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Original Papers

A new tetraploid species of *Tacinga* (Cactaceae) from Ceará, Northeastern Brazil

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Abstract

A new species of cactus, *Tacinga mirim* (Cactaceae: Opuntioideae), is described and illustrated. *Tacinga mirim* is like a miniature version of *T. palmadora*, as far as is known, endemic to the state of Ceará, Northeastern Brazil. Although some populations of the new species have been known since 2009, they had been wrongly identified as *T. palmadora*. The description of the new species was made based on morphological and karyotypic analysis. Morphologically, it differs from *T. palmadora* by the much smaller size, semi-prostrate habit, smaller and deciduous stem-segments, lower density of spines, slightly larger and wide-open flowers, smooth pericarpel, and the globose to obovoid, purplish ripe fruit. The karyotype of *T. mirim* differs from *T. palmadora* in being tetraploid (not diploid), by presenting chromosomes that are twice as large, eight of which are submetacentric (differing from the fully metacentric standard karyotype of *T. palmadora*). The distribution of the new species is associated with the Caatinga of the crystalline basement of the northwestern hinterland of Ceará, found at relatively low altitudes (190–360 m). The IUCN category of threat for the new taxon was preliminary assessed. Both EOO and AOO indicate that the species is endangered (EN–B1-2ab).
Key words: biodiversity, Caatinga, cytotaxonomy, endemic, semiarid.

Resumo

Uma nova espécie de cacto, *Tacinga mirim* (Cactacaeae: Opuntioideae), é descrita e ilustrada. *Tacinga mirim* é como uma miniatura de *T. palmadora*, até onde se sabe, endêmica do estado do Ceará, nordeste do Brasil. Apesar de algumas populações da nova espécie serem conhecidas desde 2009, elas vinham sendo erroneamente identificadas como *T. palmadora*. A descrição da nova espécie foi feita a partir de análise morfológica e cariotípica. Morfologicamente defere de *T. palmadora* pelo tamanho muito menor, o hábito semiprostrado, os segmentos menores e decíduos, a menor densidade de espinhos, flores um pouco maiores e com grande angulo de abertura, pericarpelo liso e o fruto globoso a obovóide, roxo quando maduro. O cariótipo de *T. mirim* difere de *T. palmadora* por ser tetraploide (ao invés de diplóide), por apresentar cromossomos duas vezes maiores, dos quais oito são submetacêntricos (diferindo do padrão cariotípico totalmente metacêntrico de *T. palmadora*). A distribuição da nova espécie está associada à Caatinga do embasamento cristalino do interior do Ceará, em altitudes relativamente baixas (190–360 m). A categoria de ameaça do novo táxon segundo a IUCN foi avaliada preliminarmente. Tanto a EOO como a AOO indicam que a espécie é ameaçada (EN–B1-2ab).
Palavras-chave: biodiversidade, Caatinga, citotaxonomia, endêmica, semiárido.

Introduction

The traditional circumscription of the genus *Tacinga* Britton & Rose comprised only two species, both endemic to eastern Brazil: *T. funalis* Britton & Rose and *T. braunii* E. Esteves Pereira (Taylor *et al.* 2002). Based on morphological characteristics of the flower, pollen, and seed, Taylor *et al.* (2002) transferred four more species and a hybrid (all endemic to eastern Brazil) from *Opuntia* to *Tacinga*: *T. inamoena* (K. Schum.) N.P.

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Taylor & Stuppy, *T. palmadora* (Britton & Rose) N.P. Taylor & Stuppy, *T. werneri* (Eggli) N.P. Taylor & Stuppy, *T. saxatalis* (F. Ritter) N.P. Taylor & Stuppy, and *T.* × *quipa* (F.A.C. Weber) N.P. Taylor & Stuppy. In the two decades that followed, one more species was recombined from *Opuntia*: *Tacinga lilae* (Trujillo & M. Ponce) Majure & R. Puente, and five more were described, including two nothospecies: *T. subcylindrica* (M. Machado & N.P. Taylor) M. Machado & N.P. Taylor, *T. armata* J.G. Freitas & E.M. Almeida, *T. gladispina* J.G. Freitas & E.M. Almeida, *T.* × *flamea* J.G. Freitas & E.M. Almeida, and *T.* × *grandiflora* N.P. Taylor & Zappi (Machado & Taylor 2003; Majure *et al.* 2013; Freitas *et al.* 2021; Taylor *et al.* 2023).

Except for *T. lilae*, which is from Venezuela (Majure *et al.* 2013), all the species of the genus are endemic to Eastern Brazil (Machado & Taylor 2003; Taylor & Zappi 2004; Freitas *et al.* 2021; Taylor *et al.* 2023). The range of most of the species is associated with the Caatinga biome (Taylor & Zappi 2004), but there are also some records in the Cerrado - only on limestone outcrops associated with semi-deciduous forests (Taylor & Zappi 2004; Gonzaga *et al.* 2023). In terms of evolution, there are still no molecular analyses covering all species in the genus, but preliminary data indicate the *T. palmadora* + *T. lilae* complex as a likely basal group. On the other hand, species with unique morphological characteristics (*T. funalis* and *T. braunii*), and the polyploids (*T. inamoena* and *T. subcylindrica*) appear to constitute more derived groups (Majure & Puente 2014; Martins 2022; Barrios-Leal *et al.* 2024).

Here we describe another species, that was first collected in 2009 by the first author, along with Nigel Taylor, Marlon C. Machado, Domingos Cardoso, Marcelo F. Moro, and Antônio Sérgio F. Castro, during a systematic survey of Cactaceae in the state of Ceará (Menezes *et al.* 2011). The plant was first found in Santa Quitéria and later in several other municipalities (Menezes *et al.* 2011, 2013). At the time, the most obvious features that differentiate the new species from *T. palmadora* (Britton & Rose) N.P. Taylor & Stuppy (reduced size, smaller stem-segments, and less spines) were interpreted as local peculiarities of the population due to the effects of vegetation management and livestock. Thus, it had been initially treated as *T. palmadora* (Menezes *et al.* 2011, 2013; Menezes & Ribeiro-Silva 2015).

Recently, in the second update to "Cacti of Eastern Brazil", Taylor *et al.* (2022) revised some features of the genus and drew attention to the differences between the plant described here and the typical form of *T. palmadora*, recommending further studies. The typical form of *T. palmadora*, found in other Northeastern states (Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia), is a tall erect shrub, with flower morphology resembling that of *T. werneri*. However, the plants from Ceará are much smaller and have a flower morphology that resembles *T. subcylindrica*. Thus, new collections were made and the same population of Santa Quitéria was revisited to carefully assess the peculiarities of this *Tacinga* from Ceará.

Material and Methods

Fieldwork

Fieldwork was carried out on December 2022, in Santa Quitéria, Canindé, and surrounding areas (Ceará, Brazil). The main previously known population, from the locality of Piabas (municipality of Santa Quitéria, Ceará, Brazil), was the first one visited for this study. A second important population was discovered in the Reserva Imburanas da Volta - a private protected area in the municipality of Canindé. Additional occurrence points were also recorded in Canindé, in the surroundings of the Reserva Imburanas da Volta. The position of each population was recorded with GPS for later mapping.

Morphological analysis

Morphological descriptions, measurements, and photographs were taken from live specimens in the field. Some samples were collected as vouchers and others were cultivated until anthesis or fruit ripening. All samples were deposited in the Prisco Bezerra Herbarium (EAC). Additional specimens from EAC were also analyzed. The general botanic terminology follows Harris & Harris (2001). For unique Cactaceae features the standards of Hunt *et al.* (2006) were used. All the measurements were taken with a caliper and follow the order length × width (for plain structures) or length × diameter (for solid structures).

Karyotype analysis

Chromosome Preparation - stem-segments of four individuals (*M.O.T. Menezes*, *437*, *438*, *443*, and *444*) were cultivated for karyotype analysis. Tips of young roots were pre-treated with 8-hydroxyquinoline (8HQ) for 20 hours at 4 °C. They were then fixed in Carnoy 3:1 (ethanol: acetic

acid) for 2 to 24 hours at room temperature and stored at -20 °C in the fixative. For staining with fluorochromes, the young roots fixed with Carnoy were washed in distilled water and digested with an enzymatic solution (3% cellulase / 1% pectolyase). The cell dissociation of the root apical meristem was performed following the protocol established by Alves *et al.* (unpublished data). The cell dissociation of the meristem was carried out using an ultrasonic cleaner (power between 30W or 50W) for 1 minute. For this purpose, 0.5 ml microtubes containing digested root tips were used and rapidly washed in 100 µL of 3:1 fixative solution (methanol: acetic acid), which was then removed and added back to the microtube. The glass slides were preheated and 10 µL of the cell suspension was pipetted onto each slide. After completely drying at room temperature, the slides were briefly dipped in 60% acetic acid and incubated in a laboratory oven at 37 °C for 30 minutes.

ND-FISH and CMA/DAPI Staining - After three days the glass slides were fixed in Carnoy for 15 minutes, then dehydrated in an alcohol series: 70% alcohol for 3 minutes, followed by 100% alcohol for 3 minutes. The glass slides were then incubated in the laboratory oven at 60 °C for 30 minutes and cooled at room temperature for 10 minutes. The hybridization mix was prepared containing 2x SSC and 5S probe. 20 µL of the mix was used per slide, which was covered with a 22 x 22 mm coverslip. Hybridization was carried out in a humid chamber in the laboratory oven at 37 °C for 2 hours. After hybridization, coverslips were removed with a 2x SSC wash and rinsed in 4x SSC for 10 minutes without agitation (Cuadrado *et al.* 2009). After drying, the slides were stained with 10 µL of CMA3 (0.1 mg/mL) for one hour, washed in 2x SSC, air-dried, and mounted with 10 µL of McIlvaine/ glycerol buffer (pH 7.0) (1:1, v/v) containing DAPI (1 µg/mL). The best cells were imaged using an Axion Imager A2® microscope with ZEN® software and the images were subsequently edited using Adobe Photoshop CS3® version 10.0.

Geographic distribution and evaluation of conservation status

The maps were prepared with QGIS (Sherman *et al.* 2011), using the geographic coordinates obtained in field and data from SpeciesLink (<https://specieslink.net/>). The geographic data were compared with the distribution of *Tacinga palmadora* (occurrence points obtained from SpeciesLink).

Geographic coordinates of the populations were also used to assess the conservation status of the new species, using the Geospatial Conservation Assessment Tool - GeoCAT (Bachman *et al.* 2011; Kew Gardens 2023), which evaluates the conservation status based on the extent of occurrence (EOO) and the area of occupancy (AOO). For this we used the standard 2 km cell. The habitat loss was assessed through the publicly available MapBiomas Project (2024), which monitors Brazil's deforestation based on the classification of images from the Landsat satellite (Sousa Jr. *et al.* 2020). Based on these data, we evaluated the loss of natural vegetation between 1985 and 2022 in the municipalities in which the new species occurs.

Results and Discussion

We found eight populations / occurrence points in field, from where we collected five specimens with flowers and/or fruits (*Menezes 435*, *437*, *439*, *443*, and *444*). These samples we used as original material (holotype and paratypes). The examination of herbarium collections returned seven records previously identified as *T. palmadora* for Ceará. Five of them were indeed *T. mirim* and were used as paratypes (see additional material examined). However, two of them were not determined, as they lacked reproductive parts and/or diagnostic traits. The first is the collection *M.O.T. Menezes 242* (EAC 48813), from Viçosa do Ceará (in the extreme northwest of Ceará), that may be a hybrid of *T. inamoena* with some spiny *Tacinga* (probably not *T. palmadora*, considering its distribution). The second is the collection *J.R. Andrade 156* (PEUFR 50295) from Milagres, in the very southeast of the state. Considering the density of spines (up to 5–6 per areole) and the size of the stem-segment, this specimen is certainly not *T. mirim*. However, the herbarium-sheet consists of only a single vegetative stem-segment and lacks diagnostic traits to determine the species. Thus, although it might belong to *T. palmadora*, it could represent any other spiny species of the genus, therefore the occurrence of *T. palmadora* in Ceará is yet to be confirmed.

Among the most distinctive morphological traits of *T. mirim*, we highlight the reduced height, the number of stigma lobes (4–5), deciduous stem-segments, wide-open flowers, purplish fruits when fully ripe, and the narrow floral tube, causing the stamens to be almost parallel to the pistil (Figs. 1-2). The typical form of *T. palmadora*, found in

Figure 1 – a-g. General aspect of *Tacinga mirim* – a. flat stem-segments with spines and flowerbud; b. growth habit, with less than 50 cm height; c. M.O.T. Menezes collecting data on a young individual of *T. mirim*; d. growing on rocks along the Curu river, in mun. Canindé-CE; e. flat stem-segments with immature fruit; f. small individual showing roots; g. aggregated areoles in the apex of a young stem. (a,e. *Menezes 435*; b. *Menezes 437*; g. *Menezes 437*, cultivated). Photos: a,b,e,g. M.O.T. Menezes; c,d,f. L.J. Carvalho.

other Northeastern states (Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia), is an erect shrub, reaching up to 4 m tall (Hunt *et al.* 2006a; Taylor & Albuquerque-Lima 2020), with conspicuously tuberculate pericarpel, and a perianth that does not strongly diverge from the floral axis, resembling the flower of *T. werneri* (Taylor & Zappi 2004 - Fig. 6.3; Hunt *et al.* 2006b - Fig. 438.5; Taylor *et al.* 2022 - Fig. 6). The plants from Ceará differ by having a semi-prostrate habit with rather small and almost terete stem-segments, a smooth pericarpel, and a wide-open flower, resembling *T. subcylindrica*. However, *T. mirim* differs from the latter by the presence of spines, flat stem-segments, and the purplish fruit, which is also bigger.

The flowers of *T. mirim* and *T. palmadora* have similar size, but remarkably different morphology. Locatelli & Machado (1999) recorded that *T. palmadora* is pollinated by the hummingbird *Chlorostilbon lucidus* (Shaw 1812), which visits the flower hovering in the air (no landing platform needed). Indeed, the flowers of *T. palmadora* are narrow (1.5–2.0 cm wide) and do not form a landing platform. Regarding anthesis, the flowers of *T. palmadora* open mainly around 05:30h (with some flowers opening around 15:00h) and the anthesis lasts for about 48 hours (Locatelli & Machado 1999). In the case of *T. mirim* the flowers are wide-open and may reach up to 3.3 cm in diameter, building a possible landing platform to flower visitors such as bees and butterflies. However, no observations were made on this matter, so further studies on anthesis and flower visitors of *T. mirim* are still needed. Additionally, with no systematic observations having been carried out yet, it is only known that its flowers open at dawn and close around 13:00h.

The clonal reproduction through the pericarpel of fallen fruits plays an important role in the propagation of *T. lilae* (Trujillo & Ponce 1990 *apud.* Majure *et al.* 2013), *T. palmadora* (Meiado 2012), and *T. armata* (Freitas *et al.* 2021). It was also recorded for *T. mirim* (Fig. 2a). Additionally, *T. mirim* also exhibits clonal reproduction by abscission of terminal stem-segments. These two ways of clonal reproduction play an important part in the formation of dense thickets up to 2 m in diameter found in this species (Fig. 1b).

Tacinga mirim has a karyotype of $2n$ = 44 (Fig. 3a), primarily composed of relatively symmetrical metacentric chromosomes and few submetacentric (36M and 8SM), with sizes ranging from 1.89 to 3.37 µm. Additionally, it presents four CMA+ heterochromatic bands and four 5S rDNA sites. Two of the four CMA+ bands and two of the four 5S sites are located in the interstitial region on the long arm of chromosome pair 21. The other two 5S sites, as well as the CMA+ bands, are located in the terminal region of the short arm of chromosome pairs 6 and 9, respectively (Fig. 3b). This karyotype differs remarkably from the one of *T. palmadora*, which is diploid ($2n$ = 22), composed of metacentric chromosomes (22M) with sizes ranging from 0.80 to 1.11 µm (Alves *et al.* 2019), and exhibits only one chromosome pair with visible terminal CMA^+ bands and two interstitial 5S rDNA sites (Fig. 1c-d).

With this karyotype, we confidently dismiss the hypothesis of *T. mirim* being a nothospecies. We base this conclusion on the observations that nothospecies generally emerge in regions where parental species co-occur, exhibiting resemblances to them (Freitas *et al.* 2021; Taylor *et al.* 2023). The only other species of the genus present throughout the state of Ceará are *T. inamoena* and *T. subcylindrica*. Although both are also tetraploid, they have a remarkably different morphology from *T. mirim*. Also, a hybrid between these species should have 3 submetacentric chromosomes, be thornless, and have red, orange or yellow fruits. However, *T. mirim* does not have any of these features.

Tacinga mirim and the other tetraploid species of the genus (*e.g.*, *T. inamoena*, *T. subcylindrica*, *T. gladispina*, and *Tacinga* × *flammea*) share some cytogenetic characteristics, such as the chromosomal number (2n = 44), the prevailing presence of metacentric chromosomes, and the recurrent presence of terminal CMA heterochromatic bands and interstitial 5S rDNA sites (Alves *et al.* 2019). However, these species diverge in other aspects, including the karyotypic formula, chromosome size, and the number and location of CMA bands and 5S rDNA sites (Alves *et al.* 2019; Freitas *et al.* 2021). Until now, *T. mirim* seems to be the only taxon presenting a karyotypic formula of 36M + 8SM and CMA^+ bands = 2i+2t (Tab. 1).

The tetraploid species are usually the smaller plants in the genus *Tacinga*, reaching height of no more than 35–60 cm (diploid and hexaploid species are bigger - Tab. 1). Except for *T. gladispina*, which is erect (Freitas *et al.* 2021), all the tetraploid are semi-prostrate, forming clumps of mats (Tab. 1). Either the reduced habit is an ancestral trait

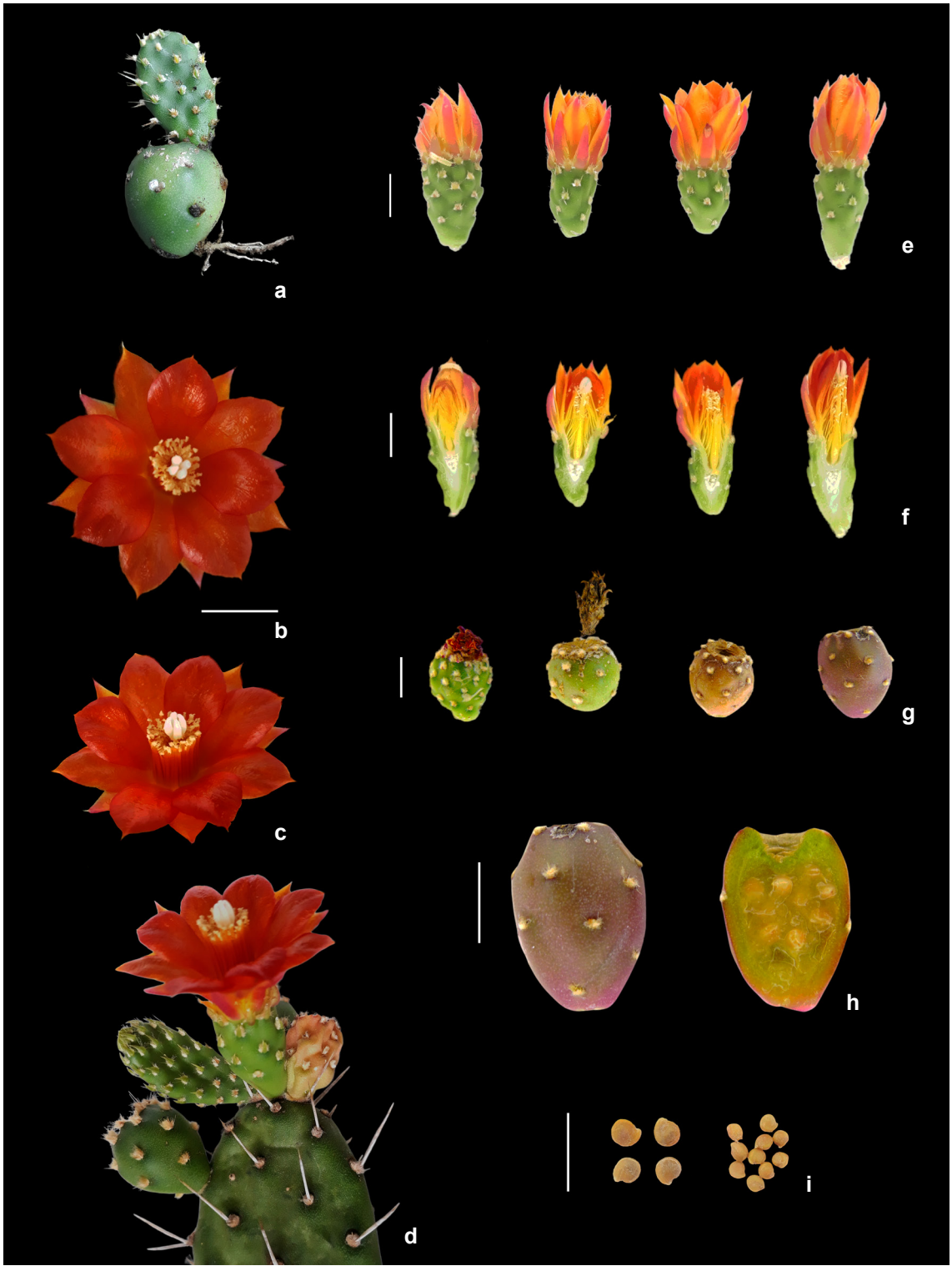

Figure 2 – a-i. Reproductive aspects of *Tacinga mirim* – a. vegetative propagation by fallen fruits; b-c. flower in anthesis; d. flower and immature fruit in the apex of the stem-segment; e. post anthesis flowers; f. flowers in longitudinal section; g. fruits at different stages of maturation; h. open fruit; i. fully developed x undeveloped seeds. (b-f. *Menezes 437*; g. respectively, *Menezes 444*, *439*, *435*, and *444*; h. *Menezes 444*; i. *Menezes 437* and *444*, mixed). Bars: 1 cm. Photos: M.O.T. Menezes.

inherited from a putative tetraploid ancestor or the tetraploidy represents a homoplasic trait possibly related to the low height of these plants (which may affect pollination).

Tacinga mirim is the second endemic cactus taxon to be recorded in the state. The other one is *Pilosocereus chrysostele* subsp. *cearensis*. These two endemics may be a consequence of the extensive highlands that surround the state (Serra da Ibiapaba, Chapada do Araripe, Chapada do Apodi), acting as biogeographical barriers and promoting reproductive isolation during Pleistocene and Holocene. This hypothesis is supported by some cases of long distance vicariance in other Cactaceae (Menezes *et al.* 2012). Unfortunately, there are no genetic studies evaluating this hypothesis for *Tacinga* yet.

Taxonomic treatment

Tacinga mirim M.O.T. Menezes *sp. nov.* Type: BRAZIL. CEARÁ: Santa Quitéria, Piabas, 30.XII.2022, fl. and fr., *M.O.T. Menezes 437* (holotype EAC 67017).

Tacinga mirim is a semi-prostrate cactus forming clusters no more than 50 cm tall and up to 200 cm wide with stem-segments flat to terete, small, spiny, and deciduous near the apex; wide-open flowers, dark orange to red; fruits globose to obovoid, purplish epicarp. It differs from *Tacinga palmadora* in several aspects: the small size, the semi-prostrate habit, the smaller stem-segments (half the size), which may be flat to oblong, smaller areoles with less spines (max. 3, usually 1–2), which are also thicker. Additionally, it features slightly larger flowers, with wide-open perianth-segments, a pericarpel with an almost smooth surface (with tubercles scarcely pronounced only when the plant is dehydrated), fruits globose to slightly obovoid (orange to purplish when mature and with occasional spines). Also, the species is tetraploid ($2n = 44$), unlike *T. palmadora*, which is diploid ($2n = 22$). Its size, growth habit, and the wide-open flowers resemble those of *T. subcylindrica*, however, the plant is spiny, its pericarpel is larger, and fruits have different color, size, and shape.

Subshrub, with taproot, semi-prostrate, 35–50 cm tall, usually growing in clusters 60–90(–200) cm wide due to vegetative propagation, irregular sympodial branching; stem-segments flat to terete, elliptical to obovate, 4.4–8.5(–11) × 2.4–4.0 cm, epidermis olive to dark green, bearing areoles

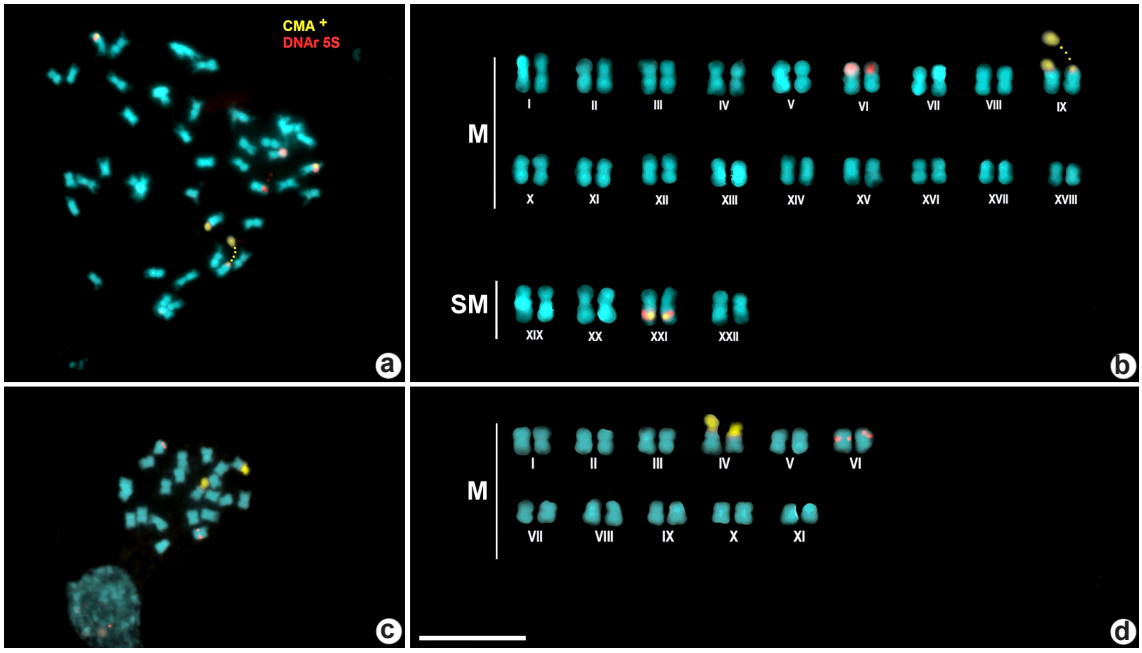

Figure 3 – a-d. Metaphase cells with double staining CMA/DAPI and ND-Fish, and karyogram organized by chromosomal type, Metacentric (M) and Submetacentric (SM) – a-b. *Tacinga mirim*, tetraploid with $2n = 44$; c-d. *T. palmadora*, diploid with $2n = 22$. Bar: 10 µm. Photos: L.I.F. Alves.

Table 1 – Compared morphology and karyotype of the known species of the genus *Tacinga*.

Species	Habit / height	Stem-segments	Spines	Inner perianth segments	Fruit	Karyotype	Karyotypic formula
Tacinga braunii [1]	shrubby or semi-scandent (< 600 cm)	cylindric to flat	-	pale green to purplish	narrowly urceolate; greenish; spineless	2n = 22 (A19)	20M + 2SM (A19)
Tacinga funalis [1]	shrubby, decumbent or scandent (< 1200 cm)	cylindric	-	pale green	Bottle-shaped; greenish to reddish or purple; spineless	2n = 22 (C13)	22M (A19)
Tacinga saxatilis [1]	shrubby, forming clumps (< 400 cm)	flat	acicular*	yellow to orange	globose to depressed-globose; brownish green to wine-red; spineless?	2n = 22 (M12)	?
Tacinga palmadora [1,6]	shrubby, forming clumps (< 400 cm)	flat	acicular*	orange	turbinate to obovoid; greenish to reddish or purple; spineless?	2n = 22 (C13)	22M (A19)
Tacinga inamoena [1]	shrubby, forming clumps (< 50 cm)	flat	-	orange	globose to depressed-globose; yellow to orange; spineless	2n = 44 (M12)	44M 40M + 4SM 32M + 12SM 12SM + 32M (A19)
Tacinga subcylindrica [2]	subshrub, usually forming dense mats (< 35cm)	oblong	-	orange-red	globose; dark orange to red; spineless	2n = 44 (A19)	42M + 2SM (A19)
Tacinga gladispina [4]	erect shrub (< 60 cm)	flat	acicular, flat base	orange	depressed-globose; depressed-globose; spineless	2n = 44 (F21)	40M + 4SM (F21)
Tacinga mirim	semi-prostrate subshrub (< 50 cm)	flat to oblong	acicular	dark orange to red	globose to slightly obovoid; dark orange to purplish; rarely spiny	2n = 44 (TW)	36M + 8SM (TW)
Tacinga lilae [3,7]	erect shrub (<120 cm)	flat*	acicular*	red*	Barrel-shaped; purple	2n = 66 (M12)	?
Tacinga werneri [1]	shrubby (< 100 cm)	flat	acicular*	bright red	elongate ovoid; pale greenish white to white; spineless	2n = 66 (A19)	52M + 14SM (A19)

Species	Habit / height	Stem-segments	Spines	Inner perianth segments	Fruit	Karyotype	Karyotypic formula
Tacinga armata [4]	erect shrub (< 80 cm)	flat	acicular	red	oblong to globose; dark green to pinkish; spiny	2n = 66 (F21)	42M + 2SM (F21)
Tacinga × *quipa* [5]	spreading subshrub (< 35cm)	flat or curved	inconstant / contorted	orange-red	"resembling those of *T. inamoena*"	Expected to be 2n = 33	?
Tacinga × *flammea* [4]	erect shrub (< 50 cm)	flat	acicular	orange with red edges	oblong; reddish orange; spineless	2n = 55 (F21)	49M + 6SM (F21)
Tacinga × *grandiflora* [5]	Subshrub (< 40cm)	flat / elliptic-oblong	-	lustrous greenish gold	"resembling those of *T. funalis*"	Expected to be 2n = 33	?

Source of morphological traits: 1 = Hunt *et al.* (2006a; 2006b); 2 = Machado & Taylor (2003); 3 = Majure *et al.* (2013); 4 = Freitas *et al.* (2021); 5 = Taylor *et al.* (2023); 6 = Taylor & Albuquerque-Lima (2020); 7 = Majure (personal communication). Source of karyotypes: A19 = Alves *et al.* (2019); C13 = Castro *et al.* (2013); F21 = Freitas *et al.* (2021); M12 = Majure *et al.* (2012); TW = This Work. * = trait obtained from the photographs of the cited publications.

with glochids and spines (sometimes spineless in the lower half), segments usually deciduous near the apex (at least in the dry season); Areoles 1–1.5 cm apart, 32–38 per segment face, round, 2–3 mm in diameter, bearing white felt (greyish when old), glochids and deciduous vestigial leaves (in young stem-segments) or spines (in mature stem-segments); glochids golden yellow, c. 1 mm; spines acicular, yellow when young, turning white to grey when old, (0–)1–2(–3) per areole, (7–)10–26(–35) × 0.5–1.0 mm; Flowers arising in the distal third of the stem-segments, 3.1–3.6(–4.1) × 2.6–3.3 cm, pericarpel pyriform, smooth to slightly tuberculate, 1.7–2.1 cm, olive-green, bearing areoles with glochids and occasional spines (seen only in fruit), outer perianth-segments narrowly lanceolate, pink with orange lateral edges, inner perianth-segments ovate and mucronate, dark orange to red, stamens erect, surrounding the style (almost parallel to it), anthers yellow, inner filaments yellow, outermost ones reddish orange, style yellow with 4–5 white stigma-lobes, which are fully projected beyond the stamens; Fruits deciduous when ripe, globose to obovoid, with a sunken apex, funiculus slightly depressed, 1.7–2.5 × 1.4–1.7 cm, bearing 21–25(–28) areoles with white felt, golden yellow glochids, bristles, and rarely spines (< 1 cm), pericarp orange turning purplish when fully ripe, funicular pulp translucent; Seeds, c. 14 per fruit, some aborted, 4 × 3 mm when fully developed.

Additional material examined (paratypes): BRAZIL. Ceará: Canindé, Reserva Imburanas da Volta, 30.XII.2022, *M.O.T. Menezes 443, 444* (EAC 67019; EAC 67020). Catunda, 24.I.2011, *M.O.T. Menezes 268* (EAC 48810). Santa Quitéria, Piabas, 22.I.2009, *M.O.T. Menezes 170, 172* (EAC 44394; EAC 44395); 30.XII.2022, *M.O.T. Menezes 435, 439* (EAC 67016; EAC 67018); Serra do Pajé, 8.V.1997, *L.W. Lima-Verde* (EAC 25522). Sobral, Taperuaba, VII.2017, *E.B. Souza; F.F. Araújo 4755* (EAC 61320).

This species was collected with flower-buds and open flowers in July, December, and January; with fruits in December and January.

The epithet comes from Nheengatu *mi'ri*, which means small (Miranda 1946), in allusion to its reduced dimensions. It is a tribute to the native language of the indigenous people from *Pindorama*, who suffered genocide with the invasion of European colonialists from the 16th century onward (Ribeiro 1995). The word is still used today in Brazil with the meaning of small or childlike.

The distribution of *T. mirim* is restricted to northern Ceará state and completely disjunct from the distribution of *Tacinga palmadora* (Fig. 4). The currently known range of *T. mirim* is also dozens to hundreds of kilometers apart from the core distribution of *T. palmadora*, which includes the states of Bahia, Pernambuco, Sergipe, Alagoas, Paraíba, and Rio Grande do Norte. *Tacinga mirim* is found in the northwestern inland lowlands ("depressão sertaneja") of Ceará,

from 190 to 360 m above sea level[1] (Fig. 5). The terrain is mostly flat, with a crystalline basement and shallow rocky substrate, where rock outcrops are very common. The climate is tropical semiarid (Aw / Bsh), with a mean annual temperature of 26–28 °C and precipitation of 600–900 mm / year (Climate-Data.org 2023). The rainy season occurs during autumn and summer, especially between January and May. The dry season lasts for six to eight months (Nimer 1972), and vegetation usually becomes dormant (IBGE 2012). The species inhabits deciduous and semideciduous shrublands and forests (and probably other kinds of vegetation associated with the Caatinga - Fig. 5). It grows on sandy, clayey or stony substrates (including rocky outcrops) and develops well both under full sun and partial shade (in savanna) or in the shade of trees (in dry forests). It often grows in the dry riverbeds of intermittent streams. In the savanna, it occurs associated with *Calliandra spinosa* Ducke, *Cenostigma pyramidale* (Tul.) Gagnon & G.P.Lewis, *Cereus jamacaru* DC., *Croton jacobinensis* Baill., *Melocactus zehntneri* (Britton & Rose) Luetzelb., *Mimosa tenuiflora* (Willd.) Poir., *Pilosocereus chrysostele* subsp. *cearensis* P.J.Braun & Esteves, *Xiquexique gounellei* (F.A.C. Weber) Lavor & Calvente, among other typical *Caatinga* elements. In the dry forests, it is associated with the occurrence of *Amburana cearensis* (Allemão) A.C.Sm., *Cenostigma pyramidale* (Tul.) Gagnon & G.P.Lewis, *Cereus jamacaru* DC., *Commiphora leptophloeos* (Mart.) J.B.Gillett, *Cordia oncocalyx Allemão, Croton blanchetianus* Baill., *Erythrina velutina* Willd., *Mimosa arenosa* (Willd.) Poir., *Pseudobombax marginatum* (A.St.-Hil., Juss. & Cambess.) A.Robyns, *Xiquexique gounellei* (F.A.C.Weber) Lavor & Calvente among others.

The extent of occurrence (EOO) of *Tacinga mirim* is 3,033.22 km², while the area of occupation (AOO) is 36.00 km². Thus, they both fit the range criteria for the Endangered category of the IUCN Red List (B1 and B2). Two conditions for geographic threaten are also observed. First, there are only five locations of occurrence (see Material examined) - meeting

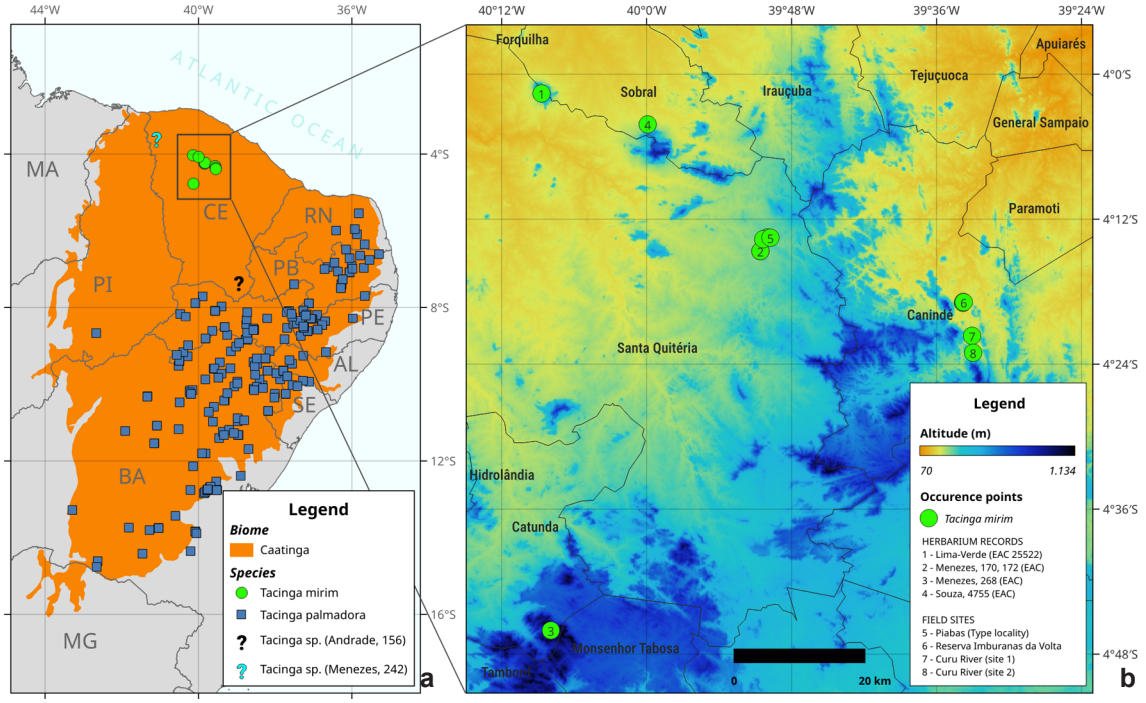

Figure 4 – a-b. Distribution of – a. *Tacinga mirim* and *T. palmadora* in Northeastern Brazil; b. detailed distribution of *Tacinga mirim* in Ceará. Maps: M.O.T. Menezes.

[1] A single collection was found with a higher elevation: *Menezes 268* (EAC 48810), with 978 m.

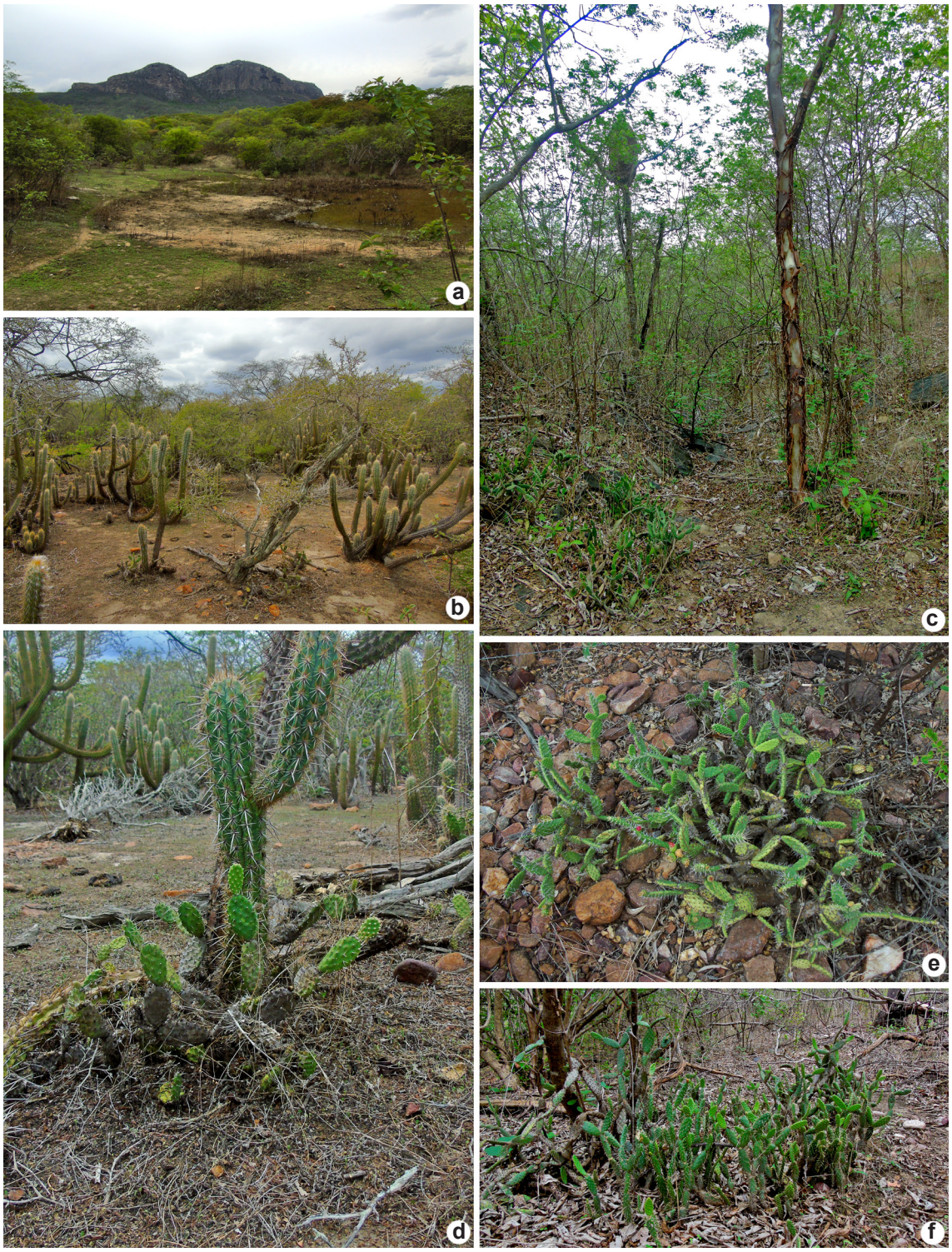

Figure 5 – a-f. Habitat and growth habit of *Tacinga mirim* – a. landscape of the area of occurrence; b. habitat at the type locality (Savana); c. habitat in the Reserva Imburanas da Volta (Dry Forest); d. growing in association with *Xiquexique gounellei* (Piabas); e. growing in rocky soil (Piabas); f. growing in a litter rich soil in the dry forest (Reserva Imburanas da Volta). Photos: M.O.T. Menezes.

the condition "a" for endangered. Second, the habitat of the new species is in decline - meeting the condition "b" for endangered. According to the MapBiomas Project (2024), the municipalities in which the *T. mirim* occurs suffered natural vegetation loss ranging from 4 to 16% of their extent between 1985 and 2022 (Fig. 6). The deforestation is associated mostly with farming and livestock (Vieira *et al.* 2017) - activities that were also seen in fieldwork. In the type locality, in Santa Quitéria, the habitat loss in worrying, since 71,46% of the extent of the municipality has some degree of environmental disturbance (Vieira *et al.* 2017). Furthermore, in 2020, the state government signed an agreement with a consortium formed by two large companies to implement a huge mining project in Santa Quitéria (Brazilian Ministry of Mines and Energy 2024). According to the environmental impact assessment (Tetra Mais Consultoria 2022), the so called 'Santa Quitéria Project' will benefit from an investment of 460 million dollars to mine phosphate and uranium, near the border with Canindé (Fig. 6). When fully working it aims an estimated production of 1,050,000 tons/year of phosphate fertilizers, 220,000 tons/year of dicalcium phosphate, and 2,300 tons/year of uranium (Tetra Mais Consultoria 2022). The impact assessment presented by the mining corporates mentions the presence of *Tacinga palmadora* (probably *T. mirim*) in the area under the direct influence of the project (Tetra Mais Consultoria 2021, p. 917; 927). However, as no voucher is mentioned, the occurrence of populations in the immediate surroundings of the mining is uncertain. In any case, the closest populations, from Canindé and Piabas/Santa Quitéria (type locality), are just 29 and 32 km away, respectively. Therefore, considering the severity and extent of the direct and indirect impacts caused by mining, these populations may suffer impacts with the installation of the project. Rigorous studies are necessary in the proposed mining area in order to confirm the presence of *T. mirim* in the region and, if needed, reevaluate the environmental impacts.

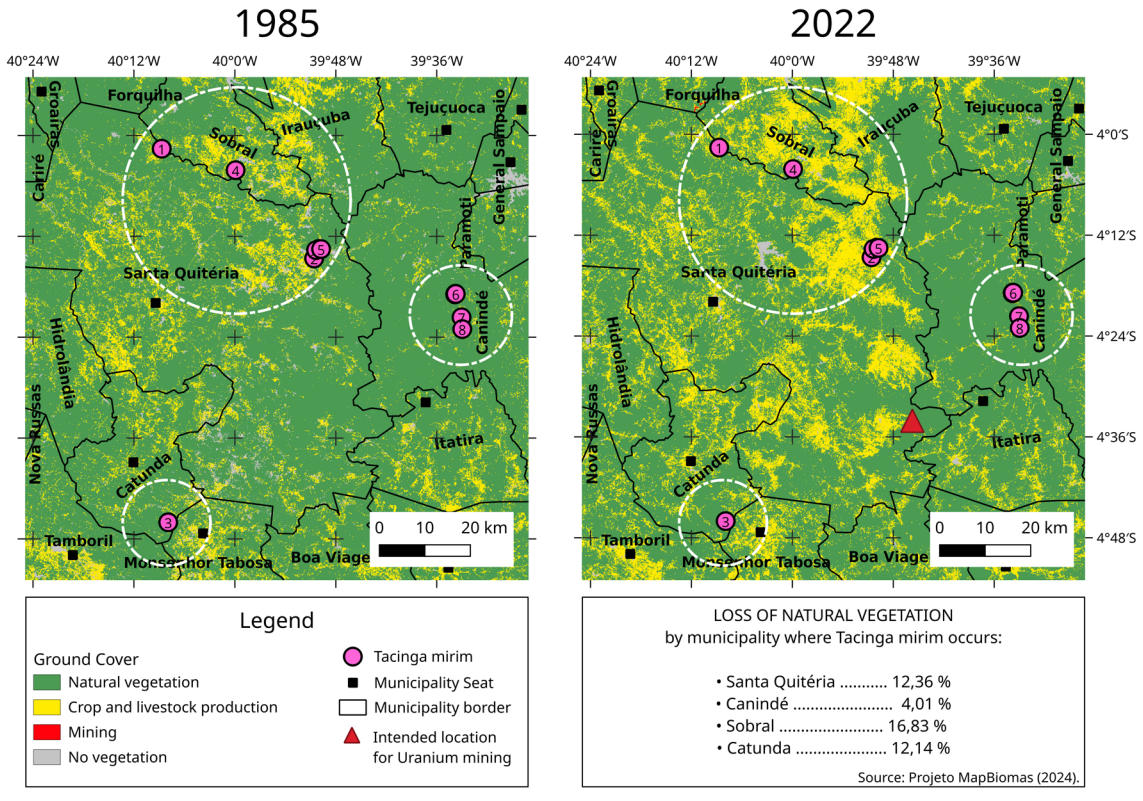

Figure 6 – Habitat loss in the area of occurrence of *Tacinga mirim* between 1985 and 2022, highlighting the surroundings of the known populations.

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Data availability statement

In accordance with Open Science communication practices, the authors inform that all data used in this manuscript is publicly available.

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