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Geographic range extension of *Rapatea paludosa* Aubl. (Rapateaceae) to Maranhão state, northeastern Brazil

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Abstract
Expansion of the geographic distribution of *Rapatea paludosa* Aubl. (Rapateaceae) to the state of Maranhão, northeastern Brazil. The occurrence of *R. paludosa* is reported for the flora of Maranhão from the municipality of Cândido Mendes. This is the second species of the genus found in the state. The collected samples are also the second record of *R. paludosa* in the Northeastern Region of Brazil, adding information on its geographic distribution. *Rapatea paludosa* is described, illustrated, and its distribution mapped.

Keywords
Amazonian domain, Belém, endemism center, monocots, new occurrence.

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Introduction

Rapateaceae Dumort. is an angiosperm plant family comprising 19 genera and circa 131 species distributed in the Neotropics, except for the monotypic genus *Maschalocephalus* Gilg & K.Schum. (*M. dinklagei* Gilg & K.Schum.), which is endemic to Liberia and Serra Leone in West Africa (Givnish et al. 2000; Praia et al. 2016). Aublet (1775) published the first work on Rapateaceae, describing *Rapatea paludosa* Aubl. Fifty-four years later, Dumortier (1829) characterized the family as plants bearing flowers with large bivalve spathes. The taxonomy of the family was subsequently improved by Seubert (1847), Körnicke (1873), and Maguire (1958, 1962, 1965, 1979). The first phylogenetic studies based on morphological characteristics and molecular data were performed by Givnish et al. (2000, 2004), which confirmed the genus-level taxonomy proposed by Maguire (1958, 1962, 1965, 1979).

Nine genera (none endemic) and 41 species (eight endemics) of Rapateaceae have been reported throughout Brazil except for the southern states (Praia et al. 2019). Despite the diversity of the family, few taxonomic studies exist on the Brazilian Rapateaceae. These studies include new occurrences, surveys of species, and descriptions of new species (Poeppig and Endlicher 1838; Maguire 1958, 1979; Forzza and Costa 2005; Rodrigues and Flores 2010; Romanini and Wanderley 2012; Praia et al. 2016; Berry and Krahl 2017).

Rapatea Aubl. is a predominantly South American genus with circa 25 species of terrestrial herbs distributed in Bolivia, Brazil, Colombia, Ecuador, French

Guiana, Guyana, Panama, Peru, Suriname, Venezuela, and Trinidad and Tobago (Aymard and Arellano-Peña 2016; Tropicos 2019). It is the most species-rich genus of Rapateaceae in Brazil, with approximately 14 species, three of which are endemics: *Rapatea pycnocephala* Seub., *Rapatea rugulosa* Maguire, and *Rapatea undulata* Ducke (Aymard and Arellano-Peña 2016; Praia et al. 2019). Only one species, *Rapatea pycnocephala*, has been recorded in Maranhão state (Praia et al. 2019), and we report here the first collection of *Rapatea paludosa* in this state, which is also the second report in the Northeastern Region of Brazil, along with its collections from the state of Bahia (Praia et al. 2019).

Methods

During field collections in northwestern Maranhão state (Fig. 1), we collected specimens of *Rapatea paludosa*. The survey was carried out in November 2017 at the Sete Irmãos farm (01°51′23″ S, 045°48′19″ W) and at the Sítio José Pedro (01°48′41″ S, 045°46′17″ W), which are both within the municipality of Cândido Mendes. This region of Cândido Mendes is part of the Amazon Rainforest domain and is characterized by the Am climate type (tropical monsoon) according to Köppen climate classification (Alvares et al. 2013). The average annual temperature is between 26 °C and 27 °C, and the annual rainfall is from 2,300 to 2,500 mm, with the months between January and June having the highest concentration of rain (NuGeo 2016). The Sete Irmãos farm comprises approximately 7,000 ha with circa 3,000 ha of well-preserved Terra Firme and Gallery Forests, which are crossed by the Macaxeira River and other small tributary streams of the Maracaçumé River. This fragment of primary Amazonian vegetation is one on the largest in private areas in Maranhão state (Koch and Araújo-Silva 2014; Celentano et al. 2017). Adjacent to the Terra Firme Forest (domain of the Amazon Forest) and Sete Irmãos farm is Sítio José Pedro, another private area of circa 200 ha, with a fragment of Gallery Forest. Both are part of the Belém Endemism Center, a poorly studied, species-rich area under serious threat due to deforestation and other anthropic activities (Almeida and Vieira 2010; Celentano et al. 2017, 2018).

The specimens were herborized according to the usual botanical methodology (Fidalgo and Bononi 1989)

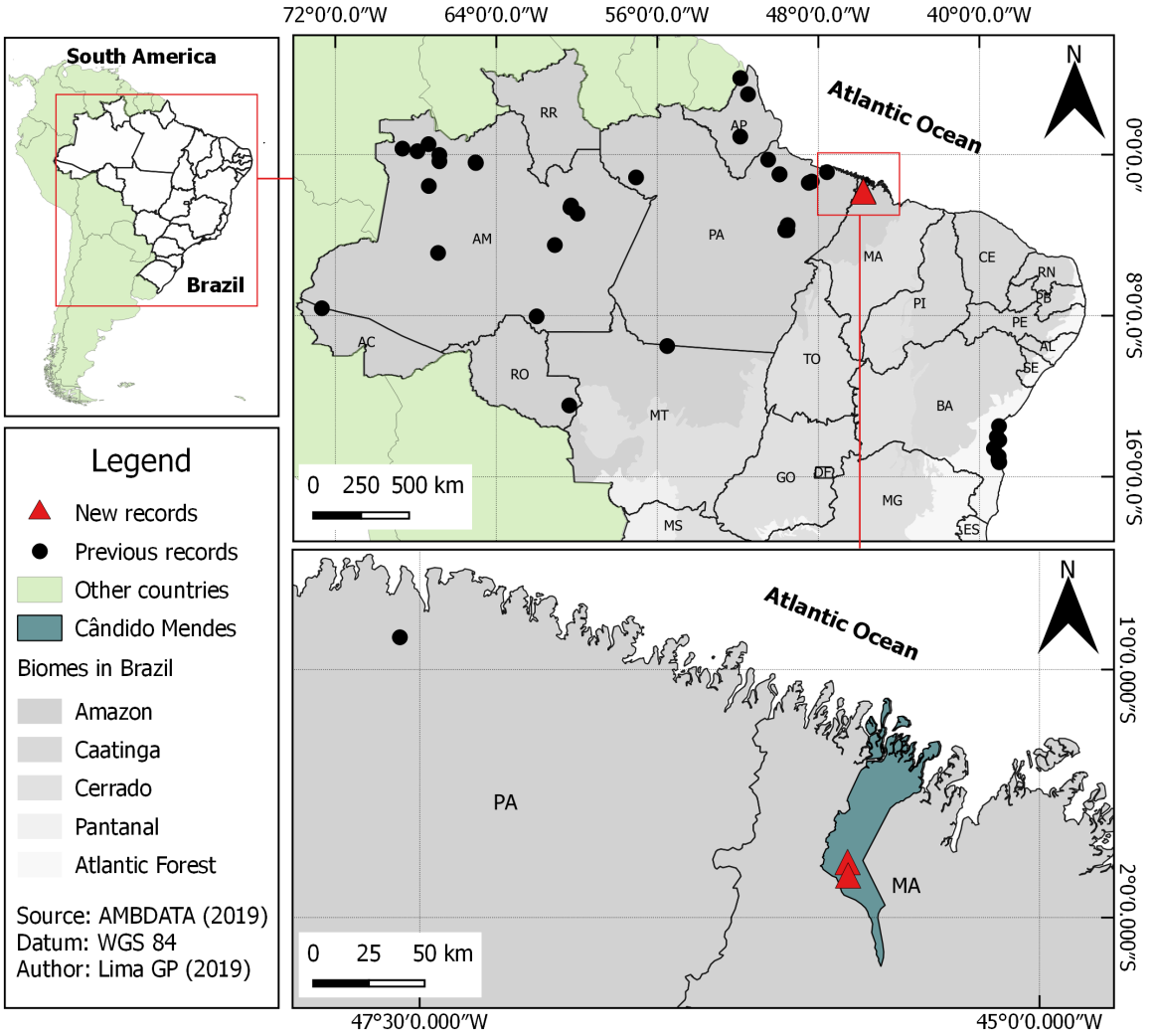

Figure 1. Collection sites of *Rapatea paludosa* Aubl. on the Brazilian territory, highlighting the location of the new records in the municipality of Cândido Mendes, Maranhão state.

and incorporated into the MAR herbarium (acronym follows Thiers 2019) of the Federal University of Maranhão. Identification keys and relevant literature (Maguire 1965; Harris and Harris 1994; Forzza and Costa 2005; Aymard and Arellano-Peña 2016; Praia et al. 2016) were used to identify the species. The names of the authors and abbreviations follow International Plant Names Index (IPNI 2019). The species' geographic distribution is in accordance with the online databases Flora do Brasil 2020 (2019), Tropicos (2019), and SpeciesLink (2019). A map was prepared with QGIS 2.16.3 (QGIS Development Team 2019) using the WGS84 datum. We mapped the new occurrences and also 38 records (Appendix, Table A1) from the SpeciesLink (2019) and Reflora (2019) databases, that were identified as *R. paludosa* based on the literature cited above. Figures of specimens were edited using GIMP 2.10.6 (GIMP Team 2019).

Results

Identification key to the species of Rapateaceae in Maranhão state, Brazil (modified from Praia et al. 2016)

1. Inflorescence capituliform; spikelet pedicellate, usually with pedicel >1 cm long; bracteole with long-acuminate or aristate apex ..... *Rapatea paludosa*
1′. Inflorescence glomerulate; spikelet sessile; bracteole with apiculate apex..... *Rapatea pycnocephala*

***Rapatea paludosa* Aubl.**, Hist. Pl. Guiane 1: 305, t. 118. 1775.
Figure 2a, b

Type. French Guiana: J.B.C.F. Aublet s.n. (holotype, P00675175!).

New records. Brazil: Maranhão • Cândido Mendes, Sete Irmãos farm, Cumaruzal River (01°49′50″ S, 045°46′19″ W), 03 November 2017, *A.W.C. Ferreira, M.J.C. Silva, G.P. Lima 1* (MAR 11120) • Cândido Mendes, Sítio José Pedro, a tributary to the Cumaruzal River (01°48′59″ S, 045°46′26″ W), 03 November 2017, *A.W.C. Ferreira, M.J.C. Silva, G.P. Lima 2* (MAR 11121).

Description. Herb 70–100 cm tall. Leaf symmetrical with mucilage at the base; sheath 19–30 cm long; petiole absent; leaf blade 84–137 × 6–9.5 cm, wide-lanceolate, glabrous, discolored, faces with inconspicuous roughness, prominent central vein on both sides, prominent secondary veins on the abaxial face, apex acute, base attenuate. Inflorescence capituliform, terminal, axis flattened to convex, spikelets ca 50–70; scape 15–40 × 0.6–1.9 cm, flattened, sparsely pubescent, sulcate; two spathiform bracts at the apex of the scape, 10.5–23 × 4.7–6.5 cm, lanceolate to wide-lanceolate, connate at the base, distinct from the central axis of the inflorescence, erect, persistent, apex acute, base cordate or subcordate; spikelet pedicellate, with a series of terminal bracteoles and a single flower; pedicel 1–1.8 cm long, sparsely pubescent; bracteoles 11–13 per spikelet, heterogeneous, proximal bracteoles 0.64–1.1 cm long, distal bracteoles 1.2–1.45 cm long, oblong to elliptic-lanceolate, papyraceous, apex brown and long-acuminate or aristate. Flower with pedicel 1.0–2.1 cm long; sepals 0.75–1.5 cm long, briefly connate at the base forming a hyaline-membranous tube, lanceolate lobes, navicular, papyraceous; petals 0.6–1.45 cm long, yellow, connate forming a hyaline-membranous tube; stamens 6; filaments generally conical at the base and adnate to the corolla tube, tomentose; anthers 0.4–0.75 cm long, yellow, with apical appendages up to 0.15 cm long, brown; ovary 0.5–0.15 cm long; style 4–6.5 mm long, central; stigma ca. 0.5 mm long, simple, swollen, brown. Loculicidal capsule, 0.5–0.65 × 0.28–0.35 cm, ovate, obovate to ellipsoid, yellowish. Seed 0.27–0.33 mm long, ellipsoid to oblong, brown when ripe, longitudinally striate.

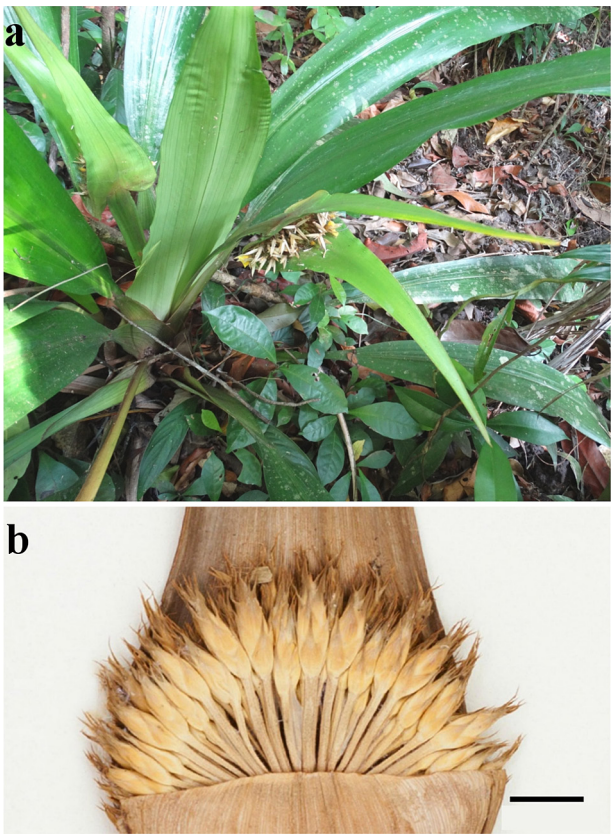

Figure 2. *Rapatea paludosa* Aubl. (MAR 11120). **a.** The plant in its natural habitat. **b.** Capituliform inflorescence, side view (photographs by GPL and AWCF). Scale bar = 1 cm.

Discussion

Rapatea paludosa occurs in Brazil, French Guiana, Guyana, Panama, Suriname, and Venezuela (Tropicos 2019). In Brazil, specimens were reported in areas of the Amazon Forest and Atlantic Forest, in the states of Acre, Amapá, Amazonas, Pará, Rondônia, Tocantins, Mato Grosso, and Bahia (Praia et al. 2019). According to the revised data available on SpeciesLink (2019), the new records in Maranhão state were collected at 225 km southeast of its nearest previous occurrence, which is localized at the village of Campos Martins Pinheiro,

Magalhães Barata municipality, Pará state (NY 1066375; Appendix, Table A1; Fig.1).

The new records of *R. paludosa* in Maranhão expand the geographical distribution of this species further east in the Brazilian Amazon than previously know. This new records in Maranhão are the second record in the Northeast Region of Brazil, as it had already been reported in the state of Bahia (Praia et al. 2019). The Atlantic Forest is called "Hiléia Baiana" in its southern part in Bahia due to its floristic and phytophysiognomic similarities with the Amazon region (Coelho and Amorim 2014; Fontes et al. 2017). That is where *R. paludosa*, a species typical of the Amazon (Praia et al. 2016), were collected (Appendix, Table A1). The occurrences of *R. paludosa* from the Hiléa Baiana are disjunct from the species' occurrences in the Amazon, and this distribution pattern is probably due to Quaternary climate changes which previous caused a partial overlap of the Amazon and Atlantic Forests (Fontes et al. 2017).

The new records place *R. paludosa* in the Amazon Forest of Maranhão, one of the most endangered of this biome in Brazil, as only 25% of the original forest persists in that state (Celentano et al. 2017, 2018). Historically, deforestation accelerated in the 1960s with the opening of highways and incentives to develop agriculture on public lands. In the 1980s, the construction of the Carajás–São Luís railroad and iron, steel, and pig iron plants led to intense devastation of the Amazon Forest in the state (Almeida and Vieira 2010; Celentano et al. 2017, 2018).

The conservation of the remaining forest areas in Maranhão is of utmost importance since successive anthropic impacts could compromise the existing natural areas, leading to in the disappearance of species, or even taxa unknown to science (Koch and Araújo-Silva 2014; Rodrigues et al. 2017). As observed for *R. paludosa*, the conservation of forest fragments and systematic floristic surveys has resulted in new records for the flora of Maranhão and the filling of some knowledge gaps (Koch and Araújo-Silva 2014; Ferreira et al. 2017, 2018; Guarçoni et al. 2018a, 2018b; Silva Junior et al. 2018).

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Authors' Contributions

AWCF, MJCS, and GPL collected and photographed the plant. AWCF and GPL identified and described the specimen. GPL revised herbarium collections. AWCF, MJCS, and GPL wrote the text. AWCF, MJCS, GPL, and EBAJ revised the text.

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Appendix

Table A1. Collection records of *Rapatea paludosa* in Brazil used for producing of the distributional map. Herbaria acronyms follow Thiers (2019).

State	Latitude	Longitude	Herbarium	Catalog no.
Acre	07°37′52″ S	072°40′10.9″ W	NY	1066379
Amapá	00°53′46″ N	051°53′15″ W	HUEFS	181134
Amapá	03°48′00″ N	051°52′48″ W	NY	1066360
Amapá	03°00′00″ N	051°30′00″ W	NY	952133
Amapá	03°48′00″ N	051°53′00″ W	IAN	114779
Amazonas	00°10′09.3″ N	067°55′27″ W	NY	1066357
Amazonas	00°18′00″ N	068°40′00″ W	NY	2239583
Amazonas	00°31′12″ N	067°22′12″ W	NY	1066358
Amazonas	00°00′56.6″ S	066°49′53.7″ W	NY	2239582
Amazonas	00°19′48″ S	066°49′48″ W	NY	2239587
Amazonas	00°23′00″ S	065°02′00″ W	INPA	158110
Amazonas	00°24′51.1″ S	065°01′09.1″ W	NY	2239586
Amazonas	01°33′20.2″ S	067°21′20.2″ W	NY	2239614
Amazonas	02°31′30″ S	060°17′24″ W	NY	2239618
Amazonas	02°37′24.9″ S	060°19′25.1″ W	NY	1075020
Amazonas	02°55′46″ S	059°58′29″ W	HUEFS	143928
Amazonas	04°29′23.9″ S	061°05′45.4″ W	NY	2239622
Amazonas	04°52′58″ S	066°53′44.9″ W	NY	1181896
Amazonas	08°02′00″ S	062°00′00″ W	INPA	127051
Bahia	13°29′00″ S	039°02′00″ W	CEPEC	101532
Bahia	14°00′54″ S	039°08′20″ W	CEPEC	88621
Bahia	14°10′48″ S	039°01′12″ W	NY	1131835
Bahia	14°35′35.2″ S	039°17′03.8″ W	NY	1198404
Bahia	14°58′48″ S	039°03′00″ W	NY	1131834
Bahia	15°10′02″ S	039°03′29″ W	NY	1192908
Bahia	15°16′48″ S	039°01′12″ W	NY	1131833
Mato Grosso	09°30′22.9″ S	055°30′55.2″ W	NY	1039601
Pará	00°15′00″ S	050°30′00″ W	NY	2239616
Pará	0°52′12.0″ S	047°34′48.0″ W	NY	1066375
Pará	00°58′12″ S	049°55′48″ W	NY	2239581
Pará	00°58′55.1″ S	049°56′23.6″ W	NY	2239578
Pará	01°07′50.1″ S	057°03′35″ W	NY	2239620
Pará	01°20′00″ S	048°20′00″ W	NY	1075018
Pará	01°23′59″ S	048°28′58.4″ W	NY	2239585
Pará	03°30′00″ S	049°32′00″ W	MO	2159695
Pará	03°45′00″ S	049°39′00″ W	MO	2168254
Pará	03°45′03.8″ S	049°32′50.3″ W	NY	1066359
Rondônia	12°27′21″ S	060°22′52″ W	RB	645052