Rodriguésia 73: e01192021. 2022
http://rodriguesia.jbrj.gov.br
DOI: http://dx.doi.org/10.1590/2175-7860202273082

Original Paper

Flora of Ceará, Brazil: Loranthaceae

Marcelo Oliveira Teles de Menezes[1,6,7], *Brian Leslie Stannard*[2], *Claudenir Simões Caires*[3], *Maria Iracema Bezerra Loiola*[4] & *Marcelo Freire Moro*[5,6]

Abstract

This study provides a taxonomic treatment for the species of Loranthaceae in the state of Ceará, Northeastern Brazil. The survey was made based on the previous consultation of virtual herbaria, in loco visits, material loans, and photographs of diagnostic traits sent by herbarium curators. Morphological traits and geographic coordinates of all specimens collected in the State were recorded to prepare the distribution maps, identification key, and taxonomic descriptions for each taxon. A total of 184 specimens (discounting duplicates) from 30 herbaria were studied. Eight species are recorded for Ceará: *Passovia pedunculata*, *Passovia pyrifolia*, *Psittacanthus cordatus*, *Psittacanthus dichroos*, *Psittacanthus eucalyptifolius*, *Struthanthus marginatus*, *Struthanthus polyrrhizus*, and *Struthanthus syringifolius*. None are included in the IUCN Red List. However, four of them were collected inside protected areas (*i.e.*, *Passovia pedunculata*, *Psittacanthus cordatus*, *S. polyrrhizus*, and *S. syringifolius*).

Key words: biodiversity, Caatinga, mistletoe, semiarid, taxonomy.

Resumo

Este estudo traz um tratamento taxonômico das espécies de Loranthaceae no estado do Ceará, nordeste do Brasil. O levantamento foi feito a partir de consulta prévia em herbários virtuais, visitas *in loco*, material de empréstimo e fotografias de caracteres diagnósticos enviadas por curadores de herbários. Características morfológicas e coordenadas geográficas de todos os espécimes coletados no estado foram registradas para elaborar mapas de distribuição, uma chave de identificação e descrições taxonômicas de cada táxon. Foram estudados um total de 184 espécimes (excluindo duplicatas) de 30 herbários. Foram registradas oito espécies no Ceará: *Passovia pedunculata*, *Passovia pyrifolia*, *Psittacanthus cordatus*, *Psittacanthus dichroos*, *Psittacanthus eucalyptifolius*, *Struthanthus marginatus*, *Struthanthus polyrrhizus* e *Struthanthus syringifolius*. Nenhuma delas é citada na Lista Vermelha da IUCN. No entanto, quatro delas foram coletadas dentro de Unidades de Conservação (*Passovia pedunculata*, *Psittacanthus cordatus*, *S. polyrrhizus* e *S. syringifolius*).

Palavras-chave: biodiversidade, Caatinga, erva-de-passarinho, semiárido, taxonomia.

Introduction

Loranthaceae Juss. is one of the five families of hemiparasitic plants in Santalales (Nickrent 2011; Su *et al*. 2015; Nickrent *et al*. 2019). Currently, 77 genera and ca. 950 species are recognized, occurring in tropical and temperate regions worldwide (Stevens 2001 onwards). The plants of the family are usually known as mistletoes (in Brazilian Portuguese, "*erva-de-passarinho*", "*enxerto*" or "*enxerto-de-passarinho*"). It forms a

[1] Instituto Federal de Educação, Ciência e Tecnologia do Ceará, Campus de Fortaleza, Depto. Educação, Lab. Biologia, Benfica, Fortaleza, CE, Brazil. ORCID: <https://orcid.org/0000-0003-2129-6843>.

[2] Retired Researcher, Royal Botanical Gardens Kew, Richmond, London, UK. ORCID: <https://orcid.org/0000-0003-0077-4949>.

[3] Universidade Estadual do Sudoeste da Bahia, Depto. Ciências Naturais, Vitória da Conquista, BA, Brazil. ORCID: <https://orcid.org/0000-0002-2012-5164>.

[4] Universidade Federal do Ceará, Depto. Biologia, Lab. Sistemática e Ecologia Vegetal - LASEV, Campus do Pici, Fortaleza, CE, Brazil. ORCID: <https://orcid.org/0000-0003-3389-5560>.

[5] Universidade Federal do Ceará, Instituto de Ciências do Mar - Labomar, Meireles, Fortaleza, CE, Brazil. ORCID: <https://orcid.org/0000-0003-4527-346X>.

[6] Universidade Federal do Ceará, Prog. Pós-graduação em Sistemática, Uso e Conservação da Biodiversidade, Fortaleza, CE. Brazil.

[7] Author for correspondence: teles@ifce.edu.br

monophyletic clade, with strong molecular support (Nickrent *et al.* 2010, 2019; Su *et al.* 2015), and differs from other families of the order mainly by having dichlamydeous flowers forming a calyculus at least in pistillate flowers (Kuijt & Hansen 2015). Basal Loranthaceae, like *Gaiadendron* G.Don, are root hemiparasites, and thus, are usually shrubs or trees, with both regular roots and haustorial roots (Kuijt & Hansen 2015; Caires *et al.* 2020). However, most Loranthaceae are stem hemiparasites, having an herbaceous or shrubby appearance. They also lack regular roots since they grow entirely attached to their host plants. In this case, only haustorial and sometimes epicortical roots are present (Kuijt & Hansen 2015).

The family generally offers keystone resources (such as fruits and leaves) to the herbivores (Anderson & Braby 2009; Okumbamichael *et al.* 2011, 2016; Griebel *et al.* 2017). On the other hand, as parasites, mistletoes may reduce host productivity (Press & Phoenix 2005; Doležal *et al*. 2016). In extreme cases, Loranthaceae can also impact woody crops like cocoa, kola nut, bush mango (Ogunmefun *et al.* 2013), guava, lime (Zaroug 2013), and coffee (Amon *et al*. 2015).

In Brazil, Caires *et al.* (2020) recognize 86 species arranged in 11 genera: *Psittacanthus* Mart. (33 species), *Struthanthus* Mart. (21 spp.), *Passovia* H.Karst. (16 spp.), *Oryctanthus* Eichler (3 spp.), *Oryctina* Tiegh. (3 spp.), *Peristethium* Tiegh. (3 spp.), *Ligaria* Tiegh. (2 spp.), *Phthirusa* Mart. (2 spp.), and *Gaiadendron* G.Don, *Pusillanthus* Kuijt., and *Tripodanthus* Tiegh. (each with 1 spp.). The most important taxonomic monograph for the Brazilian Loranthaceae was done by Eichler (1868) in Martius' *Flora brasiliensis*. The author recognized 112 Neotropical species, including 34 currently placed in Santalaceae (formerly included in subfamily "Viscae"). Since then, publications mainly focused on regional accounts or studies on specific genera (*e.g.*, Sugiyama & Mantovani 1987; Sugiyama 1992; Rizzini 1995; Moreira & Rizzini 1997; Caetano *et al.* 2002; Stannard 2004; Reif & Andreata 2011; Dettke & Waechter 2014; Caires 2018; Araújo *et al*. 2020). In Northeastern Brazil, the only states that present floristic treatments are Paraíba (Vasconcelos & Melo 2015) and Sergipe (Oliveira & Caires 2018). However, studies in the Caatinga also include the Flora of Pico das Almas in Bahia (Stannard 1995), the Flora of the São Francisco River (Siqueira-Filho *et al.* 2012), and the Flora of Parque Nacional do Catimbau in Pernambuco (Vasconcelos & Melo 2016).

So far, the state of Ceará has had no floristic or taxonomic studies focusing on Loranthaceae. In Ceará, herbarium records for the family result from eventual collections or general floristic surveys, such as Ribeiro-Silva *et al*. (2012). During a survey of the EAC herbarium, Loiola *et al.* (2020) recorded five species of Loranthaceae for Ceará, while Caires *et al.* (2020) list 11 species for the state, based on records from many herbaria.

This study is part of the "Flora do Ceará: Conhecer para conservar" project, which intends to increase the region's plant biodiversity knowledge, serving as the base for further studies in the family.

Material and Methods

A preliminary list of Loranthaceae collections in Ceará was compiled using the *species*Link (<https://specieslink.net/>) and Reflora Virtual Herbarium (<http://floradobrasil.jbrj.gov.br/reflora/herbarioVirtual/>) databases. Additional records were gathered from collections not included in these databases, such as BM, S, and HUVA (acronyms according to Thiers, continuously updated). The acronyms of non indexed herbaria are according to the Rede Brasileira de Herbários (<https://www.botanica.org.br/catalogo-da-rede-brasileira-de-herbarios/>).

Morphological descriptions, illustrations, identification key, and distribution maps were based on dried specimens housed at EAC, HCDAL, HUVA, UFRN, K, and BM. Herbarium visits and loans occurred in 2019 and 2020. When it was neither possible to personally visit a collection nor to loan material, specimens were identified using images available at the virtual herbaria or photos of diagnostic traits taken and sent by the curators. Specimens without images and/or not determined by specialists were ignored.

Taxon authorities follow Caires *et al.* (2020). Morphological descriptions and illustrations follow Harris & Harris (2001) for general botanic terminology. The terminology for morphological features unique to Loranthaceae follows Eichler (1868) and Kuijt & Hansen (2015). Measurements were taken in millimeters using a caliper, always following the order length × width or length × diameter, in the case of solid structures.

Whenever possible, dry specimens were used as references for morphological descriptions (including colors recorded in field notes). When not, we used data from the literature (Eichler 1868;

Sugiyama & Mantovani 1987; Sugiyama 1992; Rizzini 1995; Stannard 1995; Kuijt 2009; Dettke & Waechter 2014; Vasconcelos & Melo 2015; Caires 2018).

Additional material (preferably from neighboring states) was analyzed when few sheets were available for a given species. Whenever numerous sheets were available for a given species, we sought to cover morphological diversity and geographical distribution in the "selected material" list. A complete list of all records is presented as supplementary material. A dichotomous key was elaborated based on shared and specific features that are usually used in taxonomic treatments for Loranthaceae.

Distribution maps were prepared using QGIS (Sherman *et al*. 2011), using the geographic coordinates of the collections whenever they were available. Otherwise, we used the geographical coordinates for the municipality. The shapefiles with all records are available in the supplementary material. Collections missing proper identification or precise location information were ignored for mapping purposes.

Results and Discussion

We examined 184 herbarium specimens[1], from 30 herbaria: ASE, BM, CEN, CEPEC, EAC, ESA, HCDAL, HPL, HST, HUEFS, HUESB, HUVA, HVASF, IAN, INPA, IPA, K, MAC, MO, MOSS, NY, P, R, RB, SPF, TEPB, UB, UFP, UFRN, and VIES. The most representative collection for the State of Ceará is EAC, with 111 of the specimens. We ignored five specimens due to the absence of diagnostic traits in the exsiccate. Thus, we worked with 179 specimens that were used for taxonomic analysis and mapping.

Based on these records, we recognized eight species for Ceará (Figs. 1-3). None of them appear in the IUCN Red List. The number of species for Ceará accepted in the present study differs from the available literature. Four species previously cited for Ceará were not confirmed in our study: *Tripodanthus acutifolius* (Ruiz & Pav.) Tiegh., *Struthanthus flexicaulis* (Mart.) Mart., *Struthanthus elegans* (Mart.) Mart., and *Struthanthus polyanthus* (Mart.) Mart. There was a single record of *T. acutifolius* for Ceará (listed by Caires *et al*. 2020): *F.F. Araújo 94* (EAC, HUEFS). This plant was examined, and we verified that it was a misidentification since its morphology undoubtedly matches *Passovia pedunculata* (Jacq.) Kuijt.

For *S. elegans*[2], there is also a single voucher, listed by the Reflora Virtual Herbarium: *F. Allemão 765* (P). Although not physically examined, the high-resolution photo available online allows confidently to identify it as *Struthanthus polyrrhizus* (Mart.) Mart., based on the leaf and the inflorescence morphology.

In the case of *S. flexicaulis*, two vouchers had been previously cited for Ceará. Ribeiro-Silva *et al.* (2012) cites a collection by *S.L. Cartaxo s.n.* (HST 18473), while both Loiola *et al*. (2020) and Caires *et al*. (2020) cite a collection by *J. Paula-Souza 10958* (EAC, ESA). Both specimens undoubtedly correspond to *S. polyrrhizus*. Although both species are commonly confused, they easily distinguish themselves by the very distinct leaf morphology.

The only uncertainty regarding records of other species of Loranthaceae in Ceará is *S. polyanthus*. Rizzini (1956: 115) bases the species' occurrence in Ceará on a single voucher, *A. Loefgren 664* (S). However, their herbarium online catalogue does not acknowledge this specimen, and according to the curator team, the whole collection is indefinitely boxed to move to a new building. Thus, we are recording here only eight species of Loranthaceae for Ceará. This number is in line with the species richness recorded in other states in Northeastern Brazil. Vasconcelos & Melo (2015) also recorded eight species for the state of Paraíba (10 species were initially listed, but some of them were lately synonymized), while Oliveira & Caires (2018) recorded seven species for the state of Sergipe.

Taxonomic treatment

Loranthaceae Juss., Ann. Mus. Natl. Hist. Nat. 12: 292 (1808), *nom. cons.*

Stem hemiparasites, herbaceous or shrubby, erect, ascending, scandent or decumbent; stems densely to sparsely branched, cylindric, sometimes compressed when dried, straight or flexuose, slender to robust, epidermis peeling or not, lenticellate or not; haustorium present, epicortical climbing roots present or not. Leaves sessile or petiolate, opposite to subopposite, elliptic to orbicular, symmetric or asymmetric, smooth or coriaceous, often crass, venation palmate or pinnate, margins entire or marginate, repand, sinuate to undulate.

[1] This number ignores 27 specimens that either could not be located or belong to herbaria that were closed due to the COVID-19 pandemic.

[2] Currently a synonym of *Struthanthus orbicularis* (Kunth) Eichler (Caires *et al*. 2020).

Figure 1 – a-h. Species of Loranthaceae that occur in Ceará – a. *Passovia pedunculata*; b. *Passovia pyrifolia*; c. *Psittacanthus cordatus*; d. *Psittacanthus dichroos*; e. *Psittacanthus eucalyptifolius*; f. *Struthanthus marginatus*; g. *Struthanthus polyrrhizus*; h. *Struthanthus syringifolius.* (a-g. by C.S. Caires; h. by M.O.T. Menezes).

Inflorescences axillary and/or terminal, corymb-like, umbel-like, racemes or panicles; bracteoles free or fused; flowers grouped in triads. Flowers bisexual or unisexual, sessile or pedicellate, conspicuous (large and/or bright-colored) or inconspicuous (small and/or faint-colored); perianth hexamerous; stamens usually dimorphic (alternating longer and shorter), filaments flat or filiform, anthers dorsifixed or basifixed; ovary inferior, 1-seeded, style simple, straight or twisted, thick to slender, stigma undifferentiated to capitate, papillate or not. Fruits ellipsoid to globose berries, with varied colors, often becoming atro-vinaceous when totally ripe.

Key to the species of Loranthaceae from Ceará state, Brazil

1. Flowers pedicellate, longer than 15 mm (*Psittacanthus*; Fig. 2a) 2
1'. Flowers sessile, shorter than 15 mm (*Passovia* and *Struthanthus*; Fig. 2b) 4
2. Leaves sessile; base cordate; venation palmate (Fig. 2c)..... 3. *Psittacanthus cordatus*
2'. Leaves petiolate; base acute, attenuate, cuneate, truncate or round; venation pinnate (Fig. 2d) 3
3. Floral buds clavate (Fig. 2e), petals red with yellow apex (Fig. 1d), style twisted at base (Fig. 3a)..... 4. *Psittacanthus dichroos*
3'. Floral buds sigmoid (Fig. 2f), petals yellow (Fig. 1e), style straight..... ..... 5. *Psittacanthus eucalyptifolius*
4. Filaments flat with concave sides (Fig. 2g), anthers basifixed (*Passovia*)..... 5
4'. Filaments filiform (Fig. 2h), anthers dorsifixed (*Struthanthus*) 6
5. Stems and inflorescence axis with epidermis intact; flowers unisexual, petals light green, pale yellow or white ..... 1. *Passovia pedunculata*
5'. Stems and inflorescence axis with epidermis red and peeling (Fig. 3b); flowers bisexual, petals orange to red ..... 2. *Passovia pyrifolia*
6. Stems straight; central bracteole longer than the laterals (Fig. 3c); ripe fruit > 10 mm long; epicortical roots not seen ..... 8. *Struthanthus syringifolius*
6'. Stems flexuose (especially young shoots); bracteoles equal (Fig. 3d); ripe fruit < 8 mm long; epicortical roots often present..... 7
7. Mature leaf-blades ovate to elliptic-lanceolate, apex acuminate to acute (Fig. 3e); racemes (sometimes panicles) ..... 6. *Struthanthus marginatus*
7.' Mature leaf-blades cordate, apex truncate, emarginate or mucronate (Fig. 3f); corymbs (elongating into racemes as they develop)..... ..... 7. *Struthanthus polyrrhizus*

1. *Passovia pedunculata* (Jacq.) Kuijt, Novon 23(2): 177 (2014). Figs. 1a; 2b,g; 3g

Plants scandent, herbaceous; young stems compressed, mature stems compressed or cylindric, epidermis not peeling, lenticellate; epicortical climbing roots present. Leaves opposite to subopposite; petiole 4–10 mm long; blade elliptic to ovate, rarely round, 25–48 × 12–36 mm, smooth to coriaceous, base round, cuneate or attenuate, margin entire, slightly sinuate-undulate, hyaline, apex acute to slightly acuminate, rarely obtuse or round; venation pinnate, central and laterals veins conspicuous. Inflorescences axillary and/or terminal, 1 per axil, panicle or raceme, 50–72 mm long, epidermis not peeling; flowers grouped in subsessile to pedunculate triads; peduncle 2–5 mm long, triads 4–7 pairs per inflorescence; bracteoles equal, scale-like, acute or acuminate, rarely round. Floral buds polyhedric, straight, apex acute. Flowers 4–6 mm long, sessile to subsessile, unisexual, hexamerous; petals light green, pale yellow or white; stamens dimorphic, filaments flat, with side concavities, anthers basifixed, cuspidate; style thick, stigma capitate, papillate. Fruit 4–9 × 3–6 mm, ellipsoid to globose, orange-yellow.

Selected material: Aiuaba, Estação Ecológica de Aiuaba, 27.VIII.2019, fr., *J.R. Lemos* & *P. Matias 227* (EAC); Estrada da Confiança, 5.II.1997, fl., *L.W. Lima-Verde 389* (EAC). Barroquinha, Bitupitá, 10.VI.2016, fl. and fr., *E.B. Souza et al. 4249* (EAC, HUEFS). Camocim, Lago Seco, 13.VI.2014, fl., *E.B. Souza et al. 3137* (EAC). Crateús, RPPN Serra das Almas, 28.IV.2004, fl., *J.L. Andrade* (EAC 33841); 22.II.2000, fr., *L.W. Lima-Verde*

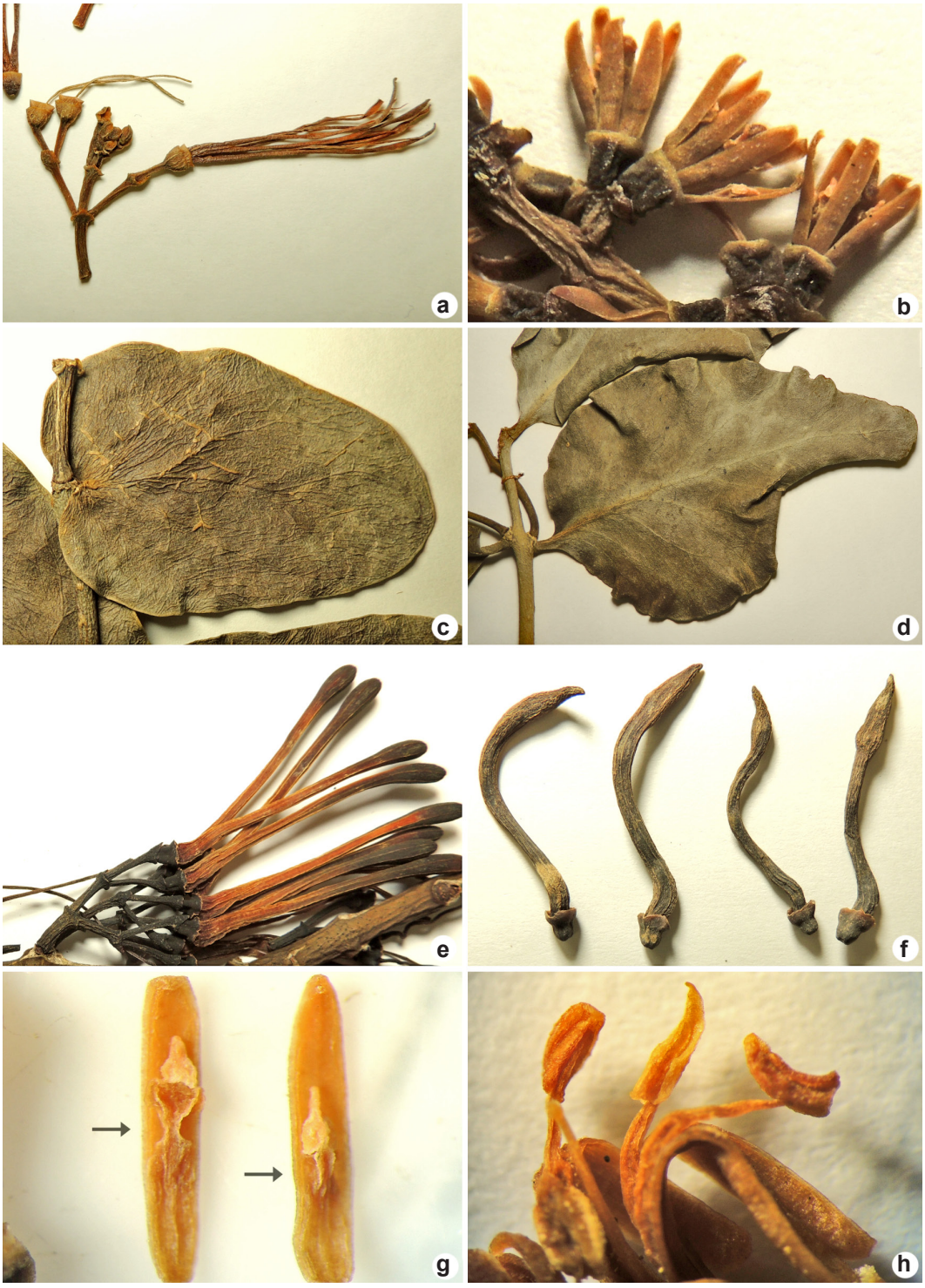

Figure 2 – a. *Psittacanthus cordatus* – flowers. b. *Passovia pedunculata* – flowers. c. *Psittacanthus cordatus* – sessile leaf. d. *Psittacanthus eucalyptifolius* – petiolate leaf. e. *Psittacanthus dichroos* – flower bud (clavate). f. *Psittacanthus eucalyptifolius* – flower buds (sigmoid). g. *Passovia pedunculata* – stamen: flat filament with concava sides. h. *Struthanthus syringifolius* – stamen: filiform filament. [a. *Martins & Figueiredo* (EAC 8345); b. *Andrade* (EAC 33841); c. *Souza et al.* (EAC 30000); d. *Castro* (EAC 24535); e. *Araújo 6*; f. *Fernandes & Matos* (EAC 7373); g. *Andrade* (EAC 33841); h. *Alencar 1*].

et al. 1138 (EAC). Santa Quitéria, Serra do Pajé, Fazenda Intan de Cima, 7.V.1997, fr., *M.A. Figueiredo* (EAC 25568). Sobral, Taperuaba, Refúgio de Vida Silvestre Pedra da Andorinha, 6.I.2017, fl., *F.F. Araújo 94* (EAC, HUEFS); 24.II.2017, fr., *E.B. Souza et al. 4435* (EAC). Ubajara, Jaburuna, 7.IX.1995, fr. *L.M.R. Melo & L.W. Lima-Verde* (EAC 23484).

Passovia pedunculata differs from *Passovia pyrifolia* by the color of its petals (Fig. 1a-b). Sometimes stems, leaves and even inflorescences may resemble those of *Struthanthus syringifolius*. A reliable differentiation is the shape of the floral buds (polyhedric in *Passovia pedunculata vs*. clavate in *S. syringifolius* - Fig. 3g-h) and the stamens (see identification key and Fig. 2g-h).

This species is one of the most widely distributed in the Neotropics and also exhibits a considerable morphological variation (Kuijt 2014). In Ceará, it is recorded mainly in the western highland semideciduous forests of the Serra da Ibiapaba ("*mata seca*"), in the Caatinga shrublands and the coastal forests ("*mata de tabuleiro*") - Fig. 4. It was collected in three protected areas: Refúgio de Vida Silvestre Pedra da Andorinha, Estação Ecológica de Aiuaba and RPPN Serra das Almas.

The species was collected with flowers in April and June, and with fruits in May, August, and September.

2. *Passovia pyrifolia* (Kunth) Tiegh., Bull. Soc. Bot. France 42: 172 (1895). Figs. 1b; 3b

Plants decumbent, herbaceous; stem cylindric, epidermis peeling red or greyish-brown (when scales fall), sparsely lenticellate; epicortical climbing roots exclusively basal. Leaves opposite to subopposite; petiole 6–13 mm long; blade elliptic, slightly lanceolate, oblong, ovate or round, 39–94 × 21–63 mm, smooth to coriaceous, base round, rarely cuneate or truncate, margin sinuate to undulate, apex obtuse, cuspidate, mucronate, rarely emarginate; venation pinnate (both central and laterals veins conspicuous). Inflorescences axillary, 1–2 per axil, raceme, 38–97 mm long, epidermis peeling red; flowers grouped in subsessile triads; peduncle up to 1 mm long, triads 6–12 pairs per inflorescence; bracteoles equal, scale-like, acute or rarely round. Floral buds polyhedric, straight, acute. Flowers up to 1 mm long, sessile to subsessile, bisexual, hexamerous; petals orange to red; stamens dimorphic filaments flat, with side concavities, anthers basifixed, acuminate; style thick, stigma papillate. Fruit 3–5 × 2–3 mm, ellipsoid, purple (recorded in a single sheet as yellow - probably not fully ripe).

Selected material: Baturité, congl. 117, Inventário Florestal Nacional, 26.X.2014, fr., *R. Moura et al. 1105* (EAC); Oiticica, 26.XII.1997, fr., *A.S.F. Castro* (EAC 26000); Morro dos Jesuítas, 26.XII.1997, fl., *A.S.F. Castro 492* (EAC). Guaramiranga, Sítio Cana Brava, 13.XI.1993, fl. and fr., *M.R.L. Oliveira* (EAC 20956); Sítio Mont'Rey, 17.I.2013, fr., *I.R. Coriolano 12* (EAC). Itapipoca, Comunidade Quilombola Nazaré, 22.XII.2016, fr., *J.C.M.S.M. Sobczak 379* (EAC). Pacoti, Sítio Germinal, 31.VII.1941, fr., *P. Bezerra 309* (EAC). Viçosa do Ceará, 6.I.1987, fr., *A. Fernandes & M.A. Figueiredo* (EAC 14903).

Passovia pyrifolia can be easily identified by its microscopic rusty-furfuraceous scales, which gives the plant a rusty-floccose aspect (Fig. 3b), as well as by its red flowers (Fig. 1b). However, it is important to highlight that sometimes very old collections may have lost both the scales and the color of the flowers.

Passovia pyrifolia occurs in more humid habitats in the semideciduous and evergreen forests associated with the highlands of like Baturité, Meruoca, and Ibiapaba ("*mata seca*" and "*mata úmida*" - Fig. 5). Records of specimens collected inside protected areas were not found. However, most of the collections are from Serra da Ibiapaba and Serra de Baturité. Thus, it may occur within vast protected areas, such as the "APA Serra da Ibiapaba" and the "APA Serra de Baturité".

The species was collected with flowers in January, July, and December, and with fruits in January, June, October, November, and December.

3. *Psittacanthus cordatus* (Hoffmanns.) G.Don, Gen. Hist. 3: 416 (1834). Figs. 1c; 2a,c

Plants erect, shrubby; stem cylindric, grey, densely branched, densely leafy, sometimes with smooth longitudinal fissures or protuberances, epidermis not peeling, rarely lenticellate; epicortical climbing roots not seen. Leaves opposite, sessile, blade oblong to ovate-cordate, 33–95 × 14–51 mm, coriaceous, base cordate, margin entire, marginate, sinuate to undulate (sometimes crenate), apex round (rarely obtuse); venation palmate. Inflorescences axillary and/or terminal, 1 per axil, raceme, 53–111 mm long, epidermis not peeling; flowers grouped in pedunculate triads; peduncle 7–11 mm long, triads 3–7(–22) pairs per inflorescence; bracteoles scale-like, round to obtuse. Floral buds clavate, straight, acute. Flowers 26–43 mm long, pedicel 10–15 mm long, bisexual, hexamerous; petals intense orange to red; stamens dimorphic, filaments filiform, anthers dorsifixed, linear, narrow oblong or slightly acuminate; style long, straight, clavate, darkened in

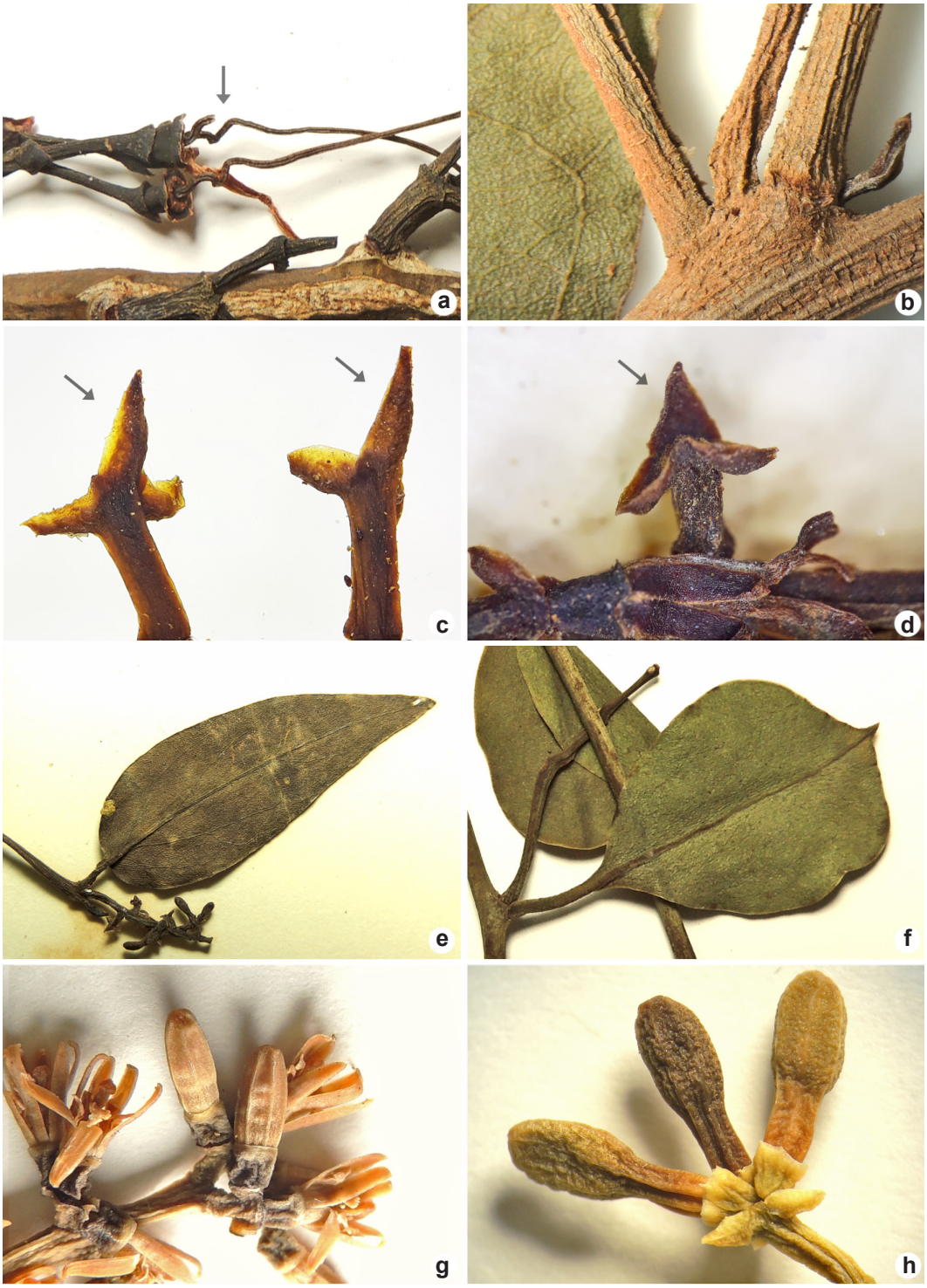

Figure 3 – a. *Psittacanthus dichroos* – style twisted at the base. b. *Passovia pyrifolia* – microscopic rufous-furfuraceous scales. c. *Struthanthus syringifolius* – central bracteole longer than laterals. d. *Struthanthus marginatus* – central bracteole equal to laterals. e. *Struthanthus marginatus* – lanceolate leaf blade. f. *Struthanthus polyrrhizus* – cordate leaf blade. g. *Passovia pedunculata* – flower buds (polyhedral). h. *Struthanthus syringifolius* – flower buds (clavate). [a. *Araújo 6*; b. *Coriolano 12*; c. *Gomes & Silveira 1130*; d. *Bezerra* (EAC 508); e. *Bezerra* (EAC 508); f. *Castro 2695*; g. *Andrade* (EAC 33841); h. *Gomes & Silveira 1130*].

the stigma. Fruit 7–13 × 5–6 mm, ellipsoid, yellow, becoming atro-vinaceous when totally ripe.

Examined material: Aiuaba, Estação Ecológica de Aiuaba, 16.IV.1980, fr., *P. Martins & M.A. Figueiredo* (EAC 8345); Lagoa do Meio, 11.IV.1991, fl., *M.A. Figueiredo 144* (EAC, MOSS, TEPB); Lagoa da Boiada, 06º35'S, 40º18'W, 26.IV.1996, fl. and fr., *M.A. Figueiredo et al. 592* (EAC, IPA, K); 26.II.1997, fl., *L.W. Lima-Verde & L.M.R. Melo 492* (EAC); Sítio Vale do Boi, 5.IV.2000, fl. and fr., *E.B. Souza et al.* (EAC 30000); Barra, 06º35'57.9"S, 40º18'51.6"W, 5.VI.1997, fl. and fr., *E.O. Barros & M.M.A Souza 114* (EAC); Estação Ecológica de Aiuaba, 16.IV.1980, fr., *P. Martins & M.A. Figueiredo* (EAC 8345); 06º35'S, 40º18'W, 26.IV.1996, fl. and fr., *M.A. Figueiredo et al. 592* (EAC, IPA, K); Parambu, estrada que liga Parambú a Cocci, Ponto 04 (F. 316), 18.V.1984, fl., *S.J. Filho 184* (HCDAL).

This species can be easily identified by its unique leaves, which are sessile, with palmate venation and cordate base (Fig. 2c).

This species inhabits deciduous and semideciduous forests and shrublands ("*mata seca*" and "*caatinga*") - Fig. 6. Despite being common in Northeastern Brazil, *Psittacanthus cordatus* was recorded only in the municipality of Aiuaba and surrounding areas. It was collected inside the Estação Ecológica de Aiuaba protected area.

The species was collected with flowers in February, April, and May.

4. *Psittacanthus dichroos* (Mart.) Mart., Flora 13[1(7)]: 108 (1830). Figs. 1d; 2e; 3a

Plants erect, sometimes decumbent, shrubby; stem cylindric, fissured (due to secondary growth), epidermis not peeling, lenticels not seen; epicortical climbing roots not seen. Leaves opposite to subopposite; petiole 4–9 mm long; blade cordate to ovate (from slightly ovate to slightly obovate), sometimes asymmetric, 41–54 × 35–61 mm, coriaceous, base round (slightly attenuate or cuneate), margin entire, repand, slightly sinuate-undulate, sometimes slightly crenate, apex round, obtuse or emarginate; venation pinnate (central vein conspicuous, secondary not much). Inflorescences axillary and terminal, 1(–2) per axil, corymb-like or umbel-like, 35–62 mm long, epidermis not peeling; flowers grouped in pedunculate triads; peduncle 9–15 mm long, triads 1–3 pairs per inflorescence; bracteoles cup-shaped or scale-like, acute. Floral

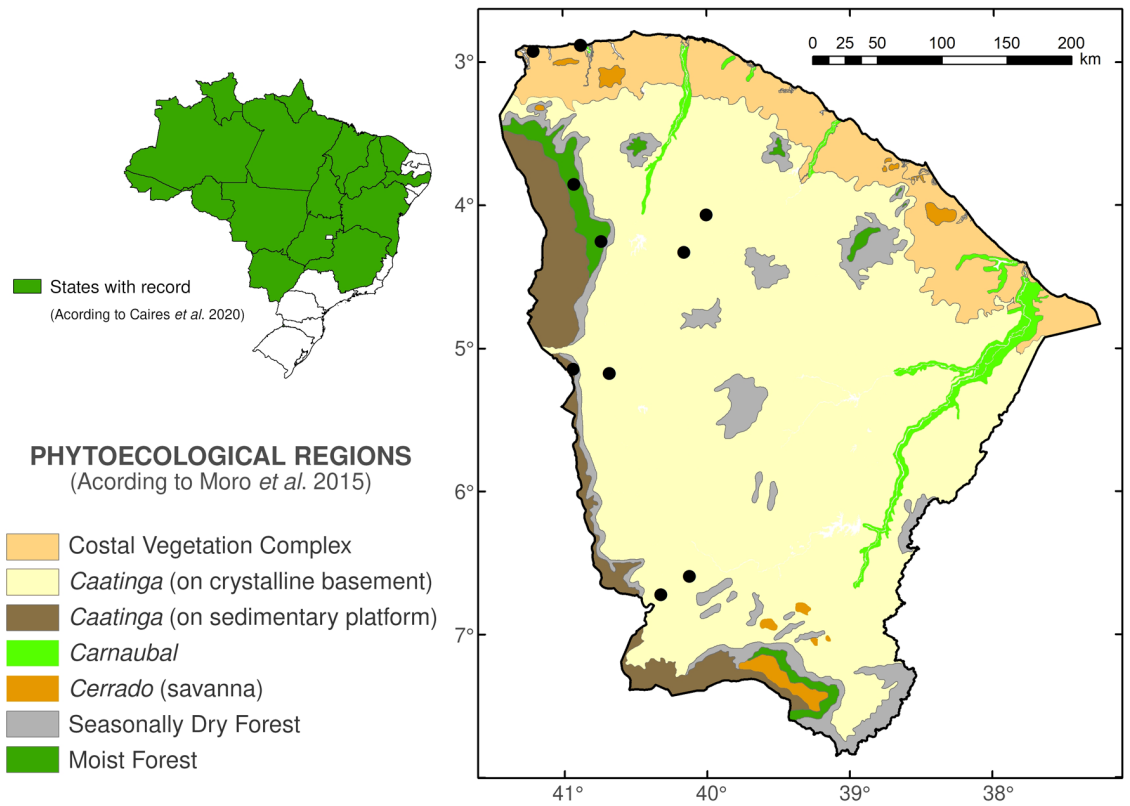

Figure 4 – Geographic distribution of *Passovia pedunculata*.

buds clavate, straight, acute. Flowers 26–49 mm long, pedicel 4–15 mm long, bisexual, hexamerous; petals red with yellow apex; stamens dimorphic, filaments filiform, anthers dorsifixed, widely oblong, slightly acuminate; style twisted at base, stigma capitate. Fruit ellipsoid, 10–13 × 6–7 mm, ellipsoid, black.

Examined material: Graça, 17.XII.2007, fl. and fr., *P.M. Teixeira 33* (UFRN, HUEFS). Pacujá, 19.XII.2007, fl., *A.A. Leopoldino 14* (UFRN, HUEFS).

Additional material: BRAZIL. BAHIA: Belmonte, Estação Experimental gregório Bondar, 2.IV.2003, fr., *P. Fiaschi 1439* (CEPEC). SERGIPE: Areia Branca, Serra de Itabaiana, 17.I.1994, fl., *J.K.S. Araújo* (ESA 11612). Itaporanga D'ajuda, Fazenda do Caju (EMBRAPA), 22.II.2008, fl., *T. Araújo 6* (EAC).

The twisted style base (Fig. 3a) is the best diagnostic trait for *Psittacanthus dichroos*. However, this feature is not easily observed before the flower is fully developed (*i.e.*, dissecting a floral bud). However, it differs from *Psittacanthus cordatus* by the leaf-blade shape, the presence of a petiole (although small), and the pinnate venation; and from *Psittacanthus eucalyptifolius* by the color of the flower (Fig. 1d-e) and the shape of the floral buds (Fig. 2e-f).

Psittacanthus dichroos seems to be associated with western highland semideciduous forests ("*mata seca*") of the *Serra da Ibiapaba* and of the coastal forests and shrublands ("*mata de tabuleiro*") - Fig. 7. It was not recorded in any protected area yet, but like *Passovia pyrifolia*, it may occur within vast protected areas.

The species was collected with flowers and fruits in December.

5. *Psittacanthus eucalyptifolius* (Kunth) G.Don, Gen. Hist. 3: 417 (1834). Figs. 1e; 2d,f

Plants erect, ascending or decumbent, shrubby; stem cylindric, epidermis not peeling, lenticellate or not; epicortical climbing roots not seen. Leaves opposite; petiole 10–20 mm long; blade broadly ovate to lanceolate, often asymmetrical, 72–170 × 32–130 mm, coriaceous, base truncate, round or cuneate to acute, margin repand to sinuate-undulate, apex obtuse to round; venation pinnate (central vein conspicuous, secondary not much). Inflorescences axillary, 1

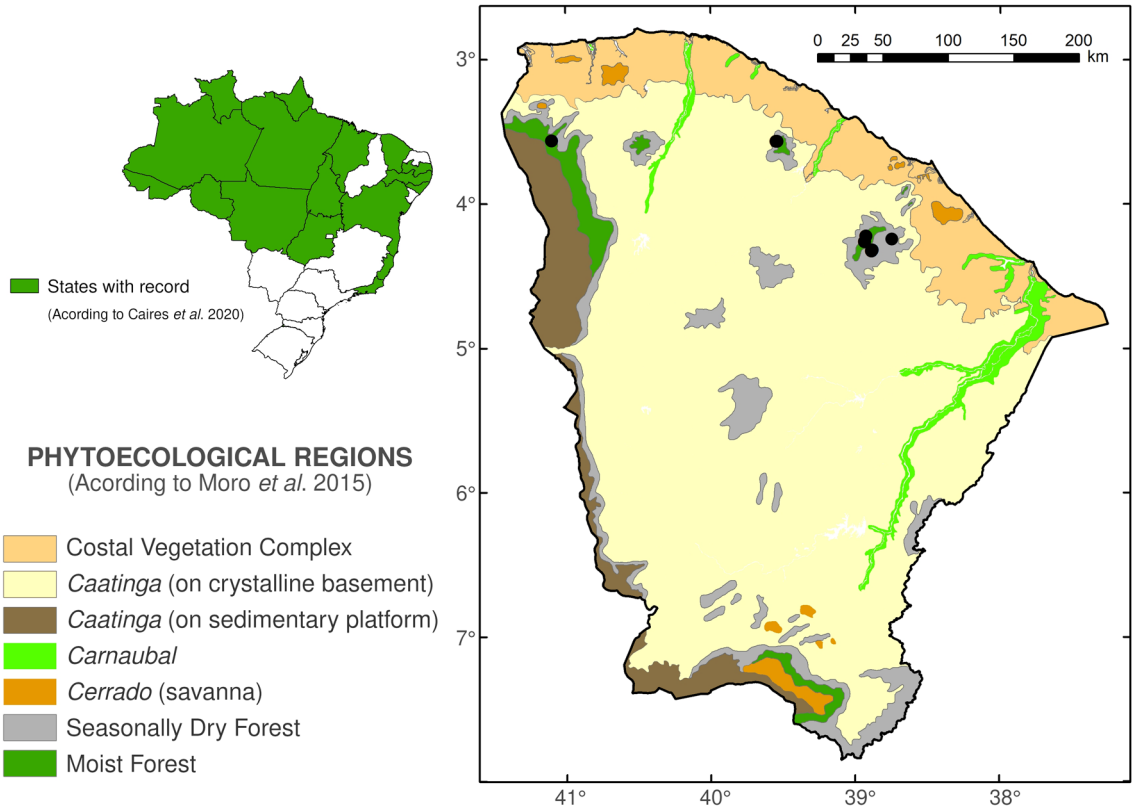

Figure 5 – Geographic distribution of *Passovia pyrifolia*.

per axil, sub-umbellate cluster, 55–120 mm long, epidermis not peeling; flowers grouped in pedunculate triads; peduncle 8–20 mm long, triads 1–3 pairs per inflorescence; bracteoles cup-shaped, round, obtuse, acute. Floral buds clavate, sigmoid, acute. Flowers 34–45 mm long, pedicel 8–13 mm long, bisexual, hexamerous; petals yellow; stamens dimorphic, filaments filiform, anthers dorsifixed, notched at the apex, crenate on the sides; style straight, slightly thickened, ridged and verrucose, stigma capitate, finely papillate. Fruit ca. 12 × 8 mm, ellipsoid, red becoming atro-purpureous when totally ripe.

Examined material: Ibiapaba, Tucum, 20.V.1997, fr., *M.A. Figueiredo 792* (EAC). Pacujá, 20.XII.2007, fl., *P. M. Teixeira 55* (HUEFS, UFRN).

Additional material: BRAZIL. BAHIA: Barra, Vereda de Dois Riachos, 7.XI.2009, fl., *A.P. Prata 2055* (ESA). PIAUÍ: Bom Jesus, Estação Ecológica Uruçui-Una, 11.IV.2009, fr., *G. Martinelli 16370* (CEN). Piripiri, 16.X.1996, fr., *A.S.F. Castro* (EAC 24535); estrada Floriano a Itaueiras, a 10 km de Floriano, 11.XI.1979, fl., *A. Fernandes & F.A. Matos* (EAC 7373).

This taxon may be easily identified by its yellow flowers (Fig. 1e), the sigmoid floral buds (Fig. 2f), and the broad, red leaves when young.

In Ceará, its distribution seems to be associated with Cerrado enclaves - Fig. 8. Thus, it is expected that in the future, additional samples may be collected in the coastal ecosystems, in which typical Cerrado species commonly occur (Castro *et al*. 2012; Moro *et al.* 2015). Records inside protected areas were not found.

The species was collected with flowers in December.

6. *Struthanthus marginatus* (Desr.) G.Don, Gen. Hist. 3: 411 (1834). Figs. 1f; 3d-e

Plants decumbent or scandent, herbaceous; stem flexuose, sinuate, much-branched, young shoots terete or slightly tetragonal, sparsely leafy, epidermis not peeling, lenticellate; epicortical climbing roots not seen. Leaves opposite to subopposite; petiole 3–4 mm long; blade ovate to elliptic-lanceolate, 31–36 × 11–13 mm, smooth, base round, margin entire or slightly sinuate, opaque or hyaline, apex acuminate to acute; venation pinnate (only central vein conspicuous). Inflorescences axillary, 1 per axil, raceme, sometimes panicle, 14–17 mm long, epidermis

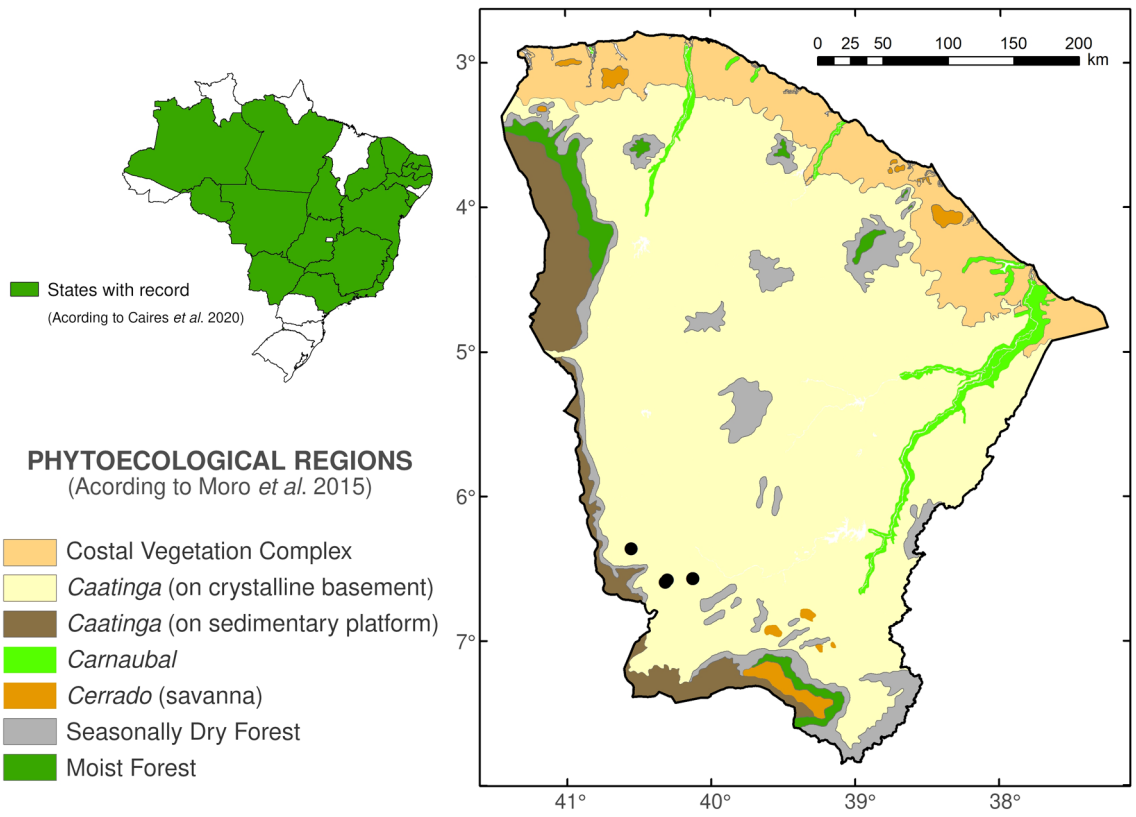

Figure 6 – Geographic distribution of *Psittacanthus cordatus*.

not peeling; flowers grouped in pedunculate triads; peduncle 1 mm long, triads 3–5 pairs per inflorescence; bracteoles equal, scale-like, acute. Floral buds clavate, straight, round. Flowers 3 mm long, sessile, unisexual, hexamerous; petals greenish-white (staminate) or white (pistillate); stamens dimorphic, filaments filiform, anthers dorsifixed, apiculate; style thick, stigma capitate, papillate, vestigial in staminate flowers. Fruit 5–8 × 3–4 mm, ellipsoid to oblongoid, green turning orange, yellow or red.

Examined material: Ibiapina, à margem da estrada entre São Benedito e Ibiapina, 9.I.1942, fl., *P. Bezerra* (EAC 508).

Additional material: BRAZIL. MINAS GERAIS: Morada Nova de Minas, Fazenda Boa Vista, a 18.2 km da cidade, 12.XI.1991, fl., *R.F. Vieira 980* (CEN). ESPÍRITO SANTO: Ibiraçu, 29.V.1990, fr., *J.M.L. Gomes & H.Q. Boudet 1161* (VIES). SERGIPE: Lagarto, assentamento Che Guevara, Mata de Dr. João, 13.IX.2012, fl., *D.A. Campos et al. 267* (ESA). Poço Redondo, Serra da Guia, 21.XI.2009, fl., *W.J. Machado 51* (ESA).

This species differs from *S. polyrrhizus* and *S. syringifolius* by the leaf-blade shape and by its racemose inflorescences, with small flowers and short peduncles. However, it is a somewhat controversial taxon that seems to be part of a complex that involves some other poor-defined species (*e.g.*, *S. concinnus* Mart.). Although its leaves generally exhibit a hyaline margin (Eichler 1868; Stannard 1995), this feature was not observed in the examined material.

It was collected in the region of the sedimentary highlands of the Serra da Ibiapaba, in semideciduous and evergreen forests ("*mata seca*" and "*mata úmida*") - Fig. 9. The only specimen known from Ceará was not collected within a protected area.

The species was collected with flowers in January.

7. *Struthanthus polyrrhizus* (Mart.) Mart., *Fl. bras.*, vol. 5, part. 2 (1868). Figs. 1g; 3f

Plants scandent, herbaceous; stem very flexuose especially at apex, epidermis not peeling, slightly to very lenticellate, rarely not; epicortical climbing roots present. Leaves opposite to subopposite; petiole 4–12 mm long; blade elliptic,

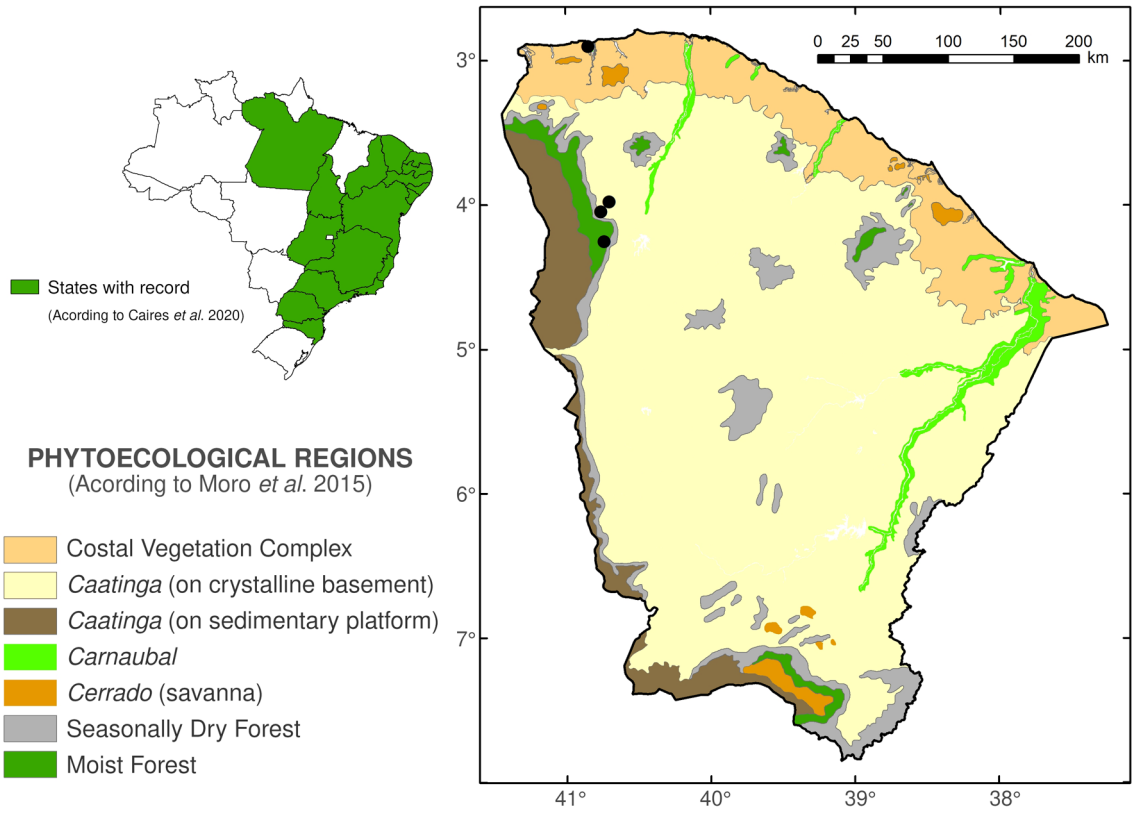

Figure 7 – Geographic distribution of *Psittacanthus dichroos*.

obovate or orbicular when young, cordate when mature, 11–40 × 10–40 mm, smooth to coriaceous, base round, cuneate, obtuse or attenuate, margin entire or slightly sinuate, rarely marginate, apex round or acute when young, truncate, emarginate or mucronate when mature; venation pinnate (central vein conspicuous, secondary may or not be conspicuous). Inflorescences axillary, 1–2 per axil, corymb (turning into raceme as it develops), 32–51 mm long, epidermis not peeling; flowers grouped in pedunculate triads; peduncle 1–7 mm long, usually shorter in staminate flowers, triads 2–8 pairs per inflorescence; bracteoles equal, scale-like, acute. Floral buds cylindric to slightly clavate, straight, round. Flowers 2–4 mm long, sessile, unisexual, hexamerous; petals cream; stamens dimorphic, filaments filiform, anthers dorsifixed, cordate, shortly apiculate or acuminate in staminate flowers, staminodia lanceolate in pistillate flowers; style thick in pistillate flowers, filiform in staminate flowers, stigma capitate, papillate. Fruit 5–9 × 2–6 mm, ellipsoid to globose, red, becoming atro-vinaceous when totally ripe.

Selected material: Aiuaba, 8.IX.2008, fl. and fr., *S.L. Cartaxo* (HST 18473). Aracati, Estêvão, 4.VII.2013, fl., *A.S.F. Castro 2695* (EAC). Barbalha, Chapada do Apodi, 28.IV.2009, fl., *J.R. Maciel et al. 1060* (HUESB, HVASF). Crato, Floresta Nacional do Araripe, 7.VII.2000, fl. and fr., *L.W. Lima-Verde 2190* (EAC); 1.VIII.2000, fl. and fr., *L.W. Lima-Verde 2216* (EAC). Jardim, arredores da comunidade Olho d'Água, 07º35'23"S, 39º18'30"W, 22.I.2014, fl. and fr., *B.M.T. Walter et al. 6589* (EAC, CEN, HUEFS, RB, UFP). Novo Oriente, Baixa Fria, Planalto da Ibiapaba, 28.III.1990, fr., *F.S. Araújo 24* (EAC). Quixeré, 17.IV.1999, fl., *A.S.F. Castro* (EAC 28022). Poranga, Ibiapaba Norte, 21.V.1997, *M.A. Figueiredo & J. Augusto* (EAC 25813). Santa Quitéria, 2.15 km SE (em linha reta) da sede da fazenda Itatai, 04º35'7"S, 39º46'46"W, 25.IV.2012, *J. Paula-Souza et al. 10958* (EAC, ESA, RB). Santana do Cariri, Chapada do Araripe, próximo ao povoado do Rogério, 5.V.1998, fl., *M.A. Figueiredo & L.W. Lima-Verde* (EAC 26769). Serra do Araripe, IX.1838, fl. and fr., *G. Gardner 1681; 1681-A* (K).

The main diagnostic trait for this taxon is the shape of the leaf-blade. The petiole develops before the leaf-blade, so young leaves usually have petioles that may be as long as the blade itself. Eichler (1868) differentiated this species in his identification key

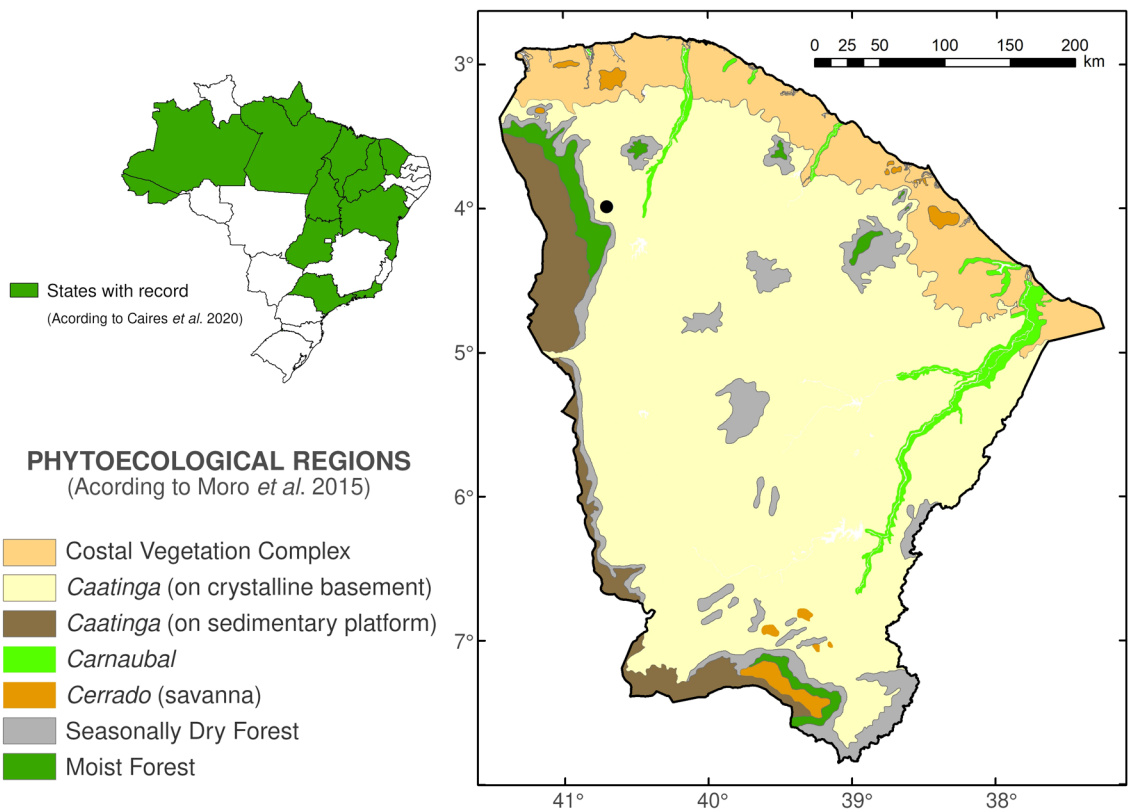

Figure 8 – Geographic distribution of *Psittacanthus eucalyptifolius*.

by its corymbose inflorescences. However, in the species' description, he recognizes that with subsequent development, all inflorescences become racemose (*tota inflorescentia magis racemosa evadit*). Indeed, most of the examined samples exhibited racemes rather than corymbs.

In Ceará, it has a widespread distribution, occurring in different kinds of vegetation, especially along the Jaguaribe river basin (Fig. 10). It was collected in the FLONA do Araripe protected area.

The species was collected with flowers and fruits all year long.

8. *Struthanthus syringifolius* (Mart.) Mart., *Fl. bras.*, vol. 5, part. 2 (1868). Figs. 1h; 2h; 3c,h

Plants decumbent, sometimes erect or ascending, herbaceous; stem straight, cylindric, epidermis not peeling, slightly to very lenticellate, rarely not; epicortical climbing roots not seen. Leaves opposite to subopposite; petiole 7–26 mm long, canaliculate; blade ovate, ovate-lanceolate or ovate-orbicular, oblong-lanceolate, 29–88 × 18–59 mm, smooth to coriaceous, base cuneate to obtuse or round, margin entire or slightly sinuate-undulate, opaque or hyaline, apex acuminate, apiculate or aristate; venation pinnate, often obscure, sometimes with both central and secondary veins conspicuous. Inflorescences axillary and/or terminal, 1 per axil, raceme, sometimes axillary leaves fall giving the impression of a panicle, 18–60(–85) mm long, epidermis not peeling; flowers grouped in pedunculate triads; peduncle 3–9 mm long, triads 3–7 pairs per inflorescence; bracteoles unequal (medial longer than the laterals), scale-like, acute. Floral buds clavate, straight, round. Flowers 5–8 mm long, sessile, unisexual, hexamerous; petals white; stamens dimorphic, filaments filiform, anthers dorsifixed, apiculate in staminate flowers, staminodia ovate-cordate, narrow or acute in pistillate flowers; style thick, stigma capitate in pistillate flowers, filiform in staminate flowers, stigma capitate, globose, papillate Fruit 9–11 × 5–6.5 mm, ellipsoid, orange or red, becoming atro-vinaceous when totally ripe.

Selected material: Aiuaba, Estação Ecológica de Aiuaba, 8.X.2013, fl., *M.I.B. Loiola & F.A.L. Magalhães 2162* (EAC). Aratanha, Sítio Chaves, 15.X.1978, fl., *A. Fernandes* (EAC 4160). Baturité, Sítio Taveira, 27.IV.2005, fr., *V. Gomes & A. Xavier* (EAC 52261).

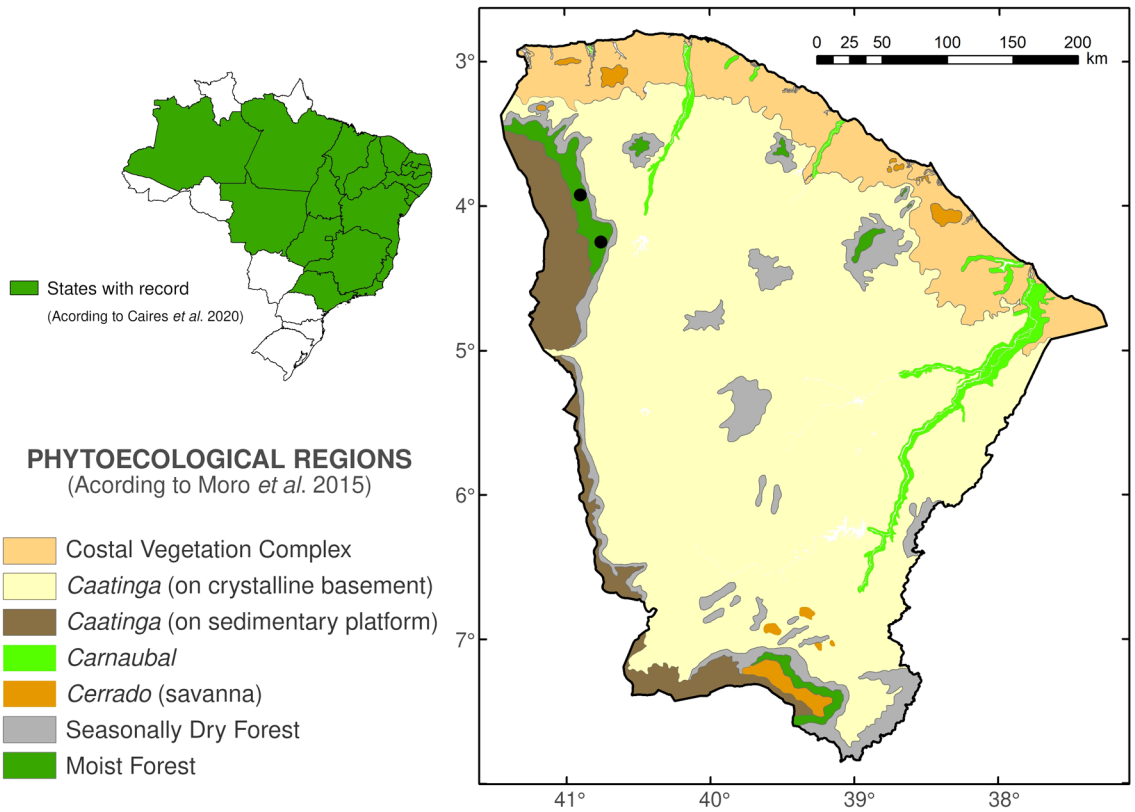

Figure 9 – Geographic distribution of *Struthanthus marginatus*.

Cascavel, estrada da Caponga, 26.X.1992, fl., *F.S. de Araújo* (EAC 21916). Cratéus, RPPN Serra das Almas, 18.VII.2001, fr., *M.S. Sobrinho & M.M.A. Bruno 247* (EAC). Crato, Flona do Araripe, 20.II.2000, fr. *L.W. Lima-Verde 2363* (EAC). Fortaleza, Campus do Itaperi (Universidade Estadual do Ceará), 3.VIII.2018, fr. *E.M.P. Lucena et al. 182* (EAC); Campus do Pici (estacionamento da Química), 24.IV.2019, fl., *M.O.T. Menezes 401* (EAC); Parque Estadual do Cocó, 13.XII.2019, fl., *F.F.S. Lopes & S.M. Morais* (EAC 64240); Praça da Gentilândia, 17.XII.2018, fl., *P.L.R. Alencar 1* (EAC); 27.II.2019, fr., *M.O.T. Menezes 398* (EAC). Granjeiro, 25.III.1936, fl., *P. Luetzelburg 25853* (EAC, IPA). Guaramiranga, Sítio Mont'Rey, 14.XI.2012, fl. and fr., *I.R. Coriolano & B.L.M. Almeida 7* (EAC). Icapuí, APA da Redonda, 9.VIII.2000, fl., *R.S. Oliveira* (EAC 30401). Ipú, road Tianguá-Crateús, between Guaraciaba do Norte and Ipú, 04°15'S, 40°45'W, 11.XII.1986, fr., *J. Jangoux et al. 1834* (K, NY). Meruoca, Sítio Santo Antonio, 5.IX.1995, fr., *A. Fernandes* (EAC 13609). Pacajus, Aldeia, Sítio Pacoti, 18.I.1998, fl., *E.B. Souza* (EAC 23373). Penaforte, 30.X.2009, fl., *J.R. Maciel & L.S.P. Souza 1357* (UB). Santana do Cariri, APA da Chapada do Araripe, Cancelão, 07°12'35"S, 39°35'24"W, 27.X.2010, fl., *I.M. de Andrade 4045* (HUEFS). Tauá, Tecelão, bacia do Rio Carrapateira, 22.VII.2014, fl., *R.C. Gomes* (EAC 57381). Ubajara, PARNA Ubajara, sede, 21.I.1999, fr., *A. Fernandes et al.* (EAC 27959). Cariri cearense, 25.III.1936, fl., *P. Luetzelburg 26351* (EAC).

The main diagnostic trait for this species within the genus is the dimorphism of the bracteoles (Fig. 3c). Vegetative samples may morphologically resemble *Passovia pedunculata* but differ due to the stamens (Fig. 2g-h) and the shape of the floral buds (Fig. 3g-h).

In Ceará, *S. syringifolius* is very widespread and abundant. As *S. polyrrhizus*, it occurs in a range of environmental conditions all over the state - Fig. 11. It is frequently found in urban vegetation, mainly on cultivated trees like *Mangifera indica* L. and *Terminalia catappa* L. (M.O.T. Menezes, personal communication). It occurs inside the following protected areas: Estação Ecológica de Aiuaba, APA da Redonda, RPPN Serra das Almas, Parque Nacional de Ubajara, Parque Estadual do Cocó, FLONA do Araripe, and APA da Chapada do Araripe.

The species was collected with flowers and fruits all year long.

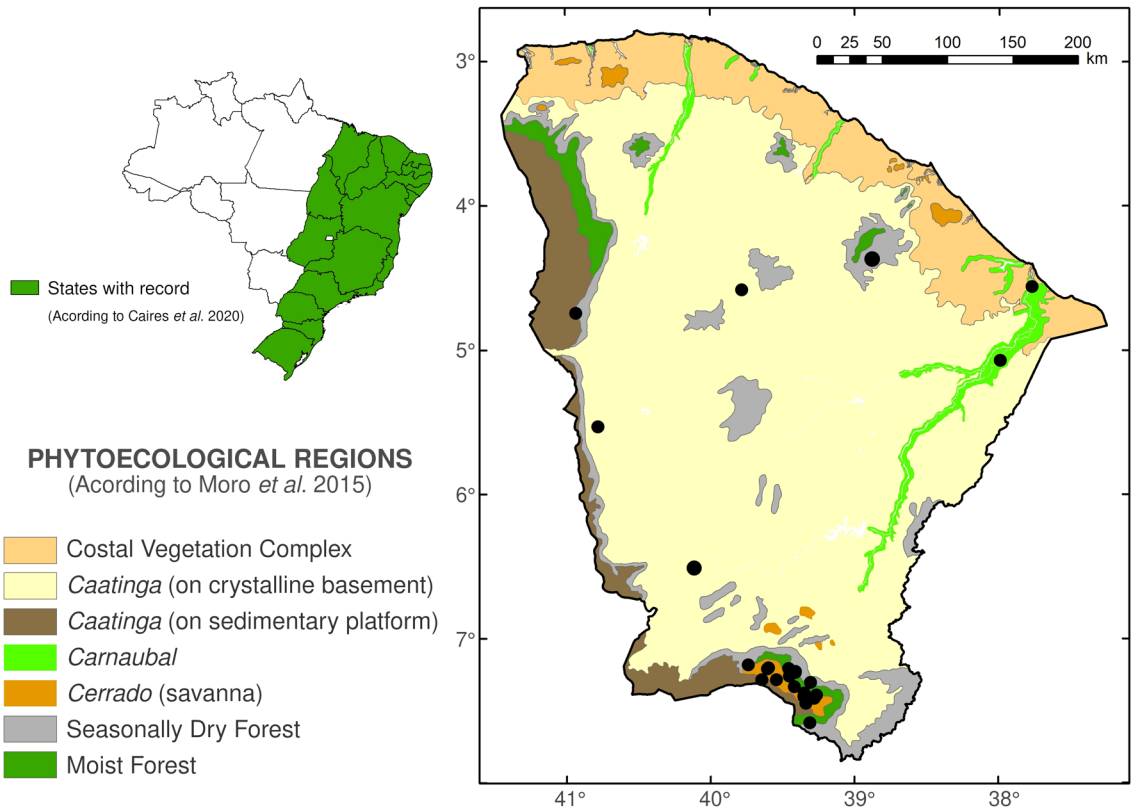

Figure 10 – Geographic distribution of *Struthanthus polyrrhizus*.

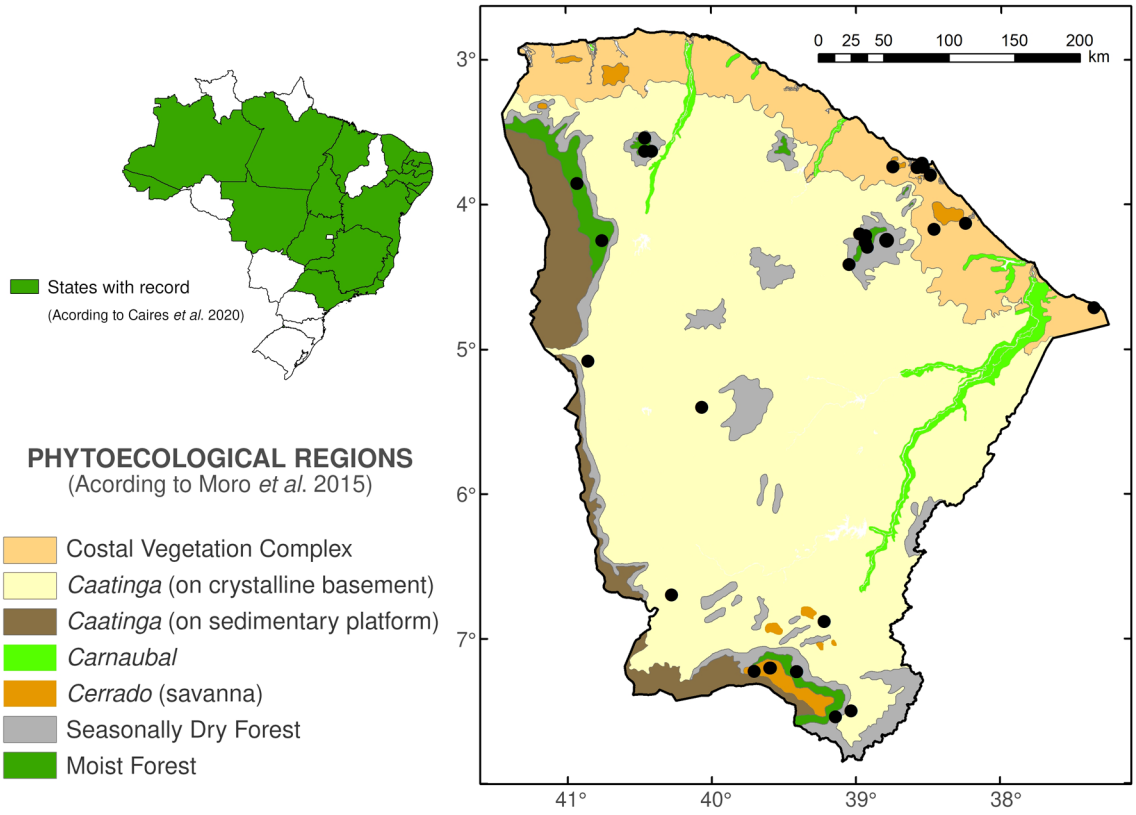

Figure 11 – Geographic distribution of *Struthanthus syringifolius*.

Supplementary data

To access the spreadsheet with all specimens gathered and the shapefile with the distribution of the species to be plotted in a GIS, please download the files at <http://doi.org/10.6084/m9.figshare.14192102>.

Acknowledgements

The authors are grateful to Eimear N. Lughada; Frederico Fabriani; Marie-Helene Weech (K); Jovita C. Yesilyurt (BM); Elnatan B. Souza (HUVA); Maria Arlene Pessoa da Silva; Luciana Silva Cordeiro; Graciele Sampaio (HCDAL); Ângela Maria Miranda (HST); Taís Rocha; José Alves de Siqueira-Filho (HVASF); Sheila Garcia (HPL); and James C. Solomon (MO). MIBL thanks CNPq, for the productivity grant (Process No. 308685/2020-2).

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Area Editor: Dra. Marli Morim
Received in July 21, 2021. Accepted in November 18, 2021.