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Taxonomy, distribution, and conservation status of *Geonoma* Willd. (Arecaceae, Arecoideae): new records for the Maranhão state, Brazil

Taxonomía, distribución y estado de conservación del género *Geonoma* Willd. (Arecaceae, Arecoideae): nuevos registros para el estado de Maranhão, Brasil

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ABSTRACT

Geonoma is one of the more diverse genera of palms in the neotropical region, which comprises 68 species distributed from southern Mexico to south-western Brazil. In Maranhão, a Brazilian state located in a transition area between the Eastern Amazon, the Cerrado, and the Caatinga, the knowledge about this genus still is deficient. For this reason, we elaborated a taxonomic study of the genus *Geonoma* for the state, based on the descriptive analysis of voucher specimens of national and international herbaria, and specimens collected in our expeditions. A total of five species were identified: *G. baculifera* (Poit.) Kunth and *G. leptospadix* Trail species were previously cited in the literature, whereas *G. maxima* (Poit.) Kunth subsp. *maxima*, *G. pohliana* subsp. *weddelliana* (H. Wendl.) A.J. Hend., and *G. poiteauana* Kunth are presented as new records. Taxonomic descriptions and distribution information are shared, as well as preliminary conservation status assessments of these species. Moreover, an identification key for all species in the state is also supplied. These findings extend the distribution and conservation knowledge of some *Geonoma* species, and are an important contribution to the identification of the taxa in the region.

Keywords. Palms, Geonomateae, Brazilian northeastern, Amazon rainforest, new records.

RESUMEN

Geonoma es uno de los géneros más diversos de palmeras en la región Neotropical, que comprende 68 especies distribuidas desde el sur de México hasta el suroeste de Brasil. En Maranhão, estado brasileño ubicado en una zona de transición entre la Amazonia oriental, el Cerrado y la Caatinga, el conocimiento sobre este género aún es deficiente. Por esta razón, elaboramos un estudio taxonómico del género *Geonoma* en el estado, que se basó en un análisis descriptivo de especímenes de herbarios nacionales e internacionales, así como de ejemplares recolectados en nuestras expediciones. Se identificaron un total de cinco especies: *G. baculifera* (Poit.) Kunth y *G. leptospadix* Trail, eran especies previamente citadas en la literatura, mientras que *G. maxima* (Poit.) Kunth subsp. *maxima*, *G. pohliana* subsp. *weddelliana* (H. Wendl.) A.J. Hend. y *G. poiteauana* Kunth son nuevos registros. Se presentan descripciones taxonómicas e información de distribución, así como evaluaciones preliminares de su estado de conservación. Además, también se proporciona una clave de identificación para todas las especies de *Geonoma* en el Estado. Estos resultados amplían el conocimiento de la distribución y conservación de algunas especies de *Geonoma*, además de ser un aporte importante para la identificación de los taxones en la región.

Palabras clave. Palmas, Geonomateae, noreste brasileño, Amazonía, nuevos registros.

INTRODUCTION

A member of the family Arecaceae, subfamily Arecoideae, *Geonoma* is one of the three largest genera of palms in the Neotropical region, together with *Bactris* and *Chamaedorea* (Henderson 2011, Palmweb c2020). This genus comprises 68 species distributed from southern Mexico to south-western Brazil (Henderson 2011). It grows in the understory of tropical forests in plains or

mountainous regions and has even been registered at altitudes of up to 3 000 m (Dransfield *et al.* 2008, Henderson 2011).

In Brazil, *Geonoma* is represented by 24 species (Henderson 2011), with widespread distribution in most states, except Paraíba, Piauí, Rio Grande do Norte, and Sergipe (Flora do Brasil c2020). The genus has a greater diversity of species in forest formations associated with the Amazon and Atlantic Biomes, but few representatives in open vegetation (Lorenzi *et al.* 2010). Nevertheless, *Geonoma* is sparsely collected in the Eastern Amazon (Henderson 2011), a region that stands out due to the low density of samples and studies related to palms (Pintaud *et al.* 2008, Alvez-Valles *et al.* 2018). About the conservation status of the genus, data are still scarce, and most taxons of *Geonoma* that occur in Brazil have not been evaluated (Elias *et al.* 2019, Flora do Brasil c2020). This scenario in Brazil only reinforces that the measurement of the extinction risk to species has needed to be addressed more since these assessments are urgently needed to guide conservation practitioners on appropriate development and conservation measures planning and the guidance of essential research (Gardiner and Bachman 2016). Twenty-five years ago, the International Union for Conservation of Nature (IUCN) Palm Specialist Group (Johnson 1996) already urgently recommended that the researchers assess all palm species' conservation status. However, to date, few advances have been observed in this regard in the country.

According to Henderson (2011) and Flora do Brasil (c2020), in Maranhão, a Brazilian state located in a transition area between the Eastern Amazon, the Cerrado, and the Caatinga, there are only two species of *Geonoma*: *G. baculifera* (Poit.) Kunth and *G. leptospadix* Trail, both catalogued in the

Amazon Forest. However, this information about the *Geonoma* richness in Maranhão is different from what was pointed out in other studies such as Lorenzi *et al.* (2010), whom also report *G. pauciflora* Mart. in Maranhão, as well as Pinheiro (2011), which declares that only *G. baculifera* occurs in the state. These divergences reinforce the existence of gaps in taxonomic knowledge in this transition region, what was already verified in a taxonomic survey carried out for other group of Arecaceae in the state (Lima and Almeida Jr 2020).

In view of the need for further studies to clarify and solve the disagreements regarding and gaps of the genus *Geonoma* in Maranhão, the present research aims to elaborate a taxonomic analysis of the species of the genus in the state. In this sense, this study presents taxonomic descriptions and an identification key for all recognized taxa, as well as a distribution map, photographic plates and preliminary conservation status assessments.

MATERIAL AND METHODS

The taxonomic treatment of the *Geonoma* in Maranhão state was based on samples at the following herbaria CEN, IAN, INPA, MAR, NY, SLUI, U, and UB, by visits to the collections or online consultations available on the platforms SpeciesLink (SpeciesLink c2021), Re flora Virtual Herbarium (Re flora c2021), and Naturalis Biodiversity Center (BioPortal c2021). All herbarium acronyms previously mentioned follow Thiers (c2020). In these collections, additional materials referring to other countries and Brazilian states were also analyzed. At the same time, sporadic field expeditions were carried out in 2016 and 2017 to the municipality of Cândido Mendes (01°51'23" South; 45°48'19" West) in Amazon rainforest, and Mirador State Park (06°37'26.4"

South; 45°52'08.8" West) in the Cerrado of the Maranhão state. The collected plants were herborized according to the usual botanical methodology (Martins and Filgueiras 2010) and deposited in the Maranhão herbarium (MAR).

Typus specimens and specialized literature were consulted to identify the samples (Lorenzi *et al.* 2010, Henderson 2011). The scientific names' spelling was verified in the databases Palmweb (c2020) and Tropicos (c2020). The description of the morphological characters was carried out following the terminologies available on Palmweb (c2020) and Henderson (2011). A taxonomic key was elaborated for the species of *Geonoma* occurring on the territory of Maranhão.

Photographic plates were assembled to allow better understanding of the distinctive characters between species. A distribution map was also generated through the Quantum GIS 3.4.5 program (QGIS Development Team c2020) using the WGS84 datum to show the distribution of the *Geonoma* species in the state.

Concerning the preliminary status of conservation of the species, criterion B proposed by the IUCN (2012) was used to estimate extinction risks. This criterion is the most widely used for estimating conservation status, due to its advantage of allowing assessments to be undertaken using distribution data only, which are in many cases the only information available (Schatz 2002, Gaston and Fuller 2009, Dauby *et al.* 2017). The Extent of Occurrence (EOO), Area of Occupancy (AOO), and number of locations, which are parameters for this evaluation, were calculated using the ConR package (Dauby *et al.* 2017) implemented in the R software version 3.5.0 (R

Development Core Team c2020). The EOO was estimated from a convex hull plotted to include all known points of the species. Areas of entirely unsuitable environment (such areas of the Atlantic Ocean) were excluded in the EOO. The AOO was estimated using the 2×2 km grids (4 km²), as recommended by IUCN (2019). The number of locations were estimated with a 10 km grid resolution. About the distribution data, we used the georeferenced specimens listed by Henderson (2011), which is the most updated revision of the group and has an extensive available database. On the other hand, we also obtained occurrence points from consulted herbarium and our field trips. When coordinates of collecting localities were not available in these new samples of the herbarium, they were estimated using Google Maps (Google c2021) and the geoLoc tool of the SpeciesLink (SpeciesLink c2021). Doubtful records of occurrence were excluded, and in the case of duplicated occurrence records, only one of the records was used in the analyses.

RESULTS AND DISCUSSION

A total of five species of *Geonoma* were identified for the Maranhão state: *G. baculifera* (Poit.) Kunth, *G. leptospadix* Trail, *G. maxima* (Poit.) Kunth subsp. *maxima*, *G. pohliana* subsp. *weddelliana* (H. Wendl.) A.J. Hend., and *G. poiteauana* Kunth. The species *G. baculifera* and *G. leptospadix* were already cited with occurrence for Maranhão (Lorenzi *et al.* 2010, Henderson 2011, Pinheiro 2011, Flora do Brasil c2020). However, *G. maxima* subsp. *maxima*, *G. pohliana* subsp. *weddelliana* and *G. poiteauana* are new occurrence records. According to Lorenzi *et al.* (2010), *G. pauciflora* Mart. is another palm of this genus that also occurs in Maranhão. However, no voucher plant materials were observed in herbaria for this species. As reported by Henderson (2011), this taxon is endemic of the Atlantic Forest of Brazil from Pernambuco to Bahia states.

Based on the latest phylogenetic study (Loiseau *et al.* 2019), each one of five species now known to Maranhão is circumscribed in a different clade: *G. maxima* subsp. *maxima* to Clade I, *G. baculifera* to Clade II, *G. poiteauana* to Clade III, *G. leptospadix* to Clade V, and *G. pohliana* subsp. *weddelliana* to Clade VII. According to Loiseau *et al.* (2019), except for *G. leptospadix* and *G. baculifera*, all other palms are not considered monophyletic based on the molecular data. Nevertheless, the authors also pointed out that new taxonomic classifications based on their results to the non-monophyletic species would require a full assessment of population genetics, morphological, and ecological evidence, which currently are still insufficient; therefore they abstained from proposing new classifications. For this reason, we continue using the species delimitations recognized by Henderson (2011) in our study, which emphasize morphological similarities and the ability to diagnose the taxa.

Taxonomic treatment

Geonoma Willd., Sp. Pl. 4: 174 (1805).

Lectotype designated by Moore (1963): *Geonoma simplicifrons* Willd.

Palm stems solitary or clustered, unarmed, pleioanthic, monoecious. Stem very short to medium size, underground, prostrate or aerial, slender, smooth, glabrous or covered with reddish or brownish scales, usually with conspicuous nodes. Leaf blade entire, bifid or pinnate (regularly or irregularly), not plicate or plicate; sheath open, splitting opposite the petiole; petiole short or long;

rachis absent, short or long. Inflorescence intrafoliar or interfoliar, unbranched or branched up to fourth order; peduncle very short to long, glabrous or tomentose; prophyll unique, tubular, narrow, short or elongate, usually closely sheathing the peduncle, glabrous or variously tomentose, deciduous or persistent; peduncular bract present, rarely vestigial or absent, deciduous or persistent, often very similar to the prophyll; rachilla short to medium, filiform or not filiform, spiky surfaces with fibrous projections, or with faint to pronounced, short, transverse ridges; flowers arranged in triads borne in pits in the rachilla; flower pits spirally, alternately, tricussately or decussately arranged throughout the rachilla, pit without upper lip or upper lip distinct, glabrous or variously hairy internally; floral bracteoles 3, irregular, membranous. Staminate flower deciduous or persistent after anthesis; sepals 3, free, imbricate; petals 3, connate proximally for about half their length into a tube, free and valvate distally; stamens 3, 6 or rarely more, filaments united into a tube proximally and free distally, thecae inserted almost directly onto the filament apices, connective and anther with different forms; pistillode small or well-developed. Pistillate flower deciduous or persistent after anthesis; sepals and petals similar in number and form to those of the staminate flower; staminodes present and united in a tube, apex of the tube with different forms. Gynoecium tricarpellate but only one carpel develops, unilocular, uniovulate; style basally inserted, elongate, exerted above the mouth of the staminodial tube. Fruit globose to ellipsoid, purple black, sometimes blue or reddish, base of the fruit with a prominent stipe or without a prominent stipe; epicarp smooth or bumpy with the numerous fibers, splitting or not at maturity; mesocarp with dense layer of fibers or without fibers; endocarp thin; seed 1, without pores, few pores or with numerous pores.

Taxonomic key to *Geonoma* species in Maranhão state, Brazil

1. Occurs in the understory of gallery forests of the Cerrado; flower pits usually decussately arranged throughout the inflorescence.....d. *Geonoma pohliana* subsp. *weddelliana*
- 1'. Occurs in the understory of the forests of the Amazon region; flower pits usually spirally arranged throughout the inflorescence
2. Inflorescence unbranched.....e. *Geonoma poiteauana*
- 2'. Inflorescence branched
3. Leaf blade regularly pinnate.....c. *Geonoma maxima* subsp. *maxima*
- 3'. Leaf blade entire, bifid or irregularly pinnate
4. Prophyll 15.4–32 cm long; rachillae with diameter > 2.5 mm; flower pits closely spaced on the inflorescence; fruit ovoid to ellipsoid.....a. *Geonoma baculifera*
- 4'. Prophyll 6–10.4 cm long; rachillae with diameter < 1.7 mm; flower pits not closely spaced on the inflorescence; fruit globose.....b. *Geonoma leptospadix*

a. ***Geonoma baculifera* (Poit.) Kunth**, Enum. Pl. 3: 233. 1841. Fig. 1a-b.

Palm 1–6 m tall, caulescent, solitary or clustered. Stem 1.5–2.3 cm in diameter; internode 1.4–7 cm long, yellowish and smooth. Leafs 6–11 per stem, bifid or irregularly pinnate, not plicate; sheath 11–21.5 cm long; petiole 6.5–25 cm long; leaf rachis 42–80 cm long; leaf bifid 59.8–108.5 cm long. pinnae 2–10 per side of rachis; basal pinna 45–70 \times 6.7–26.5 cm; apical pinna 25–32.5 \times 17–22 cm. Inflorescence branched in 1 or rarely 2 orders; prophyll 15.4–32 cm long; peduncular bract not seen; peduncle 12–39.5 cm long; rachillae 4–11, 7.5–31 cm long and 2.6–4 mm in diameter, not filiform; flower pits spirally arranged and closely spaced on the inflorescence. Fruit 8–12.8 \times 6–8.3 mm, ovoid to ellipsoid, black at maturity.

Geographic distribution. *G. baculifera* occurs in tropical lowland forests of Amazon region of Brazil (Amapá, Amazonas, Maranhão, Pará, Rondônia, and Roraima), as well as the Guianas and Venezuela (Henderson 2011). In Maranhão, this species was found in fragments of the Amazonian forest in the northwest region (Fig. 2), with specimens mainly in the Alto Turiacu Indigenous Land.

Conservation status. A total of 96 specimens were compiled for *G. baculifera*, collected in 88 different locations (Henderson 2011), which gave to this taxon an extent of occurrence (EOO) of 2 721 850 km² and an area of occupancy (AOO) estimated at 368 km². Due to its wide presence in Amazon, commonly found in relatively intact forests and protected areas, *G. baculifera* is classified as Least Concern (LC) in the present study. This classification agrees with the rating of Loftus (c2013), in which this species is considered as Least Concern (LC). However, as Loftus (c2013), we also highlight that this palm should be carefully monitored due to threats such as habitat loss, mainly in Maranhão state.

Material examined. BRAZIL. **Maranhão:** Cândido Mendes, Sete Irmãos Farm, 01°51'13" South, 45°46'13.2" West, 04 nov 2017, *G.P. Lima et al.* 666 (MAR); P.I. Guajá, Rio Turiacu, Guajá Indians, 03°07' South, 46°05' West, 17 jun 1987, *W. Baleé* 3347 (NY); Rio Gurupi, 13 mar 1958, *R.L. Fróes* 34209 (IAN); Urutawy, Ka'apor Indian Reserve, basin of Rio Turiacu, 10 km from village, 5 oct 1986, *W. Baleé* 2675 (NY).

Additional material examined. BRAZIL. **Amapá:** First waterfall on Rio Iaué, 0.5 km E of confluence with Rio Oiapoque, 02°53' North, 52°22' West, 22 aug 1960, *H.S. Irwin & L.Y.T. Westra* 47714 (NY); Macapá, Rio Matapi, entre a estrada e a foz do rio, 04 mar 1983, *B.V. Rabelo et al.* 1861 (NY). **Amazonas:** Marañ, Rio Japurá, Lago Marañ, 01°51' South, 65°36' West, 4–5 dec 1982, *T. Plowman et al.* 12235 (NY). **Pará:** 1–2 km of Repartimento, ca. 140 km on the road Marabá-Altamira, 24 oct 1977, *C.C. Berg et al.* 699 (NY); 25–35 km of Tucuruí, 03°56' South, 49°49' West, 4 nov 1981, *D.C. Daly et al.* 1213 (NY); Anajás, Caxinguba, Rio Moções, ca. 45 minutes below mouth of Igarapé Francês, 30 oct 1984, *J. Strudwick et al.* 5007 (NY); Basin of the Rio Gurupi, Tembé Indian Reserve, 6km SSW of FUNAI Post Canindé, 8 aug 1985, *W. Baleé & B.G. Ribeiro* 1549 (NY); Rio Caruá, Pacoval, 01°50' South, 55°05' West, 06–08 aug 1981, *J. Jangoux & B.G.S. Ribeiro* 1615 (NY); Rio Ora, Maje do Guama, 12 mar 1968, *C.F. Sastre* 115 (NY); Rios Pacajá and Muirapiranga, 0–5 km S of Rio Muirapiranga, 10 oct 1965, *G.T. Prance et al.* 1598 (NY); Road Campanema to Maranhão, km 107, 20 km W of Rio Gurupi, 26 oct 1965, *G.T. Prance & T.D. Pennington* 1675 (NY); Tracuateua, 01°05' South, 46°55' West, 18 nov 1981, *M.J. Balick et al.* 1303 (NY); Tucuruí, 25 km S of Represa Tucuruí on road (BR-422) to Breu Branco, 03°52' South, 49°44' West, 90 m, 15 mar 1980, *T. Plowman et al.* 9586 (NY); Tucuruí, 30 aug 1983, *J. Revilla et al.* 8376 (NY). **Roraima:** SEMA Ecological Reserve, Ilha de Maracá, 03°29' North, 61°46' West, 20 jul 1987, *W. Milliken et al.* 460 (NY); Serra da Lua, 10 km SE of Serra da Lua, 03°25–29' North, 60°11–14' West, 20 jan 1969, *G.T. Prance et al.* 9362 (NY). FRENCH GUYANA. **Arrondissement of Cayenne:** road to Mont Inéri, Approuague River, 04°21' North, 52°09' West, 10 m, 8 sep 1997, *G. Cremers et al.* 15318 (NY). GUAYANA. **Upper Takutu-Upper Esequibo:** Acarai Mountains, Watuwau Creek, 6–10 km upstream of juncture

with Chodikar River, 01°22' North, 58°42' West, 250 m, 23 feb 1994, *T.W. Henkel et al.* 4701 (NY); Basin of Essequibo River, near mouth of Onoro Creek, 15–24 dec 1937, *A.C. Smith* 2770 (NY); Kuyuwini River, trail to Kassikaityu River, 0–1 km S of camp at Anteater Head Creek, 01°55' North, 59°06' West, 260 m, 16 may 1997, *D. Clarke* 4584 (NY); Rewa River, 0–2 km S of camp, 02°59' North, 58°35' West, 150 m, 21 feb 1997, *D. Clarke* 3776 (NY). **Barima-Waini:** Kariako village, Barama River, 07°22' North, 59°42' West, 16 dec 1995, *T. van Andel et al.* 633 (U). SURINAME. **Sipaliwini:** Nature Reserve Voltz Berg, Coppename River, near Raleigh falls, on Foengoe Island in forest, 26 feb 1977, *J.C. Lindeman et al.* 167 (U). VENEZUELA. **Amazonas:** La Esmeralda, Upper Orinoco, 1 km upriver, right bank, 24 may 1994, *C. Listabarth* 12-240594 (NY); Mavaca, Alto Orinoco, Indios Guaicas (Yanomanö), jan 1970, *L. Aristeguieta & J. Lizot* 7415 (NY).

b. *Geonoma leptospadix* Trail, J. Bot. 14: 327. 1876. Fig. 1c-d.

Palm 0.5–2 m tall, caulescent, solitary or clustered. Stem 0.7–1.0 cm in diameter; internode 0.8–1.0 cm long, yellowish and smooth. Leaflets 8–17 per stem, bifid, not plicate; sheath 8.5–9.5 cm long; petiole 3.5–13 cm long; leaf rachis 25–42 cm long; leaf bifid 34–55.8 cm long. Inflorescence branched in 1 order; prophyll 6–10.4 cm long; peduncular bract not seen; peduncle 11.5–15 cm long; rachillae 3–5, 7–19.7 cm long and 0.9–1.7 mm in diameter, not filiform; flower pits spirally arranged and not closely spaced on the inflorescence. Fruit 7.3–8.1 × 6.8–7.7 mm, globose, black at maturity.

Geographic distribution. This species occurs in the Amazon lowland rainforest. In Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana, Suriname, French Guiana, and Brazil (Acre, Amapá, Maranhão, Rondônia, and Roraima) (Henderson 2011). In Maranhão, the only specimen observed to date was collected in the 1980s, within the boundaries of the Alto Turiacu Indigenous Land (Fig. 2).

Conservation status. A total of 54 specimens were compiled from 51 locations (Henderson 2011), which gave to *G. leptospadix* an extent of occurrence (EOO) of 4 618 043 km² and a restricted area of occupancy (AOO), estimated of 208 km². Due to its wide distribution in relatively intact forests, besides its occurrence in several protected areas in Amazon, this taxon is classified initially as Least Concern (LC). However, new research is necessary for Maranhão so that its geographic occurrence can be adequately documented since the only known record dates back to the 1980s, when the Amazon Forest still predominated in the state landscape (Celentano *et al.* 2017).

Material examined. BRAZIL. **Maranhão:** Carutapera, Gurupiuna, Ka'apor Indian Reserve, affluent of Rio Gurupi, 02°43' South, 46°26' West, 6 nov 1986, W. Balée & B. Ribeiro 2965 (NY).

Additional material examined. BRAZIL. **Amazonas:** Altamira, right bank of Rio Juruá, 06°35' South, 68°54' West, 14 nov 1991, R. Pardini 63 (NY); Alvarães, Lago Tefé opposite Tefé, 03°20' South, 64°50' West, 15 jan 1991, A. Henderson *et al.* 1553 (NY); Atalaia do Norte, Rio Curuçá, tributary of Javari, frontier between Brazil and Peru, 04°30' South, 71°22' West, 150 m, 12 jan

1989, *A. Henderson et al.* 877 (CEN); BR-319, Porto Velho-Manaus, 85 km N of Humaitá, Bonfutura, 07°10' South, 63°00' West, 8 apr 1985, *A. Henderson et al.* 200 (NY); Estrada Manaus-Caracaraí, BR-174 (km 97), ramal que dá acesso ao canteiro de obra da Hidrelétrica de Balbina, 100 m da margem da estrada, 8 aug 1979, *C.A. Cid et al.* 7 (NY); Maraã, Rio Japurá, ca. 5 km W of Maraã, 11 jan 1991, *A. Henderson et al.* 1538 (CEN); Maraã, Rio Japurá, environs of town of Maraã, Lago Maraã, 01°51' South, 65°36' West, 4–5 dec 1982, *T. Plowman et al.* 12236 (NY); Maraã, left bank of Rio Japurá, 02°20' South, 65°10' West, 9 jan 1991, *A. Henderson et al.* 1521 (CEN); Rio Cunchã at Deni Indian village, 06°43' South, 66°47' West, 28 nov 1971, *G.T. Prance et al.* 16491 (NY); Rio Juruá, 260 km SW of Carauari, 137 km E of Eirunepé and 2.1 km N of Cubiu, 15 apr 2012, *T. Emilio et al.* 815 (NY). **Rondônia:** Porto Velho, 4 km E of Córrego Raiz on BR-364, 24 km ENE of junction with BR-325, 26 km (by air) E of Abunã, 09°43' South, 65°08' West, 140 m, 18 apr 1987, *M. Nee* 34903 (NY). **Roraima:** Serra dos Surucucus, S of Mission station, 02°42–47' North, 63°33–36' West, 18 feb 1969, *G.T. Prance et al.* 10036 (NY).

c. *Geonoma maxima* (Poit.) Kunth subsp. *maxima*, Enum. Pl. 3: 229. 1841. Fig. 3a-c.

Palm 1.5–6 m tall, caulescent, solitary or clustered. Stem 1.2–2.5 cm in diameter; internode 1.1–10 cm long, yellowish. Leafs 7–13 per stem, regularly pinnate, not plicate; sheath 13–16 cm long; petiole 30–51 cm long; leaf rachis 75–120 cm long; pinnae 15–31 per side of rachis; basal pinna 25–41 × 0.2–1.8 cm; apical pinna 16.5–28.5 × 0.7–6.7 cm. Inflorescence branched in 2–3 orders (rarely 1); prophyll 7.5–17 cm long; peduncular bract ca. 8.3 cm long; peduncle 5–10 cm long; rachillae 9–50, 6–17.5 cm long and 2–2.5 mm in diameter, not filiform; flower pits usually spirally arranged on the inflorescence. Fruit 7.9–11.3 × 6–8.1 mm, globose to ellipsoid, purple-black at maturity.

Geographic distribution. *G. maxima* subsp. *maxima* is distributed in tropical lowland forests of Central and Eastern Amazonia (Amazonas, Pará, and Amapá), as well as of the Guyana, Suriname, and French Guiana (Henderson 2011). After this research, the area of occurrence is extended to the northwestern part of Maranhão in a remnant fragment of the Amazon Forest within the boundaries of the municipality of Cândido Mendes (Fig. 2).

Conservation status. A total of 41 specimens were compiled for *G. maxima* subsp. *maxima*, collected in 34 different locations (Henderson 2011), which gave to this taxon an extent of occurrence (EOO) of 1 132 364 km² and an area of occupancy (AOO) estimated at 140 km². Due to its wide distribution in relatively intact forests, in addition to its existence in protected areas, *G. maxima* subsp. *maxima* is classified as Least Concern (LC) in the present study. However, threats such as loss of habitat due to logging and agricultural expansion should be carefully monitored, especially in the Maranhão state, which is located within the "Arc of Deforestation" in the Brazilian Amazon and where the remaining vegetation cover of this biome represents only 25 % of the territory (Celentano *et al.* 2017).

Material examined. BRAZIL. **Maranhão:** Cândido Mendes, Sete Irmãos Farm, 01°51'50" South, 45°46'02.3" West, 10 oct 2016, A. Ferreira 1 (MAR).

Additional material examined. BRAZIL. **Amapá:** road between Calçoene and Oiapoque (BR-156), 87 km NW of Calçoene, 02°49' North, 51°23' West, 07 dec 1984, *S. Mori & R. Souza* 17265 (NY); Island of Escondido, near mouth of Cricu River, 03°43' North, 51°55' West, 12 aug 1960, *H. Irwin et al.* 47455 (NY). **Amazonas:** Manaus, 60 km N of city on road to Caracaraí, then 3 km E on ZF1, 05 aug 1986, *A. Henderson & J. Nascimento* 649 (NY); Manaus, Adolfo Ducke Forest Reserve, on Manaus-Itacoatiara road, 09 sep 1966, *G.T. Prance et al.* 2239 (NY); *ibidem*, 15 mar 1967, *H. Moore et al.* 9534 (INPA, NY); *ibidem*, 10–21 oct 1986, *A. Henderson* 664 (NY); Rio Preto da Eva, BDFF Reserve km 41, 64 km N of Manaus on BR-174 and then 41 km E on ZF-3, 29 aug 1989, *A. Henderson et al.* 1055 (CEN, NY). **Pará:** Anajás, opposite town of Anajás on Rio Anajás, 31 oct 1984, *J. Strudwick et al.* 5009 (NY); Basin of Rio Xingu, Gleba Bacajá, lote 88, just below mouth of Rio Bacajá, 03°22'20 South, 50°47'50 West, 28 nov 1980, *G.T. Prance et al.* P26519 (NY); Marabá, 24 may 1982, *R. Secco et al.* 304 (NY); Sebastião da Boa Vista, Sítio Campina, 20 oct 1984, *J. Strudwick et al.* 4671 (NY); Serra dos Carajás, ca. 10 km E of Itacaiúnas River and 4 km S on secondary road, 05°58' South, 50°25' West, 17 jun 1982, *C. Sperling et al.* 6210 (NY); Viseu, Tembé Indian Reserve, 6 km SSW of FUNAI Post Canindé, 17 aug 1985, *W. Balée & B. Ribeiro* 1591 (NY).

- d. *Geonoma pohliana* subsp. *weddelliana* (H. Wendl.) A.J. Hend., *Phytotaxa*. 17: 130–131, f. 35. 2011. Fig. 3d-e.

Palm 1.5–5 m tall, caulescent, solitary or clustered. Stem 1–2.2 cm in diameter; internode 0.7–1.1 cm long, yellowish. Leaves 8–13 per stem, irregularly pinnate, not plicate; sheath 9.5–21.5 cm long; petiole 4.5–52.5 cm long; leaf rachis 16.8–59.5 cm long; pinnae 4–42 per side of rachis, spreading in the same plane; basal pinna 9.3–48.5 × 0.3–5.8 cm; apical pinna 8.6–30 × 0.3–17.5 cm.

Inflorescence branched in 1–2 orders; prophyll 6–25.3 cm long, ridged and tomentose surface; peduncular bract 5.5–19.5 cm long; peduncle 8–33.5 cm long; rachillae 7–24, 14.5–31 cm long and 1.2–2.2 mm in diameter, not filiform; flower pits usually decussately arranged throughout the inflorescence. Fruit 7.9–10 × 5.1–7.8 mm, globose to ellipsoid, black at maturity.

Geographic distribution. This species is usually found in gallery forests, a physiognomy associated to the Cerrado. It is present in a significant part of the Brazilian Plateau (Bahia, Federal District, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Pará, Pernambuco, São Paulo, and Tocantins) and also occurs in Bolivia and Paraguay (Henderson 2011). Its presence in the state of Maranhão is confirmed for the first time at the Mirador State Park (municipality of Mirador), in the riparian forest bordering the Alpercata River, one of the main tributaries to the Itapecuru River, as well as within the boundaries of the municipality of Carolina (Fig. 2).

Conservation status. *G. pohliana* subsp. *weddelliana* presented a broad EOO of 3 355 615 km² and an AOO of 264 km², as for the 87 specimens compiled, registered in 57 different locations (Henderson 2011). Due to its extensive distribution on the Brazilian Plateau, in addition to its existence within several conservation units and to the fact that it occurs mainly in gallery forests, which are theoretically Permanent Preservation Areas (PPAs) according to the Brazilian Forest Code (Law no. 12 651), the species is classified in the present study as Least Concern (LC).

Material examined. BRAZIL. **Maranhão:** Carolina, estrada vicinal para o povoado Brejinho, 07°01'02" South, 47°27'27" West, 180 m, 21 nov 2009, *G. Pereira-Silva et al.* 14703 (CEN); Mirador, Mirador State Park, source of the Alpercata River, 28 nov 1988, *F. Noberto* 220 (SLUI); Mirador, Mirador State Park, source of the Alpercata River, 06°37'17.9" South, 45°52'16.1" West, 14 feb 2017, *A. Ferreira* 2 (MAR).

Additional material examined. BRAZIL. **Distrito Federal:** Brasília, Fundação Zoobotânica, 18 aug 1961, *E. Heringer* 8589/783 (NY, UB); Brasília, ca. 25 km E of Brasília, 700–1000 m, 23 aug 1964, *H. Irwin & T. Soderstrom* 5422 (NY); Brasília, ca. 10 km E of Brasília, near Sobradinho, 01 oct 1965, *H. Irwin et al.* 8851 (NY); Brasília, APA de Cafuringa, Nascente do Rio do Sal, Fazenda Macnamara, 21 aug 1998, *R. Martins* 211 (UB); Chapada da Contagem, ca. 20 km E of Brasília, 700–1000 m, 19 sep 1964, *H. Irwin & T. Soderstrom* 6276 (NY, UB); Chapada da Contagem, ca. 15 km NE of Brasília, 1000 m, 04 may 1966, *H. Irwin et al.* 15633 (NY, UB). **Goiás:** Chapada dos Veadeiros, ca. 20 km W. of Alto Paraíso de Goiás (formerly Veadeiros), 14° South, 47° West, 1000 m, 10 feb 1966, *H. Irwin et al.* 12479 (NY, UB); Chapada dos Veadeiros, ca. 10 km S of of Alto Paraíso de Goiás (formerly Veadeiros), 1000 m, 21 mar 1969, *H. Irwin et al.* 24838 (NY, UB); Chapada dos Veadeiros, ca. 14 km by road N of Alto Paraíso de Goiás, 04 mar 1973, *W. Anderson* 6289 (NY, UB); Serra dos Cristais, 2 km E by road of Cristalina, 1200 m, 04 apr 1973, *W. Anderson* 8138 (NY, UB); Serra dos Pireneus, 20 km NW of Corumbá de Goiás, 1250 m, 26 jan 1968, *H. Irwin et al.* 19233 (NY, UB). **Pará:** Itaituba, Estrada Satarém-Cuiabá (BR-163) - km 794, Serra do Cachimbo, Aeroporto do Cachimbo com penetração de 8 km dentro da mata, margem do Rio Formiga, 27 apr 1983, *I. Amaral et al.* 1015 (NY); Marabá, Serra dos Carajás, 20 mar 1984, *A. Silva et al.* 1937 (NY). **Mato Grosso:** 1 km E of km 264, Xavantina-Cachimbo road,

12°49' South, 51°46' West, 21 mar 1968, *D. Philcox & A. Ferreira 4606* (NY). **Mato Grosso do Sul:** Luciara, distrito de Porto Alegre, ca. 10–11 km da BR-158, 11°10' South, 51°40' West, 16 oct 1985, *J. Pirani 1258* (NY); Rio Brilhante, Rio Sta. Luzia, 06 feb 1975, *Hatschbach et al. 35907* (NY). **Minas Gerais:** São Roque de Minas, Parque Nacional da Serra da Canastra, Jaguaré (Jaguari), 1350 m, 30 sep 1999, *R. Mello-Silva et al. 1667* (NY). **Tocantins:** Aguiarnópolis, Posto Indígena São José (FUNAI Reservation-Apinajé Tribe), ca. 20 km W of Tocantinópolis, 06°30' South, 47°30' West, 09 sep 1983, *M. Balick et al. 1587* (CEN, NY).

e. *Geonoma poiteauana* **Kunth**, Enum. Pl. 3: 233. 1841. Fig. 3f.

Palm 1–2 m tall, acaulescent, solitary. Leaf blade bifid or irregularly pinnate, not plicate; sheath 12–17 cm long; petiole 18–20 cm long; leaf bifid 71.5–98.5 cm long; leaf irregularly pinnate with rachis 45.5–63.5 cm long and 2–3 pinnae per side of rachis; basal pinna 42–64 × 9–21 cm; apical pinna 37–38 × 13–14.5 cm. Inflorescence unbranched (spicate); prophyll 9–13.2 cm long, tubular; peduncular bract 16–23 cm long, tubular; peduncle 47.5–82 cm long; inflorescence axis 7.5–20 × 0.3–0.6 cm, orange at maturity; flower pits usually spirally arranged on the inflorescence. Fruit 8.7–8.1 × 7.1–6.5 mm, globose to ellipsoid, purple-black at maturity.

Geographic distribution. This species occurs in the Amazon lowland rainforest. It is found in Colombia, Venezuela, Guyana, Suriname, French Guiana, and Brazil (Amazonas, Pará, and Amapá) (Henderson 2011). After this study, the area of occurrence is extended to the northwestern part of Maranhão, with a sample collected near the Maracaçumé River, within the boundaries of the municipality of Maracaçumé (Fig. 2).

Conservation status. A total of 29 specimens were compiled from 28 locations (Henderson 2011), which gave to this taxon an extent of occurrence (EOO) of 2 330 834 km² and a restricted area of occupancy (AOO), estimated at 116 km². Due to its wide distribution in relatively intact forests, besides its occurrence in several protected areas, mainly in Guianas, *G. poiteauana* is classified initially as Least Concern (LC). However, it should be highlighted that the records of *G. poiteauana* on the Brazilian territory are still scarce, discontinuous, and old. It is represented in only nine locations, which demonstrates the need for new research to elucidate the current aspects of its geographic occurrence in the country. An example of this scenario is the distribution of this taxon in Maranhão, since the "new record" pointed out in the present article dates back to the 1950s, when the Amazon Forest still predominated in the state landscape (Celentano *et al.* 2017).

Material examined. BRAZIL. **Maranhão:** Maracaçumé, 17 jul 1958, *R. Fróes* 34499 (IAN).

Additional material examined. BRAZIL. **Amapá:** Macapá, Riozinho, 122 km NW of Porto Grande on the highway BR-210, 01°21' North, 53°15' West, 01 jan 1985, *S. Mori & R. Souza* 17611 (NY); Oiapoque, first cachoeira on Rio Iaué, 0.5 km E of confluence with Rio Oiapoque, 02°53' North, 52°22' West, 22 aug 1960, *H. Irwin & L. Westra* 47707 (NY); Rio Araguari, between Cachoeiras Travessão and Santa Maria, 01°09' North, 51°52' West, 20 aug 1961, *J. Pires et al.* 50396 (NY). **Amazonas:** Barcelos, Acãnga, across from Ilha do Japó, 01°10' South, 62°30' West, 27 jun 1979, *J. Poole* 1652 (INPA, NY); Manaus, Fazenda Porto Alegre, 02°25' South, 59°54' West, 50–125 m, 11 jun 1992, *C. Dick* 154 (NY). **Pará:** Road BR-22, Capanema to

Maranhão, km 64, vicinity of Piritoro, 05 nov 1965, *G.T. Prance & T. Pennington* 1992 (NY); Santarém-Cuiabá road (BR-163), km 1225 from Santarém, 20 nov 1977, *M. Balick et al.* 936 (NY).

In this study, we documented five species of the genus *Geonoma* for Maranhão state, and among these, three are new records: *G. maxima* subsp. *maxima*, *G. pohliana* subsp. *weddelliana*, and *G. poiteauana*. These new data reinforce the existence of taxonomic knowledge gaps in this region, as pointed out by Alvez-Valles *et al.* (2018) and Lima and Almeida Jr (2020), and also they show the importance of taxonomic studies in improving knowledge. We also highlight that some areas in the Maranhão state remain unexplored or poorly inventoried, and their study would certainly yield new interesting information to be added to the present findings.

AUTHOR'S CONTRIBUTIONS

AWCF collected and photographed part of the material. GPL identified and described the specimens examined, ran the conservation analysis, and produced the figures. AWCF, GPL and EBAJ wrote and revised the manuscript.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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FIGURES

Figure 1. Leafs and inflorescences of the *Geonoma* species investigated; **a-b.** *Geonoma baculifera*; **a.** Palm tree with irregular leafs in its natural environment (G.P. Lima *et al.* 666); **b.** Branched inflorescence in the first order with flower pits closely spaced on the rachillae (J. Jangoux & B.G.S. Ribeiro 1615). and **c-d.** *Geonoma leptospadix*; **c.** Specimen with bifid leafs (T. Emilio *et al.* 815); **d.** Branched inflorescence in the first order with flower pits not closely spaced on the rachillae (W. Balée & B. Ribeiro 2965). Photographs by G.P. Lima.

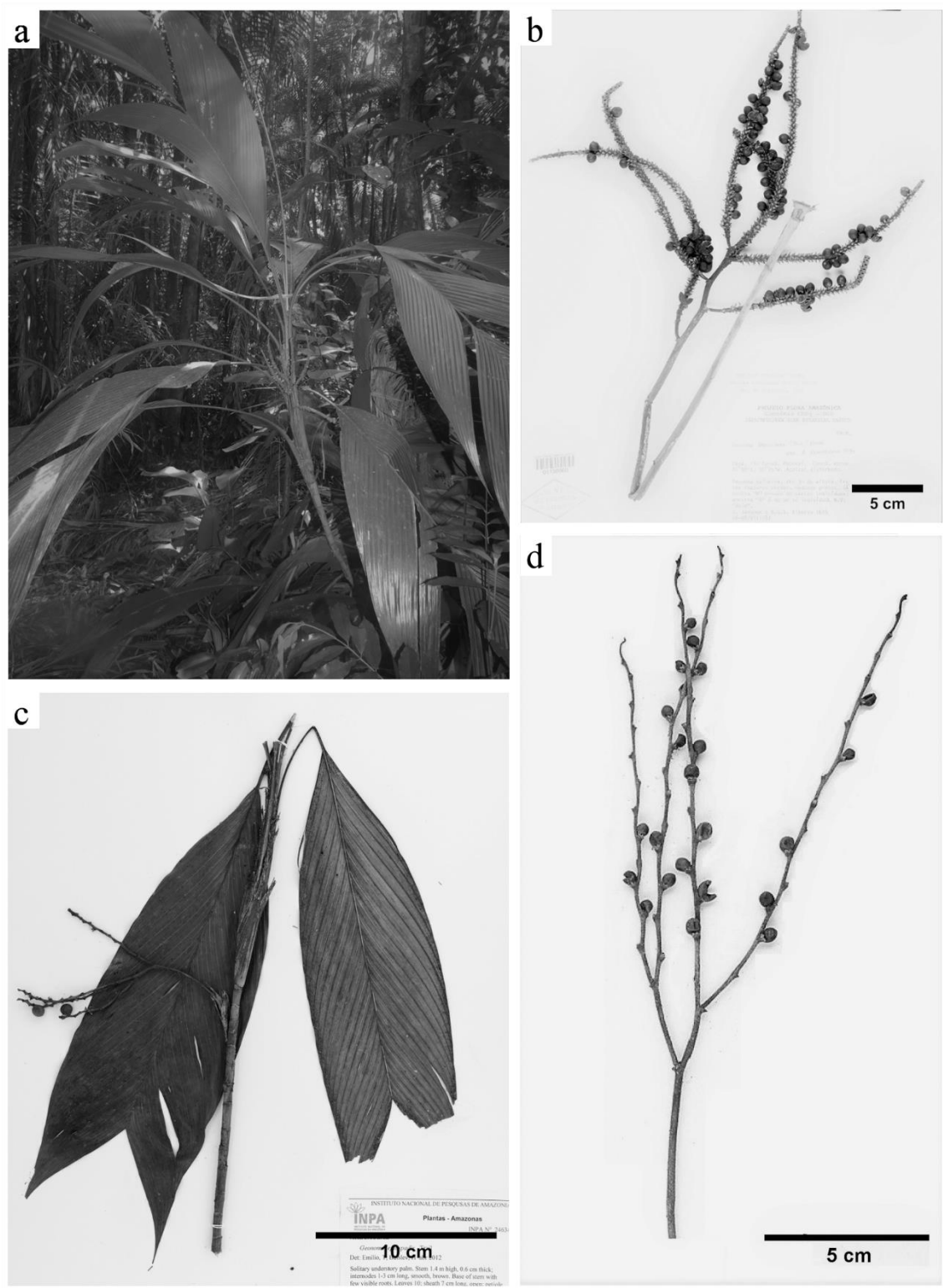


Figure 2. Geographic distribution of species of the genus *Geonoma* in Maranhão state, South America.

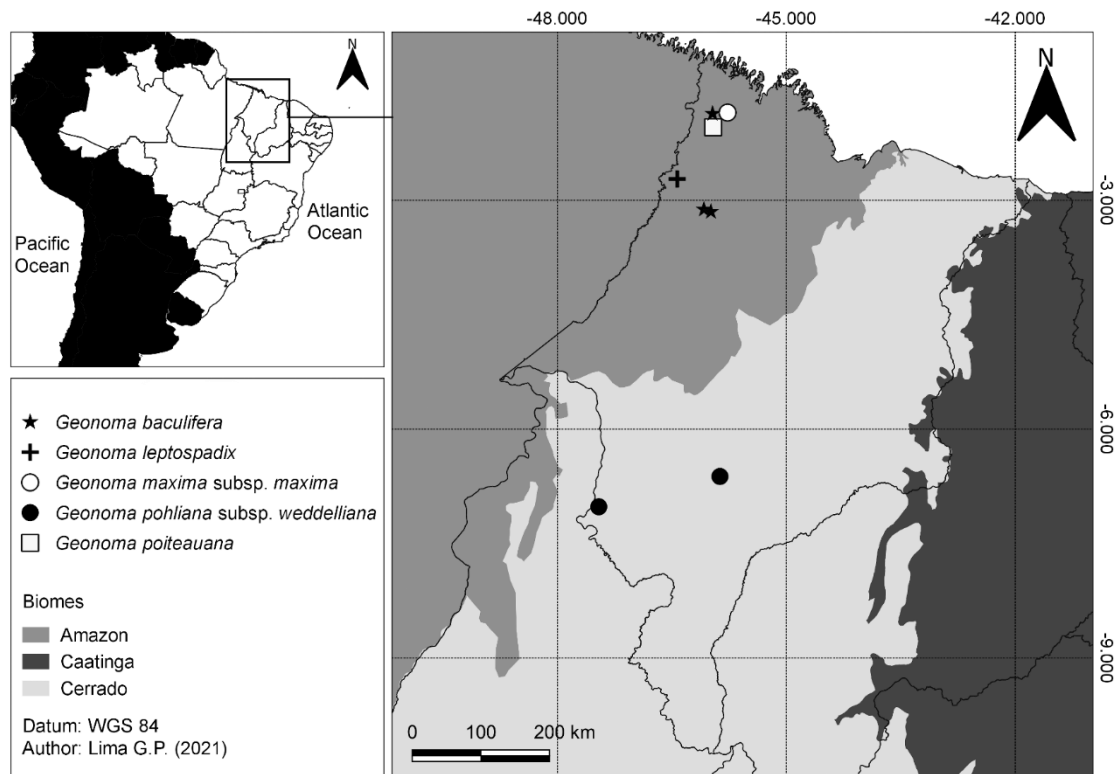


Figure 3. Morphological characters of the *Geonoma* species investigated; **a-c.** *Geonoma maxima* subsp. *maxima*; **a.** Pinnae regularly distributed on the leaf rachis (A. Henderson & J. Nascimento 649); **b.** Branched inflorescence in the second order (G.T. Prance *et al.* P26519); **c.** Fruits at maturity (A. Ferreira 1). **d-e.** *Geonoma pohliana* subsp. *weddelliana*; **d.** Palm tree in its natural environment (A. Ferreira 2); **e.** Flower pits decussately arranged throughout the rachillae (H. Irwin *et al.* 19233). **f.** *Geonoma poiteauana* - specimen (R. Fróes 34499). Photographs by G.P. Lima and A.W.C. Ferreira.

