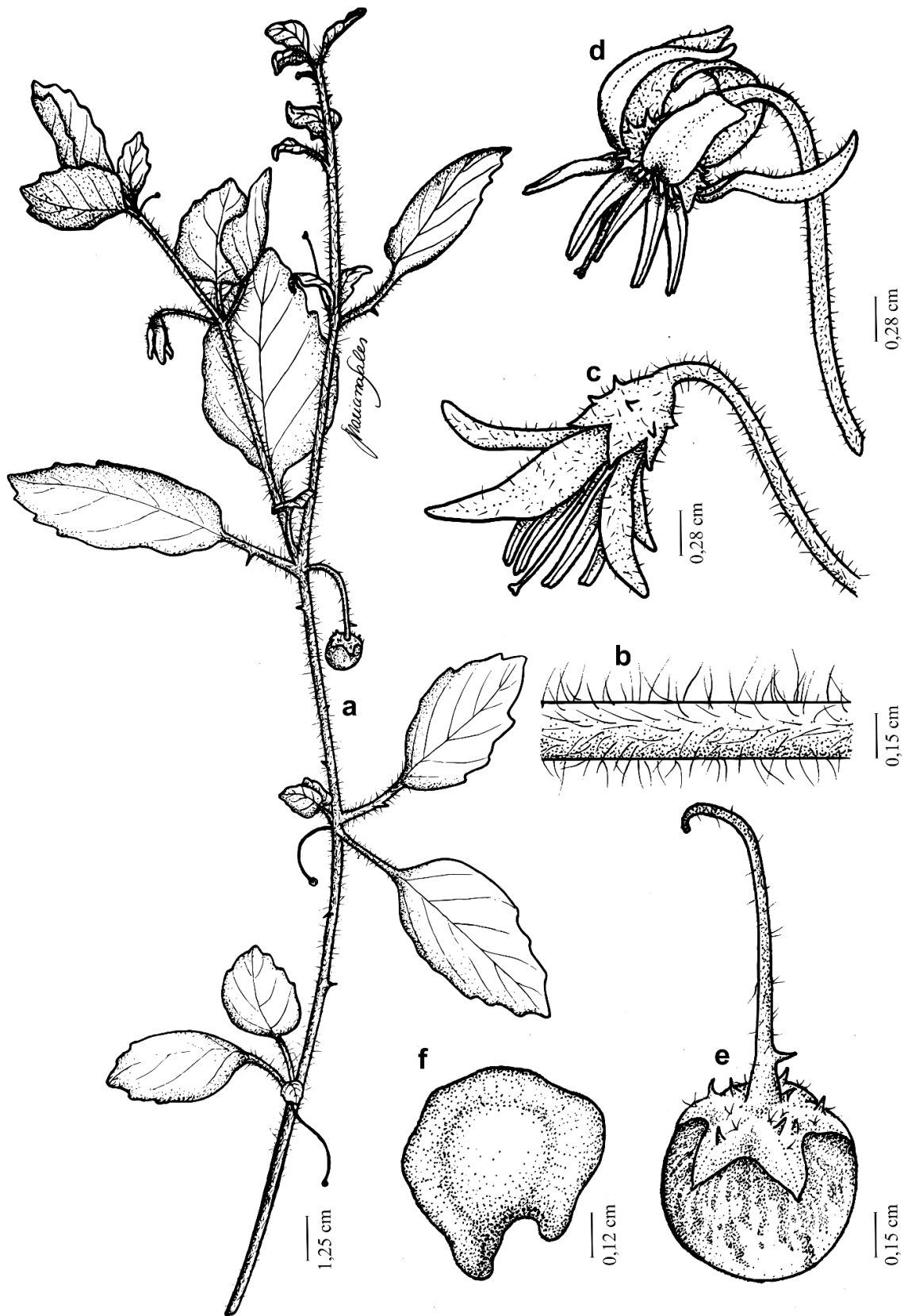
In Piauí, it is considered a new record (Tab. 1, Figs. 5-6). In the Franco rural community, Cocal,

it was only collected in home gardens, a biocultural landscape. It was collected for the first time in 2020, and in subsequent years (2021 and 2022), it

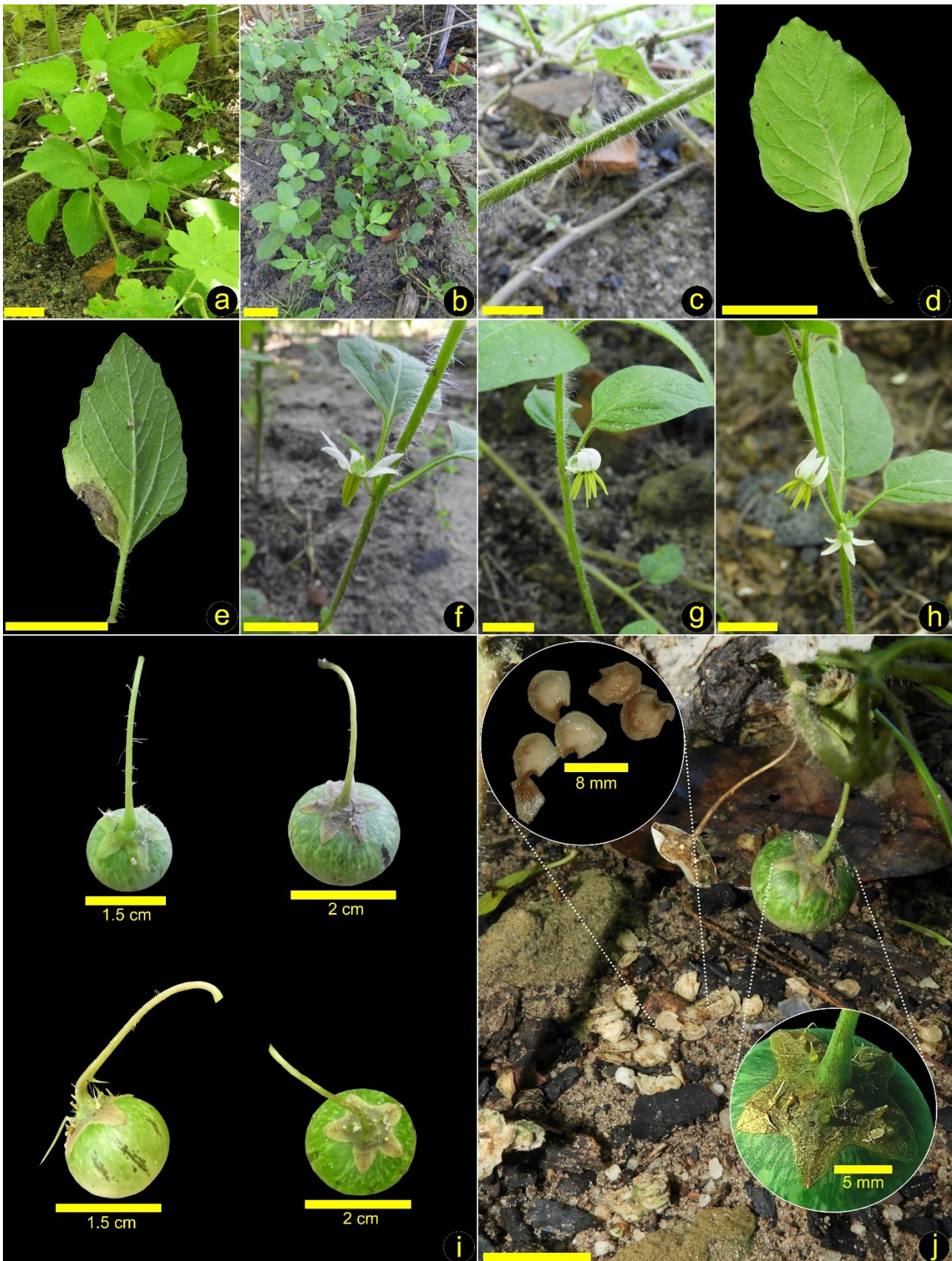
was not found during extensive botanical excursions carried out in both wet and dry seasons.

**Table 1.** Selected records of *Solanum fernandesii* between the years 1954 to 2020, highlighting the locality, community, municipality and State (AL = Alagoas; BA = Bahia; CE = Ceará; MG = Minas Gerais; PE = Pernambuco and PI = Piauí), coordinates geographic maps, and *vouchers* for collections available on SpeciesLink and of the present fieldwork.

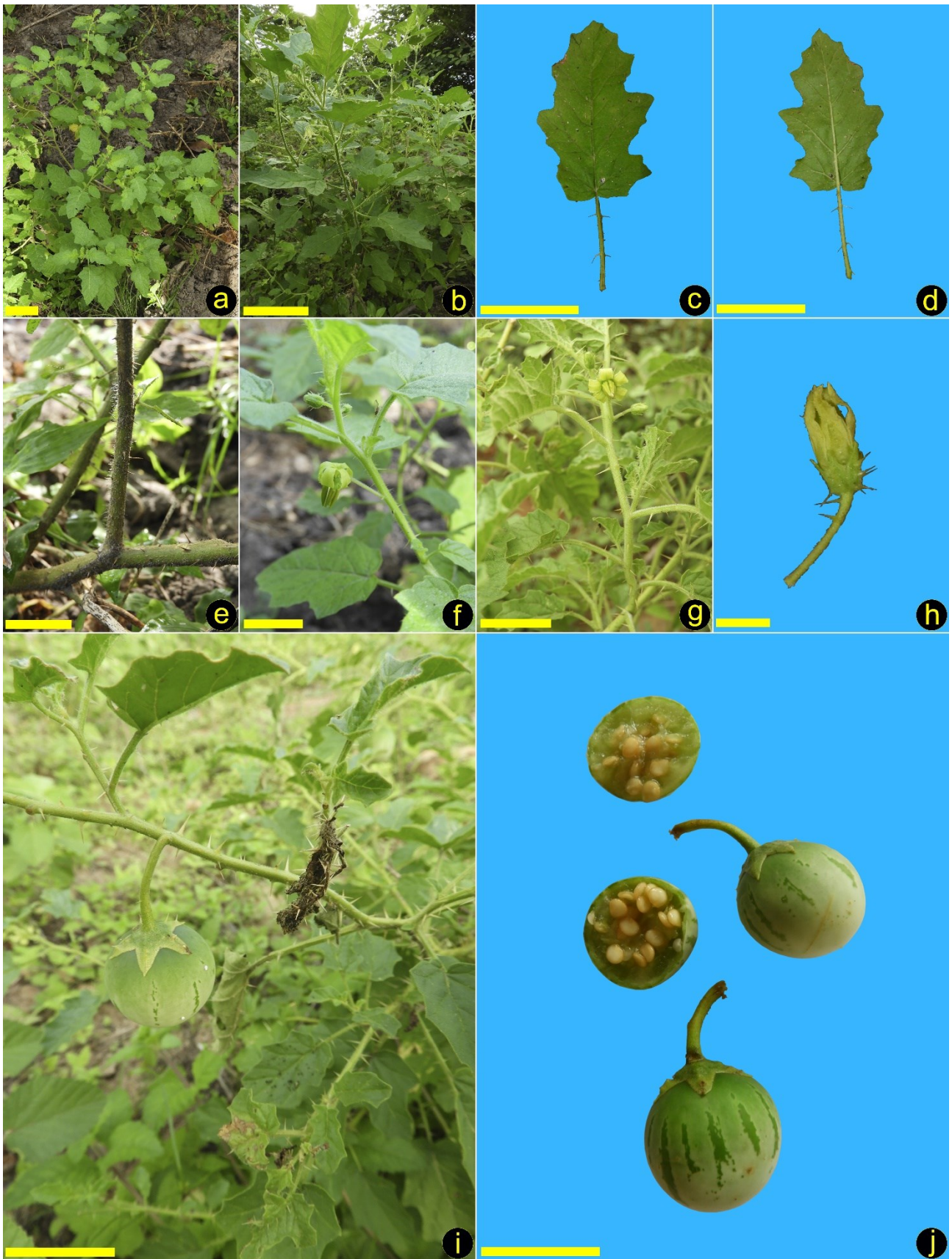
Locality, Municipality	State	Coordinates	Vouchers
Oliveira	AL	9°29'12.3"S 37°11'14.4"W	Rodrigues, M. N., Pinheiro, A. I. L. MAC 4306;
Campus da UFAL, Maceió	AL	9°33'18.9"S 35°46'31.5"W	Mota, C. MAC 51172;
Caetité	BA	14°03'36.0"S 42°28'12.0"W	Hatschbach, G. G. NY 781399
Campus da UEFS, Feira de Santana	BA	12°12'00.5"S 38°58'16.6"W	Noblick, L. R. NY 781400; Queiroz, L. P. de, HUEFS 110333; Jardim, J. G. CEPEC 118978; Jardim, J. G. HUEFS 107061; Noblick, L. R. HUEFS 2503; Discentes da UEFS, CEPEC 40317
Santa Teresinha	BA	12°43'39.0"S 39°34'11.0"W	Costa, G., Correia, F., Fonseca, G. V., Silva, L. V. P. HURB 18268;
FLONA Contendas do Sincorá	BA	13°56'34.3"S 41°05'22.9"W	Costa, G., Correia, F. R., Vitória, C. D. P. HURB 15688
Antônio Gonçalves	BA	10°36'16.1"S 40°16'13.6"W	Melo, E., Souza, R. B., Barreto, V. C. N. BHCB 105015; Melo, E. HUEFS 109545
Laje	BA	13°09'01.0"S 39°20'41.0"W	Costa, G., Correia, F., Silva, T. T. HURB 15022;
Rio de Contas	BA	13°37'13.0"S 41°45'54.0"W	Harley, R. M. HUEFS 83170;
Boa Nova	BA	14°19'56.0"S 40°13'17.8"W	Costa, G., Fonseca, W. O., Fonseca, G. V. HURB 21145
Brejinho das Ametistas, Caetité	BA	14°22'18.0"S 42°32'25.0"W	Mendes, M. S. HUEFS 151760
Campus do PICI-UFC, Fortaleza	CE	3°44'46.8"S 38°34'25.5"W	Sampaio, V. S., Moura, R. L. EAC 57399; Braga, T. S. EAC 65333; Sampaio, V. S. EAC 59188; Sampaio, V. S. EAC 57569; Sampaio, V. S., Ribeiro, R. T. M. EAC 65332; Sampaio, V. S. EAC 57182; Sampaio, V. S., Moura, R. L. EAC 57412; Sampaio V. S. EAC 57570; Sampaio, V. S., Moura, R. L. EAC 57822
Serra do Espinhaço, Monte Azul	MG	15°09'18.0"S 42°52'27.8"W	Hatschbach, G. G. NY 00701453;
Paraopeba	MG	19°16'27.8"S 44°24'15.1"W	Heringer, E. P. US 2544269
Embrapa CPATSA, Petrolina	PE	9°04'17.6"S 40°19'07.7"W	Fotius, G. IPA 31459
Barreiras, Petrolândia	PE	9°02'09.3"S 38°14'59.8"W	Andrade-Lima, IPA 7558
Comunidade rural Franco, Cocal	PI	3°29'49.9"S 41°26'16.8"W	Siqueira, J. I. A. HDELTA 7236-7238



**Figure 5.** Morphological details of *Solanum fernandesii*: a. fertile stems detailing its phyllotaxis; b. hirsute indumentum of stems; c-d. flower details; e. fruit; f. winged seed. (a-f. JIA Siqueira 379, 381, 401).



**Figure 6.** Field details of *Solanum fernandesii*: a-b. habit; c. hirsute stem; d. leaf blade adaxial surface; e. leaf blade abaxial surface; f-h. inflorescence/flower details; i. fruit details; j. details of the fruit and seeds. Bar scale: a = 5 cm; b = 10 cm; c = 2 cm; d = 4 cm; e = 3 cm; f = 1 cm; g = 1 cm; h = 1 cm; j = 2 cm. (Photos: JIA Siqueira).



**Figure 7.** Field details of *Solanum agrarium*: a-b. habit; c. leaf blade adaxial surface; d. leaf blade abaxial surface; e. hirsute stem; g-h. flower details; i-j. details of the fruit and seeds. Bar scale: a = 5 cm; b = 5 cm; c = 3 cm; d = 4 cm; e = 2 cm; f = 1 cm; g = 2 cm; h = 5 mm; i = 2 cm; j = 1,9 cm. (Photos: JIA Siqueira).

The species is very similar to *Solanum agrarium* (Fig. 7), differing mainly by having a petiolar gland, serrated leaf margins, and winged suborbicular seeds. In the study area, it flowers during the rainy summer period, especially in February and March, and fruiting occurs in the months of February, March, April, May, and June. In the warm winter (dry period), the species is not found. In the state of Ceará, it was collected flowering in February, April, May, and November and fruiting in April, and November (Sampaio et al., 2019).

Extension of Occurrence and Area of Occupancy

Before the inclusion of the record of *S. fernandesii* from Piauí, the Extension of Occurrence for this species was 478.705,565 km<sup>2</sup> (LC category) and the Area of Occupation was equal to 64.000 km<sup>2</sup> (EN category). After the inclusion of the new record, the Occurrence Extension becomes 754.583,610 km<sup>2</sup> (LC category), and the Area of Occupancy was equal 68.000 km<sup>2</sup> (EN category) (Fig. 9).

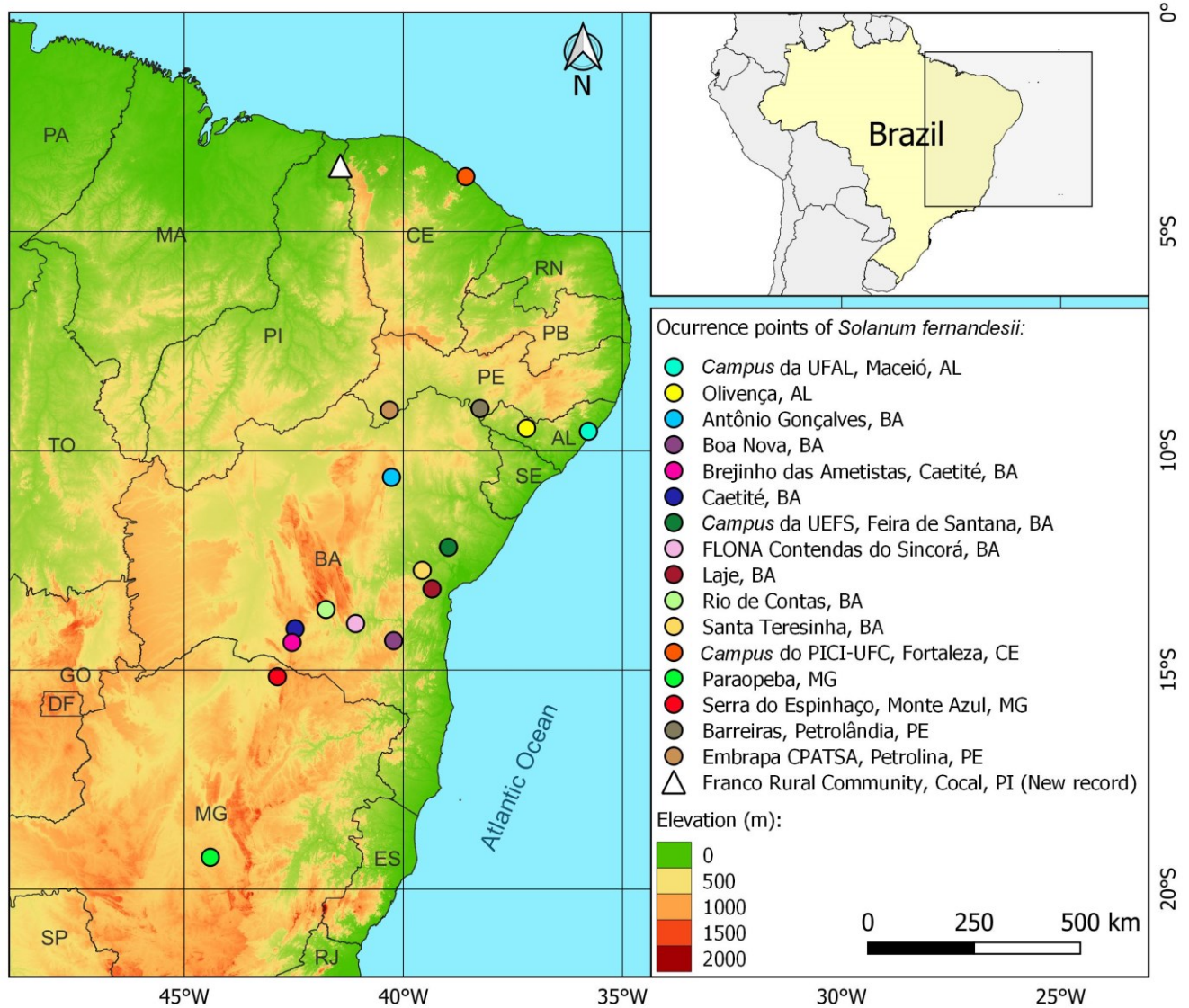
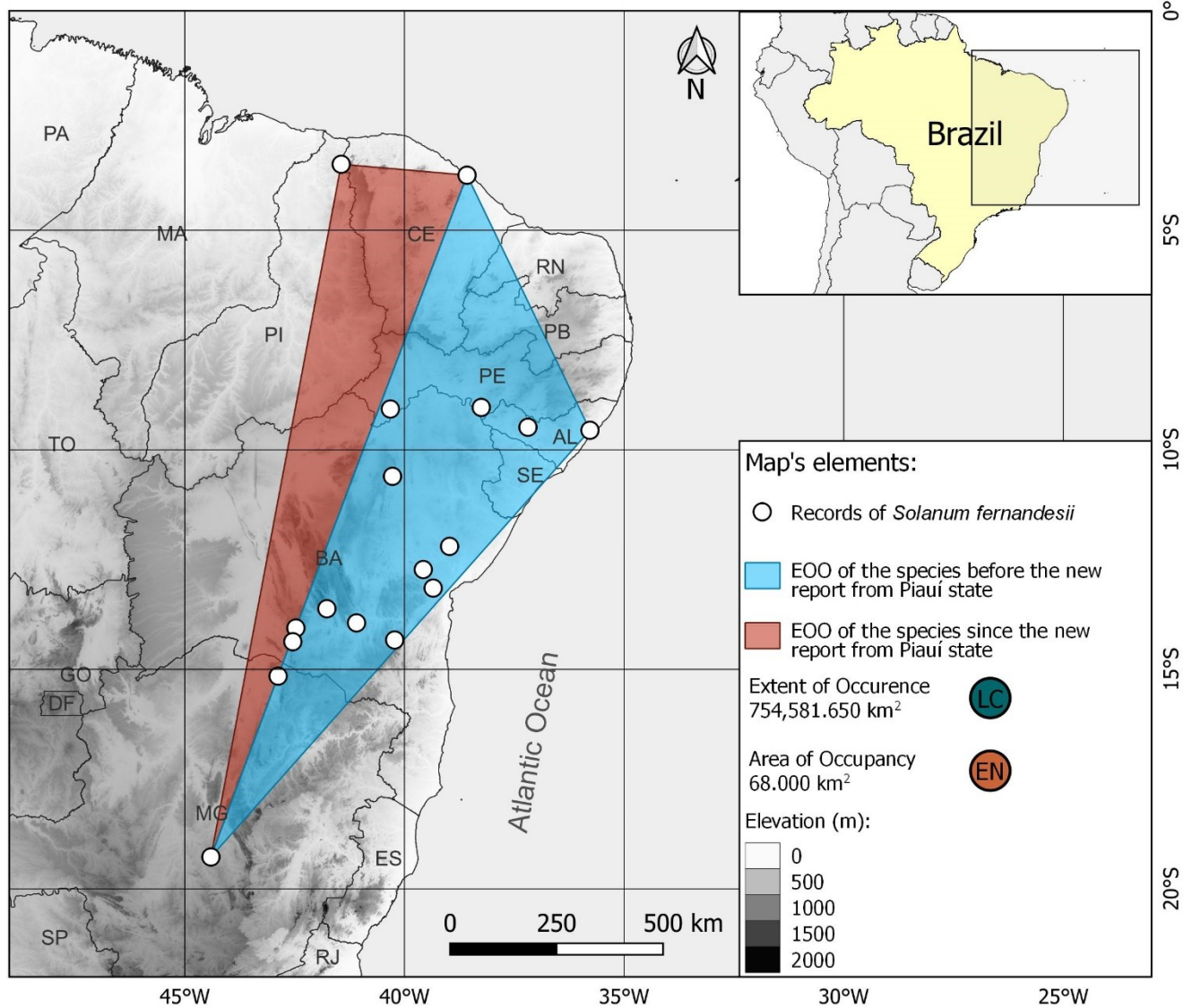


Figure 8. Geographic distribution map of *Solanum fernandesii* in Brazil.



**Figure 9.** Map showing the Extent of Occurrence and Area of Occupancy of *Solanum fernandesii*.

### Discussion

Habitats, morphology, and peculiarities of *Solanum fernandesii*

*Solanum fernandesii* was collected in a rural home garden, a space structured based on traditional, and sustainable management. Home gardens are traditional agricultural systems, possibly one of the oldest land use systems (Pushpakumara et al., 2012). In these spaces, a high diversity of species is cultivated and maintained for different purposes, which grow around the houses or close to them (Nair, 2006). As they are structured within properties, home gardens are seen as the first source of immediate contact between people and plants (Naigaga et al., 2021).

In the Franco rural community, home gardens represent spaces of great biological, cultural, and social importance, where local

residents cultivate and maintain a high diversity of plant species, especially as food and medicinal resources (Siqueira et al., 2017, 2020).

Previously, the occurrence of *S. fernandesii* was recorded for the states of Alagoas, Bahia, Ceará, Minas Gerais, and Pernambuco (Solanaceae in Flora e Funga do Brasil, 2023; SpeciesLink, 2023). With this new record from the municipality of Cocal/PI, we have expanded the knowledge associated with the distribution of this species and regarding the Flora of Piauí. In this way, Chaves (2005) carried out a great sampling effort to document and describe the flora of Cocal from the floristic record and its economic potential. However, she did not record *S. fernandesii* for the study area, having found other species belonging to the Solanaceae family, such as *Athenaea fasciculata* (Vell.) I.M.C Rodrigues & Stehmann, *Physalis angulata* L., *S. asperum*, *S. crinitum*, *S.*

*paniculatum*, and *S. paludosum*. The first author of this research collected *S. fernandesii* between February and March 2020 in the Franco rural community while conducting an ethnobotanical investigation.

The areas where the species was collected undergo regular weeding, especially in the rainy summer. Plants that are growing spontaneously and that are considered pests or that have no use are eliminated during weeding activities. However, *Solanum fernandesii* is considered a medicinal species in the Franco rural community, and due to this, it has been kept in home gardens. In this sense, home gardens represent important spaces for the conservation of biological and cultural diversity (Nunes et al., 2007; Galluzzi et al., 2010; Amberber et al., 2014; Idohou et al., 2014; Salako et al., 2014). This species was not found outside home garden areas, as commonly occurs with *S. agrarium*.

*Solanum fernandesii* and *S. agrarium* are two species that are very similar morphologically in the field (Figs. 6-7). Both species are known as *melancia-da-praia*, *melancia-do-mato* or *melancia-de-raposa* by the local population of the Franco rural community and are locally important in medicinal preparations. *Solanum fernandesii* has the indumentum of the hirsute stem (Fig. 6c), serrated leaf margins (Fig. 6d-e), presence of petiolar gland, vinaceous fruit calyx (Fig. 6i-j), suborbicular, and winged seeds (Fig. 6j) (ca. 45-72), while *S. agrarium* has the glabrescent indumentum stem (Fig. 7e), lobed and irregular leaf margins (Fig. 7d-d), absent petiolar gland, green fruit calyx (Fig. 7i-j), non-winged subreniform seeds (Fig. Fig. 7j) (ca. 211) (see Sampaio et al., 2016).

*Solanum fernandesii* is distributed in ruderal areas, coastal tablelands, and Steppe Savanna (Sampaio et al., 2016). In Ceará state, it is found in ruderal areas and in the Seasonal Semideciduous Forest of Lowlands (Sampaio et al., 2019). In the Franco rural community, it is associated with landscapes where ruderal species commonly grow. The species is endemic to Brazil (Sampaio et al., 2016; Solanaceae in Flora e Funga do Brasil, 2023). The distribution of *S. agrarium* is much wider, and the species is not endemic to Brazil (Agra et al., 2009), occurring in regions that cover areas of the Neotropics, including Bolivia, Brazil, Colombia, Guyana, Jamaica, the Netherlands, and the Venezuelan Antilles, and Venezuela (Plants of the World, 2023).

*Solanum agrarium* is considered a ruderal plant and usually occurs in dry and open soils along

roadsides, in waste places, thickets, cultivated lands, and pastures in areas with long and pronounced dry seasons (Solanaceae Source, 2023). In Brazil, this species has occurrences in Anthropogenic Areas, Caatinga (*stricto sensu*), Campo Rupestre, Cerrado (*lato sensu*), and Seasonal Deciduous Forest (Solanaceae in Flora e Funga do Brasil, 2023). Unlike *S. fernandesii*, *S. agrarium* has a wide distribution in the municipality of Cocal, being easily found in landscapes with a predominance of ruderal species, including home gardens, roadsides, thickets, pasture lands, etc.

Conservation status: Extension of Occurrence and Area of Occupancy

The increase in the number of records since the description of the species shows the growth in its Extension of Occurrence, 754.581,650 km<sup>2</sup>, considered as the Least Concern category (LC), and Area of Occupation equal to 68.000 km<sup>2</sup>, with a category considered Endangered (EN) (Fig. 9). According to Sampaio et al. (2016), the conservation status of the species is considered Least Concern (LC), mentioning criteria such as occurrence in open anthropogenic environments and lack of records in environmental protection areas. The new record from Piauí state is within the limits of the EPA of Serra da Ibiapaba. However, it is not in an area of native vegetation. This species was also collected in a Conservation Unit, in this case, the Contendas de Sincorá National Forest (see again Tab. 1).

Based on our findings, we support that the conservation status of the species can be considered Least Concern (LC category). However, this category is related to its Extension of Occurrence, which we point out to occur in different states of Northeastern Brazil, and in Minas Gerais (Southeastern region). The species has characteristics that make its conservation status worrying in relation to its Area of Occupation, considered to be in danger of extinction (EN category). Its occurrence can be wide, however, the places where it occurs are in specific areas and few individuals are found structuring the populations. In the Franco rural community, only three individuals were found in a very specific area of a rural home garden.

In the Ceará state, *Solanum fernandesii* is found only inside the *Campus do Pici*, of the Federal University of Ceará, specifically in a roundabout. The records (Tab. 1, HUEFS 2503, 107061, NY 781400, CEPEC 118978, 40317) for Feira de Santana, Bahia, are also within a university *Campus*, as is one of the records for

Alagoas (MAC 51172). Many of the records are in areas of cleared forest, roads, farms, etc. (SpeciesLink, 2023). This characteristic of being very punctual in the places of occurrence can be a decisive factor in the conservation of the species since, depending on the area where it occurring, *Solanum fernandesii* can disappear completely from the region, configuring its extinction at the local level.

In this way, in the Franco rural community, the species is more likely to disappear than *S. agrarium* because it occur in specific areas and is rare. In contrast, the second species *S. agrarium* is more frequent and has a wider distribution. On a broader scale, however, there is still no data available on population and possible threats to *S. fernandesii* so that we can trace a more accurate conservation status for the species.

Other species of *Solanum* in Cocal present conservation status with LC category, which include *S. crinitum*, *S. paniculatum*, and *S. stipulaceum* (IUCN, 2023) and are found within the EPA of Serra da Ibiapaba. With the exception of *S. fernandesii* and *S. stipulaceum*, the other species are widely distributed in the municipality, especially in ruderal areas. *Solanum crinitum* and *S. paniculatum* are found structuring large populations, especially along roadsides in the municipality. *Solanum asperum* and *S. rhytidoandrum*, despite being found in ruderal areas, are more frequent in areas of native vegetation, especially in open areas of lajeiros. *Solanum fernandesii* and *S. stipulaceum* are species that have a very punctual distribution in the municipality.

Seventeen species of *Solanum* occur in Piauí state (Solanaceae in Flora e Funga do Brasil, 2023). Nine species of *Solanum* are registered in Cocal/PI, corresponding to approximately 53% of the total diversity of the genus occurring in the State. Among the species of *Solanum* that occur in the municipality, only *S. fernandesii* and *S. stipulaceum* are endemic to Brazil. Many of them have a wider distribution in Brazil, including *S. americanum*, *S. asperum*, *S. paniculatum*, and *S. rhytidoandrum* (Solanaceae in Flora e Funga do Brasil, 2023).

### Final considerations and future perspectives

We added evidence that *S. fernandesii*, although very similar to *S. agrarium*, it can be easily recognized by the petiolar gland, serrated leaf blade margin, vinaceous fruit calyx, and winged suborbicular seeds.

Our contributions support the knowledge that *S. fernandesii* is more associated with ruderal environments, as it was collected in a home garden, a space where many species with this profile grow. As it is collected or found only in a home garden and there are no records in Piauí outside these spaces, we presented evidence of the importance of home gardens for the maintenance of rare species, contributing to the diversity and floristic richness of Piauí. In addition to being the first record of occurrence in the state, this is the first record of the occurrence of the species associated with this type of landscape, the rural home garden inserted in the semi-arid region in the north of Piauí.

Although the literature (see Sampaio et al., 2016) treats the species with a conservation status of Least Concern (LC category), a worrying finding refers to its conservation status in relation to the Species' Area of Occupation, which, by the determined values, places it within the EN category, Endangered. The results obtained in this study, in combination with the comments presented on its frequency and habitats, suggest that the species may be more at risk of local extinction in the municipality of Cocal in relation to other species of *Solanum* occurring in the same municipality. We assume that extrapolating this result to all areas where the species occurs is a limiting factor, because, although the profile and described characteristics suggest a pattern for the species, we only know well the populations occurring in the states of CE and PI (Northeastern Brazil). We need complementary data to trace or suggest a more accurate conservation status for the species.

Thus, we need to advance further in our understanding of its conservation status, and for this, we need to understand why the species, despite occurring in several states of Brazil, forms very restricted populations with few individuals. Collaborative efforts between researchers from different areas with records for the species can help to solve this knowledge gap. For this, we need to better understand its reproductive biology, pollinator networks, seed dispersal, and germination, as well as the conditions and connections between the habitats where the species grows.

Our findings, ultimately, contribute to the knowledge of the Flora of Piauí, especially with the increase in the number of species in the genus *Solanum*, which now stands at 18 species. Piauí is a state that stands out in terms of diversity and floristic richness. Despite this, joint efforts are

increasingly urgent to expand our current knowledge of the region's flora.

### Acknowledgments

The authors would like to thank the residents of the Franco rural community who assisted in the fieldwork, allowing us to find *S. fernandesii*, especially Mrs. Teresinha de Jesus Machado. Our most sincere thanks to the Botany Laboratory of the Federal University of Delta do Parnaíba (UFDPAr) for their support during the conduct of the study. The authors thank the Conselho Nacional de Desenvolvimento Tecnológico e Científico (CNPq) for awarding the Master's degree scholarship (grant 134354-2019-2) to the first author.

### References

- Agra, M.F., Nurit-Silva, K., Beger, L.R., 2009. Flora da Paraíba, Brasil: *Solanum* L. (Solanaceae). *Acta Botanica Brasilica* 23, 826-842. DOI: <https://doi.org/10.1590/S0102-33062009000300024>.
- Amberber, M., Argaw, M., Asfaw, Z., 2014. The role of homegardens for in situ conservation of plant biodiversity in Holeta Town, Oromia National Regional State, Ethiopia. *International Journal of Biodiversity and Conservation* 6, 8–16. DOI: <https://doi.org/10.5897/IJBC2013.0583>.
- Bachman, S., Moat, J., Hill, A.W., De La Torre, J., Scott, B., 2011. Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. *ZooKeys* 150, 117-126.
- Brasil., 1996. Decreto s/nº de 26 de novembro de 1996: dispõe sobre a criação da Área de Proteção Ambiental Serra da Ibiapaba, nos Estados do Piauí e Ceará, e dá outras providências. *Diário Oficial da União, Brasília*.
- Chaves, E.M.F., 2005. Florística e potencialidades econômicas da vegetação de carrasco no município de Cocal, Piauí, Brasil. 2005. 113 f. Master's Dissertation (Master's degree in Environment and Development) —Universidade Federal do Piauí, Teresina.
- Galluzzi, G., Eyzaguirre, P., Negri, V., 2010. Home gardens: neglected hotspots of agrobiodiversity and cultural diversity. *Biodiversity Conservation* 19, 3635–54. DOI: <https://doi.org/10.1007/s10531-010-9919-5>.
- Gonçalves, E.G., Lorenzi, H., 2011. *Morfologia vegetal: organografia e dicionário ilustrado de morfologia das plantas vasculares*. 2a ed. Instituto Plantarum de Estudos da Flora, São Paulo. 512p.
- Hankiso, M., Warkineh, B., Asfaw, Z., Debella, A., 2023. Ethnobotany of wild edible plants in Soro District of Hadiya Zone, southern Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 21, 1-23. DOI: <https://doi.org/10.1186/s13002-023-00588-2>.
- Hunziker, A.T., 2001. *Genera Solanacearum: the genera of Solanaceae illustrated, arranged according to a new system*. Koeltz Scientific Books, Königstein, Germany.
- Idohou, R., Fandohan, B., Salako, V.K., Kassa, B., Gbèdomon, R.C., Yédomonhan, H., Kakaï, R.L.G., Assogbadjo, E., 2014. Biodiversity conservation in home gardens: traditional knowledge, use patterns and implications for management. *International Journal of Biodiversity Science, Ecosystem Services and Management* 10, 89-100. DOI: <https://doi.org/10.1080/21513732.2014.910554>
- IPNI., 2023. International Plant Names Index. Disponível: <https://www.ipni.org/>. Accessed: 10 jan. 2023.
- IUCN., 2023. The IUCN Red List of Threatened Species. Available at: <https://www.iucnredlist.org/>. Accessed: 28 jan. 2023.
- Jacomine, P.K.T., 1986. Levantamento exploratório – reconhecimento de solos do Estado do Piauí. EMBRAPA-SNLCS/SUDENE-DRN, Rio de Janeiro, Brasil.
- Knapp, S., Bohs, L., Nee, M., Spooner, D.M., 2004. Solanaceae – a model for linking genomics with biodiversity. *Comparative and Functional Genomics* 5, 285-291.
- Knapp, S., 2008. A revision of the *Solanum havanense* Species group and new taxonomic additions to the Geminata Clade (*Solanum*, Solanaceae). *Annals of the Missouri Botanical Garden* 95, 405-458.
- Kutal, D.H., Kunwar, R.M., Uprety, Y., Adhikari, Y.P., Battarai, S., Adhikari, B., Kunwar, L.M., Bhatt, M.D., Bussmann, R.W., 2021. Selection of medicinal plants for traditional medicines in Nepal. *Journal of Ethnobiology and Ethnomedicine* 59, 1-17.
- Liu, S., Zhang, B., Lei, Q., Zhou, J., Ali, M., Long, C., 2023. Diversity and traditional knowledge of medicinal plants used by Shui people in Southwest China. *Journal of Ethnobiology and Ethnomedicine* 20, 1-53. DOI: <https://doi.org/10.1186/s13002-023-00594-4>.
- Medeiros, R.M., 2004. *Estudo agrometeorológico para o estado do Piauí*. Sema, Teresina.
- Mori, S.A., Silva, L.A.M., Lisboa, G., Coradin, L., 1989. *Manual de Manejo de Herbário*

- Fanerogâmico. 2. ed. Centro de Pesquisas do Cacau, Ilhéus.
- Naigaga, H., Ssekandi, J., Ngom., A., Sseremba, G., Mbaye, M.S., Noba, K., 2021. Ethnobotanical knowledge of home garden plant species and its effect on home garden plant diversity in Thies region of Senegal. *Environment, Development and Sustainability* 23, 7524-7536.
- Nair, P.K.R., 2006. Whither home gardens. In: Kumar, B.M., Nair, P.K.R., (eds.) *Tropical home gardens: A time-tested example of sustainable agroforestry*. Springer, New York. Pp.355-370.
- Nunes, A.T., Araújo, E.L., Albuquerque, U.P., 2007. Contribution of homegardens to the conservation of caatinga plants, Municipality of Caruaru, Pernambuco State, Brazil. *Acta Botanica Brasílica* 21, 37-47.
- Olmstead, R.G., 2013. Phylogeny and biogeography in Solanaceae, Verbenaceae and Bignoniaceae: a comparison of continental and intercontinental diversification patterns. *Botanical Journal of the Linnean Society* 171, 80-102. DOI: <https://doi.org/10.1111/j.1095-8339.2012.01306.x>.
- Plants of the World., 2023. Royal Botanical Garden, Kew: *Solanum agrarium* Sendtn. Available at: <https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:818168-1>. Accessed: 28 jan. 2023.
- Poczai, P., D'Agostino, N., Deanna, R., Portis, E., 2022. Editorial: Solanaceae VII: biology, genetics, and evolution. *Frontiers in Genetics* 13, 1-4.
- Pushpakumara, D.K.N.G., Marambe, B., Silva, G.L.L.P., Weerahewa, J., Punyawardena, B.V.R., 2012. A review of research on home gardens in Sri Lanka: the status, importance and future perspective. *Tropical Agriculturist* 160, 55-125.
- Radford, A.E., 1974. *Fundamentals of plant systematics*. Harper & Row, New York. 498p.
- Salako, V.K., Fandohan, B., Kassa, B., Assogbadjo, A.E., Idohou, A.F.R., Gbedomon, R.C., Chakeredza, S., Dulloo, M.E., Kakaï, R.G., 2014. Home gardens: an assessment of their biodiversity and potential contribution to conservation of threatened species and crop wild relatives in Benin. *Genetic Resources and Crop Evolution* 61, 313-30.
- Sampaio, V.S., Moura, R.L., Loiola, M.I.B., 2016. *Solanum fernandesii* (Solanaceae): a new species 'spiny solanum' of the Gardneri clade from northeastern Brazil. *Phytotaxa* 270, 33-40.
- Sampaio, V.S., Vieira, I.M.F., Lima-Júnior, E.A., Loiola, M.I.B., 2019. Flora do Ceará, Brasil: *Solanum* (Solanaceae). *Rodriguésia* 70, 1-27. DOI: <https://doi.org/10.1590/2175-7860201970029>.
- Sampaio, V.C., Coutinho, I.A.C., Särkinen, T., Loiola, M.I.B., 2021. Secretory and ecological function of petiolar glands in *Solanum fernandesii*: first description of resin glands in the genus *Solanum*. *Australian Journal of Botany* 70, 32-41. DOI: <https://doi.org/10.1071/BT21001>.
- Silva, R.C., 2014. Caracterização morfoanatômica de *Solanum* Clados Gardneri e *Thomasiifolium* (Solanaceae). 2005. 63 f. Master's Dissertation (Master's degree in Vegetal Biology) —Universidade Federal de Pernambuco, Recife.
- Siqueira, J.I.A., Chaves, E.M.F., Lemos, J.R., 2017. Ethnobotanical Study on The Use Medicinal Plants in Agroforestry Backyards in The Environmental Protection Area of The "Serra da Ibiapaba", Northeastern Brazil. In: Mathias, A., Laisné, N., (eds.) *Medicinal Plants: Production, Cultivation and Uses*. Nova Science Publishers, New York. Pp. 211-230.
- Siqueira, J.I.A., Vieira, I.R., Chaves, E.M.F., Sanabria-Diogo, O.L., Lemos, J.R., 2020. Biocultural behavior and traditional practices on the use of species of Euphorbiaceae in rural home gardens of the Semiarid Region of Piauí State (NE, Brazil). *Caldasia* 42, 1-42. DOI: <https://doi.org/10.15446/caldasia.v42n1.76202>.
- Solanaceae in Flora e Funga do Brasil., 2023 Jardim Botânico do Rio de Janeiro. Available at: <https://floradobrasil.jbrj.gov.br/FB225>. Accessed: 09 jan. 2023.
- Solanaceae Source., 2023. A global taxonomic resource for the nightshade family: *Solanum agrarium*. Available at: <https://solanaceaesource.myspecies.info/content/solanum-agrarium>. Accessed: 06 jan. 2023.
- Species Link., 2023. *Solanum fernandesii* in SpeciesLink. Available at: <https://specieslink.net/search/>. Accessed: 28 jan. 2023.
- Stern, S., Agra, M.F., Bohs, L., 2011. Molecular delimitation of clades within New World species of the "spiny solanums" (*Solanum* subg. *Leptostemonum*). *Taxon* 5, 1429-1441. DOI: <https://doi.org/10.1002/tax.605018>.