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FLÁVIO SOUSA SOUTO

SENNA SER. *BACILLARES* (BENTH.) H.S.IRWIN & BARNEBY (LEGUMINOSAE, CAESALPINIOIDEAE) NA MATA ATLÂNTICA AO NORTE DO RIO SÃO FRANCISCO: taxonomia e anatomia foliar

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Área de concentração: Sistemática e Evolução

Orientadora: Profª. Drª. Maria de Fátima Agra

Coorientador: Prof. Dr. Rubens Teixeira de Queiroz

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Aos meus pais, Francisco e Maria, dedico!

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RESUMO

Senna Mill. (Leguminosae) é um gênero monofilético, compreendendo 300-330 espécies com distribuição na região Neotropical e algumas espécies ocorrendo na África, Ásia e Austrália. O gênero foi dividido infragenericamente em seis seções e 35 series, baseadas em caracteres morfológicos. Destes, *Senna* ser. *Bacillares* se destaca com cerca de 50 espécies, com 23 ocorrendo no Brasil. As espécies da série são reconhecidas por suas folhas tetrafolioladas, nectários extraflorais interfolíolares, e legume bacóide, internamente polpudo. *Senna* ocorre em todos os domínios biogeográficos e formações vegetacionais do Brasil, porém é na Mata Atlântica sua maior riqueza de espécies. Neste trabalho foi ralizado um estudo taxonômico e anatômico das espécies de *Senna* ser. *Bacillares* (Leguminosae) da Mata Atlântica ao norte do Rio São Francisco, buscando caracteres morfo-anatômicos para subsidiar a taxonomia da série *Bacillares*. Os estudos taxonômicos revelaram a ocorrência de dez espécies de *Senna* ser. *Bacillares* para a área de estudo. Destas, uma nova espécie, *Senna pluribracteata*, foi descrita para o Estado da Paraíba, e dois novos registros para a área, sendo *S. angulata* var. *miscadena* para a Paraíba, e *S. georgica* var. *georgica* para o Rio Grande do Norte, enquanto *S. rizzinii* e *S. rugosa* são novas ocorrências para a Mata Atlântica. Os estudos anatômicos revelaram alguns caracteres comuns à todas as espécies estudadas, como folíolos hipoestomáticos, estômatos anomocíticos e paracíticos, epiderme e parênquima paliçádico unisseriados, mesofilo dorsiventral, nervura plano-convexa, e sistema vascular colateral. Além disso, alguns caracteres apresentaram significância taxonômica para distinguir as espécies da série *Bacillares*. Dentre estes, destacam- se a epiderme foliolar e seus anexos, a morfologia dos tricomas e ceras epicuticulares, juntamente com o formato do bordo foliolar, contornos dos pecíolos e da raque foliar, e o número de feixes vasculares centrais e acessórios. Este trabalho não só contribuiu para ampliar o número de espécies circunscritas para a área, como também enfatizou a importância da anatomia foliar como uma ferramenta adicional para a taxonomia da série *Bacillares*, e também para o gênero *Senna*.

Palavras-chave: Anatomia foliar. *Cassia*. Fabaceae. Mata Atlântica. *Senna* sect. *Chamaefistula*.

ABSTRACT

Senna Mill. (Leguminosae) is a monophyletic genus, comprising 300-330 species with distribution in the Neotropical region and some species occurring in Africa, Asia and Australia. The genus has been divided in six sections and 35 series, based on morphological characters. Of these, *Senna* ser. *Bacillares* stands out with about 50 species, with 23 species occuring in Brazil. Species of the series are recognized by their tetrafoliolate leaves, extrafloral nectaries interfliolar, and bacoid legume, internally pulpy. *Senna* occurs in all biogeographic domains and vegetation formations in Brazil, but it is in the Atlantic Forest its greater species richness. In this work wes performed taxonomic and anatomical studies of species of *Senna* ser. *Bacillares* (Leguminosae) of the Atlantic Forest north of the São Francisco River, searching for morpho-anatomical characters to support the taxonomy of the series *Bacillares*. Taxonomic studies revealed the occurrence of ten species of *Senna* ser. *Bacillares* in the study area. Of these, a new species, *Senna pluribracteata*, was described for the Paraíba State, and two new records for the area, being *S. angulata* var. *miscadena* for Paraíba, *S. georgica* var. *georgica* for Rio Grande do Norte, while *S. rizzinii* and *S. rugosa* are new occurrences for the Atlantic Forest. Anatomical studies revealed some characteristics common to all studied species, such as hypostomatic leaflets, anomocytic and paracytic stomata, epidermis and palisade parenchyma uniseriate, dorsiventral mesophyll, plane-convex midrib, and collateral vascular system. In addition, some characters showed taxonomic significance for distinguish the species of the series *Bacillares*. Among these, stand out the leaflet epidermis and their appendages, the morphology of the trichomes and epicuticular waxes, together with the shape of the leaflet edges, the contour of the petioles and the leaf rachis, as well as the number of central and accessories vascular bundles. This work not only contributed to increase the number of circumscribed species for the area, but also emphasized the importance of leaf anatomy as an additional tool for the taxonomy of the series *Bacillares*, and also for the genus *Senna*.

Keywords: Atlantic Forest. *Cassia*. Fabaceae. Leaf anatomy. *Senna* sect. *Chamaefistula*.

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1 INTRODUÇÃO

A Mata Atlântica compreende um dos 34 *hotspots* de biodiversidade do mundo, sendo formada por diversos ecossistemas, tais como as faixas litorâneas do Atlântico, florestas de baixada e encosta da serra do mar, e as florestas interioranas, incluindo os brejos de altitude. Atualmente, compreende uma área de aproximadamente 91,930 km² distribuídos em fragmentos ao longo da costa litorânea do Ceará ao Rio Grande do Sul, além dos estados de Minas Gerais e Mato Grosso do Sul. No nordeste do Brasil, a Mata Atlântica ao Norte do Rio São Francisco compreende os trechos do bioma localizados entre o Rio Grande do Norte e Alagoas.

No Brasil, o gênero *Senna* Mill. (Leguminosae, Caesalpinioideae) pode ser encontrado nos diferentes biomas e formações vegetacionais do país, entretanto, é na Mata Atlântica que o gênero tem sua maior riqueza relativa de espécies. *Senna* é um gênero taxonomicamente bastante complexo, sendo reconhecidas seis seções e 35 series, dentre as quais *Senna* sect. *Chamaefistula* (DC. ex Collad.) H.S. Irwin & Barneby é a mais diversa. Compreende cerca de 144 espécies subordinadads a 21 séries, com grande diversidade morfológica. A série *Bacillares* (Benth.) H.S. Irwin & Barneby é a mais diversa desta seção, apresentando espécies com grandes semelhanças morfológicas.

Neste trabalho foi realizado um estudo taxonômico e anatômico das espécies de *Senna* ser. *Bacillares* (Leguminosae, Caesalpinioideae) na Mata Atlântica ao Norte do Rio São Francisco, buscando determinar caracteres morfo-anatômicos que forneçam subsídios à taxonomia do grupo, além de contribui para o conhecimento da diversidade e distribuição de suas espécies. A dissertação encontra-se organizada da seguinte forma:

Fundamentação teórica: Discute-se a área de estudo de forma suscinta, caracterizando sua distribuição, fitofisionomia e centros de endemismos. Apresenta-se uma introdução a família Leguminosae e sua atual classificação subfamiliar. Um histórico de classificação e circunscrição para o gênero *Senna* e também para a sect. *Chamaefistula* ser. *Bacillares*, além de dados de distribuição e diversidade do grupo. Adicionalmente são apresentados estudos taxonômicos, florísticos, anatômicos, citogenéticos e evolutivos para *Senna*.

Capítulo I: Uma nova espécie de *Senna* ser. *Bacillares* foi descrita e ilustrada para Mata Atlântica Paraibana, incluindo informações de distribuição, fenologia, status de conservação, e uma chave analítica para a identificação das espécies ocorrentes no estado da Paraíba e notas da anatomia foliar, como também suas afinidades interespecíficas são discutidas. O manuscrito

obtido a partir deste capitulo foi intitulado: *Senna pluribracteata* (Leguminosae, Caesalpinioideae), a New Species from Paraíba State, Brazil, with Notes on Leaf Anatomy, manuscrito atualmente aceito e no prelo na Systematic Botany (anexo II).

Capítulo II: Estudo taxonômico das espécies do gênero *Senna* ser. *Bacillares* encontradas na Mata Atlântica ao norte do rio São Francisco, com chaves de identificação, descrições, comentários taxonômicos, status de conservação, dados fenológicos e de distribuição, incluindo mapas, e ilustrações. Este capítulo originou o manuscrito intitulado: *Senna* ser. *Bacillares* (Leguminosae, Caesalpinioideae) in the Atlantic Forest north of the São Francisco River, Brazil.

Capítulo III: Estudo anatômico foliar de dez espécies *Senna* ser. *Bacillares*, com morfodiagnoses microscópicas foliares (lâmina foliolar, pecíolo e raque) que contribuam para sua caracterização e identificação, que originou o manuscrito intitulado: Leaf Anatomy of Ten Species of *Senna* series *Bacillares* and their Taxonomic Significance.

2 FUNDAMENTAÇÃO TEÓRICA

2.1 A Mata Atlântica ao norte do Rio São Francisco

A Mata Atlântica é considerada um dos 34 *hotspots* de biodiversidade do mundo, abrigando uma biota insuficientemente conhecida e bastante ameaçada por ações antrópicas (MYERS et al., 2000). Originalmente compreendia uma área de aproximadamente 1.227.600 km², entretanto, devido a sua exploração irracional restam apenas cerca de 7,5% de sua cobertura, distribuída em fragmentos ao longo da costa litorânea do Ceará ao Rio Grande do Sul, além dos estados de Minas Gerais e Mato Grosso do Sul (MYERS et al., 2000; STEHMANN, 2009).

A Mata Atlântica abrange litologias do embasamento Pré-Cambriano, sedimentos da Bacia do Paraná e do Cenozoico (IESB, 2007), sendo formada por diversos ecossistemas, tais como as faixas litorâneas do Atlântico, florestas de baixada e encosta da serra do mar, e as florestas interioranas, incluindo os brejos de altitude (CAMPANILI; PROCHNOW, 2006). Apesar de estar muito fragmentada, a Mata Atlântica abriga uma alta taxa de endemismo, com cerca de 9.000 mil espécies endêmicas das mais de 15.000 conhecidas. Representa uma parcela significativa da biodiversidade do Brasil, sendo considerada uma área prioritária para conservação (MYERS et al., 2000; FLORA DO BRASIL 2020). Tal riqueza biológica pode ser explicada pelas variações ocorrentes no relevo, índices pluviométricos e nas diferentes formações vegetacionais da qual é composta (CAMPANILI; PROCHNOW, 2006; STEHMANN, 2009).

Na região Nordeste do país, a Mata Atlântica abrange áreas descontínuas sobre chapadas, serras, dunas e vales. Nesta região são encontrados quatro dos cinco centros de endemismo do bioma no Brasil, em termos biogeográficos, dos quais a Mata Atlântica ao norte do Rio São Francisco engloba os centros “Pernambuco” e “Brejos Nordestinos”, compreendendo os trechos do bioma localizados entre o Rio Grande do Norte e Alagoas. Esta área é formada por remanescentes que correspondem a aproximadamente 4% da cobertura original, sendo sua fisionomia constituída por Floresta Ombrófila Densa e Floresta Estacional Semidecidual (TABARELLI; SIQUEIRA FILHO; SANTOS, 2006; TABARELLI et al., 2006). Tais complexos vegetacionais são fortemente influenciados pela Floresta Amazônica e pela Mata Atlântica das regiões Sudeste e Sul (VELOSO; RANGEL-FILHO; LIMA, 1991; TABARELLI; SANTOS, 2004).

Na porção ao norte do São Francisco, o bioma encontra-se fragmentado em pequenos trechos de vegetação nativa, acarretando isolamento de populações e, consequentemente, a extinção de espécies (RANTA et al., 1998; TABARELLI; SIQUEIRA FILHO; SANTOS, 2006;). Neste estudo, considera-se que os brejos de altitude compreendem uma formação vegetacional inclusa no bioma Mata Atlântica. Segundo Andrade Lima (2007), os brejos de altitude ou matas serranas compreendem disjunções da Mata Atlântica dentro da Caatinga, associado a áreas serranas com altitudes superiores a 500 metros.

2.2 A família Leguminosae

Leguminosae Juss. está entre as famílias com mais rápida diversificação dentre as Angiospermas, tendo origem, provavelmente no Paleoceno, há cerca de 65 milhões de anos, e em pouco tempo todas as suas principais linhagens foram originadas (MARAZZI; SANDERSON, 2010). Atualmente, a família encontra-se bem delimitada em termos taxonômicos, compreendendo 770 gêneros e 19.500 espécies com distribuição cosmopolita, sendo mais diversas nas regiões tropicais e subtropicais, menos frequentemente nas regiões temperadas, árticas, alpinas e no sub-bosque de florestas temperadas (WOJCIECHOWSKI; LAVIN; SANDERSON, 2004; LEWIS et al., 2005; LPWG, 2017). No Brasil ocorrem cerca de 229 gêneros e 2.935 espécies, presentes em todos os domínios fitogeográficos e formações naturais (FLORA DO BRASIL, 2020). É uma família de grande valor econômico, cujas espécies são empregadas na alimentação, industria madeireira, oleífera e medicinal, e ainda utilizadas na ornamentação urbana (FRANCINO, 2006). Ecologicamente, algumas de suas linhagens apresentam raízes com nodosidades, apresentando simbiose com bactérias fixadoras de nitrogênio atmosférico (COSTA et al., 2002).

Tradicionalmente, Leguminosae era subdivida em três subfamílias: Caesalpinioideae DC., Mimosoideae DC. e Papilionoideae DC. (BENTHAM, 1870; LEWIS et al., 2005). Entretanto, Cronquist (1981) elevou o status dessas três subfamílias ao nível de famílias, todas pertencentes à ordem Fabales. Porém tal circunscrição não foi apoiada pelos estudos filogenéticos, uma vez que Leguminosae é um grupo claramente monofilético (KASS; WINK, 1996; DOYLE et al., 2000; WOJCIECHOWSKI; LAVIN; SANDERSON, 2004), corroborando, ainda, com estudos mais recentes desenvolvidos pelo LPWG (2017).

A análise do gene plastidial matK realizada por Wojciechowski, Lavin e Sanderson (2004), apoiou o monofiletismo de Papilionoideae e Mimosoideae, sendo Caesalpinioideae parafilética. Tais observações, corroboram com os estudos desenvolvidos pelo LPWG (2013), que não apoiou o tratamento de Leguminosae dividida em três subfamílias e 42 tribos,

principalmente com as suas relações intrafamiliares. Recentemente, o LPWG (2017) estabeleceu uma nova classificação intrafamiliar para o grupo, onde são reconhecidas seis subfamílias monofiléticas, fortemente sustentadas: Caesalpinioideae DC. (que inclui o Clado Mimosoideae), Cercidoideae LPWG, Detarioideae Burmeist., Dialioideae LPWG, Duparquetioideae LPWG e Papilionoideae DC.

Caesalpinioideae circunscreve 148 gêneros e 4.400 espécies com distribuição Pantropical, estendendo-se desde as regiões secas e úmidas até as zonas temperadas (LPWG, 2017). Anteriormente a subfamília compreendia cinco tribos (Caesalpinieae, Cassieae, Cercideae, Detarieae e Amherstieae), que gerava problemas filogenéticos devido à sua ampla diversidade de morfologia floral (BRUNEAU et al., 2001). Na subfamília Caesalpinioideae, o gênero *Senna* é um dos mais representativos, com ampla distribuição na região Neotropical, cujas espécies ocupam diferentes habitats e formações vegetacionais, além de exibir uma grande variedade morfológica (IRWIN; BARNEBY, 1982).

2.3 Histórico de *Senna* Mill. e *Senna* ser. *Bacillares* (Benth.) H.S.Irwin & Barneby

O gênero *Senna* originou-se, provavelmente, no início do Eoceno, há 50 milhões de anos, com seus principais clados surgindo até o início do Oligoceno, onde começaram a se diversificar até o início do Mioceno. Um grupo pequeno de espécies sem nectários extraflorais (NEFs) apresentou uma taxa de diversificação menor, enquanto um grupo mais rico com NEFs (incluindo a seção *Chamaefistula*), com aproximadamente 257 espécies, embora mais jovem a diversificação neste grupo se deu de forma mais rápida (MARAZZI; SANDERSON, 2010).

A história taxonômica de *Senna* está diretamente relacionada ao gênero *Cassia* L., que foi tratado por muitos anos como uma seção ou subgênero de *Cassia* (LINNAEUS, 1753; MILLER, 1754, 1764; PERSON, 1805; COLLADON, 1816; DE CANDOLLE, 1825; VOGEL, 1837; BENTHAM 1870, 1871). O gênero *Cassia* foi estabelecido por Linnaeus (1753), compreendendo 26 espécies, que foram diferenciadas por caracteres relacionados às folhas (folíolos, estípulas e nectários extraflorais).

Miller (1754) propôs o gênero *Senna* com base nas diferenças da morfologia floral e do fruto de *Cassia senso lato*. *Senna* teve como espécie-tipo *Senna alexandrina* Mill., cuja circunscrição foi ampliada com a descrição de mais uma espécie para o gênero: *Senna italica* Mill.

O conceito de *Senna* proposto por Miller (1754) foi questionado por vários especialistas que reconheceram *Cassia*, proposto por Linnaeus (1753). Person (1805) referiu 70 espécies

para *Cassia*, sem classificação infragenérica definida, e também estabeleceu o gênero *Cathartocarpus*, com base em cinco espécies antes circunscritas em *Cassia*. Posteriormente, Colladon (1816) citou 125 espécies para *Cassia*, agrupadas em oito seções: *Absus*, *Baseophyllum*, *Chamaecrista*, *Chamaefistula*, *Chamaesenna*, *Fistula*, *Herpetica* e *Senna*. A circunscrição de *Cassia* foi ampliada por De Candolle (1825), que agrupou 211 espécies nas oito seções citadas por Colladon (1816).

Posteriormente, Vogel (1837) referiu 278 espécies para *Cassia*, subordinadas a sete seções: *Chamaefistula*, *Chamaesenna*, *Fistula*, *Lasiorhegma*, *Prososperma*, *Psilorhegma* e *Senna*. Bentham (1870) reconheceu 189 espécies de *Cassia*, arranjadas em três subgêneros e oito seções: *Fistula* Benth (sect. típica), *Lasiorhegma* Benth. (sect. *Absus*, *Apoucoita* e *Chamaecrista*), e *Senna* Benth. (sect. *Chamaefistula*, *Chamaesenna*, *Oncolobium* e *Pososperma*). Bentham (1871) ampliou a circunscrição de *Cassia* para 338 espécies, agrupadas nos mesmos subgêneros e seções propostas em 1870. Além disso, reestabeleceu a seção *Psilorhegma*, proposta por Vogel (1837), subordinada a *Cassia* subg. *Senna*.

Irwin e Barneby (1982), observaram a diversidade dos caracteres florais e dos frutos das espécies de *Cassia* senso Linnaeus (1753), e propuseram sua segregação em três gêneros distintos: *Cassia* senso stricto, *Chamaecrista* Moench. e *Senna*, ambos pertencentes à subtribo Cassiinae. Estudos mais recentes sustentam a segregação de *Cassia* senso stricto, *Chamaecrista* e *Senna* (ACHARYA; MUKHERJEE; PANDA, 2011; TRIPATHI; GOSWAMI, 2011). Estudos filogenéticos desenvolvidos por Doyle et al. (1997) apontam *Chamaecrista* como grupo irmão de *Senna*, que poderiam ter divergido há cerca de 49,14 milhões de anos. Em contrapartida, as filogenias de Bruneau et al. (2001, 2008) e Marazzi et al. (2006) sugerem *Cassia* e *Senna* como grupos irmãos.

Na revisão taxonômica de Irwin e Barneby (1982), S*enna* compreendia 202 espécies agrupadas em seis seções: *Psilorhegma* (Vogel) H.S. Irwin & Barneby (2 spp.), *Chamaefistula* (DC. ex Collad.) H.S. Irwin & Barneby (144 spp.), *Senna* Mill. (12 spp.), *Peiranisia* (Raf.) H.S. Irwin & Barneby (42 spp.), *Paradyction* H.S. Irwin & Barneby (1 sp.) e *Astroites* H.S. Irwin & Barneby (1 sp.), e 35 series. Estudos filogenéticos realizados por Bruneau et al. (2001, 2008) e Marazzi et al. (2006) apontam *Senna* como monofilético. Todavia, das seções estabelecidas por Irwin e Barneby (1982), apenas *Psilorhegma* é suportada como monofilética, enquanto as seções *Chamaefistula*, *Peiranisia* e *Senna* foram parafiléticas. As seções monoespecificas *Aistroites* e *Paradictyon* aparecem incorporadas às seções *Chamaefistula* e *Senna*, respectivamente (MARAZZI et al., 2006).

Senna, atualmente, compreende 300-330 espécies, distribuídas principalmente nas Américas e menos frequentemente na Austrália, África e Austrália (QUEIROZ, 2009; MARAZZI; SANDERSON, 2010). O gênero está representado no Brasil por cerca de 81 espécies das quais 30 são endêmicas, ocorrentes em todos os domínios fitogeográficos e formações naturais (SOUZA; BORTOLUZZI, 2020). Seus táxons são facilmente reconhecidos pelas folhas com dois a muitos pares de folíolos, comumente com nectários extraflorais no pecíolo ou na raque foliar, flores relativamente grandes, com pétalas amarelas, ausência de bractéolas, androceu com 10 estames, sendo 6-7 férteis e 3 estaminódios, anteras poricidas, e frutos deiscentes ou não, com sementes distribuídas em uma ou duas series (IRWIN; BARNEBY, 1982; QUEIROZ, 2009).

Dentre as seções estabelecidas por Irwin e Barneby (1982), *Senna* sect. *Chamaefistula* compreende cerca de 144 espécies com ampla distribuição na região tropical e poucos táxons com ocorrência mais ao norte ou mais ao sul, em zonas temperadas quentes. As espécies desta seção são caracterizadas por possuírem glândulas peciolares presentes ou ausentes, androceu constituído por três estaminódios e sete ou raramente menos estames férteis, sendo dois estames longos, opostos à pétala central-adaxial, um estame central e quatro medianos e, frutos plano-compressos, angulares ou turgidos (IRWIN; BARNEBY, 1982).

Devido a sua complexidade, *Senna* sect. *Chamaefistula* foi dividida por Irwin e Barneby (1982) em 21 séries, dentre as quais *Senna* ser. *Bacillares* (Benth.) H.S. Irwin & Barneby circunscreve aproximadamente 50 espécies, com ampla diversidade nas Américas, em áreas tropicais e subtropicais, ocorrendo em diferentes habitats, com algumas espécies exibindo uma ampla variedade morfológica (IRWIN; BARNEBY 1982). *Senna* ser. *Bacillares* está representada no Brasil por cerca de 23 espécies, das quais 7 são endêmicas (SOUZA; BORTOLUZZI, 2020), e é considerada por Marazzi et al. (2006) como um grupo monofilético.

A série *Bacillares* foi citada pela primeira vez por Bentham (1870), correspondendo a uma serie da sect. *Chamaefistula* (*Cassia* subg. *Senna*), compreendendo oito espécies. Bentham (1871) ampliou a circunscrição, citando 25 espécies para a série *Bacillares*. Segundo Irwin e Barneby (1982), as espécies desta série são caracterizadas por possuirem folhas tetrafolioladas com nectários extraflorais intefolialares, combinada com um legume bacóide, internamente polpudo, e sementes orientadas transversalmente e dispostas lateralmente aos septos.

Espécies de *Senna* são empregadas na etnomedicina em várias partes do mundo, sendo as folhas, flores e caule utilizados no tratamento da gripe, sinusite, bronquite, resfriado,

rouquidão, dor de garganta e cabeça, reumatismo, cicatrização, inflamações, laxante e distúrbios gastrointestinais (RODRIGUES; CARVALHO, 2001; ALBUQUERQUE et al., 2007; AGRA et al., 2008; CARTAXO; SOUZA; ALBUQUERQUE, 2010; TRENTIN et al., 2011; TANGJITMAN et al., 2015; XAVIER; MOLINA, 2016). *Senna splendida* (Vogel) H.S. Irwin & Barneby, por exemplo, é empregada no tratamento de infecções renais e diarreia (ALMEIDA et al., 2005), enquanto *S. alexandrina* é utilizada no tratamento da gripe (CARTAXO; SOUZA; ALBUQUERQUE, 2010). Além disso, algumas espécies apresentam potencial forrageiro, como *S. macranthera* (DC. ex Collad.) H.S. Irwin & Barneby e *S. spectabilis* (DC.) H.S. Irwin & Barneby, empregadas na alimentação de bovinos e caprinos (LOIOLA et al., 2010), esta última espécie pode ser utilizada, ainda, em reflorestamentos, pois, assim como muitas Leguminosae, apresentam raízes com nódulos simbiônticos portando bactérias fixadoras de nitrogênio atmosférico (QUEIROZ, 2009).

O conhecimento taxonômico de *Senna* no Brasil é escasso, restrito a estudos regionais e/ou locais, o que evidencia a necessidade de esforços adicionais para coletas, estudos de campo, e uma revisão das espécies depositadas nos herbários nacionais, especialmente, nos regionais para um maior conhecimento de sua diversidade e distribuição no país. Dentre os estudos locais e/ou regionais, destacam-se os de Ducke (1953) para a Paraíba e Pernambuco; Lewis (1987) para a Bahia; Lima (1999) para Pernambuco; Rodrigues et al. (2005), no Rio Grande do Sul; Bortoluzzi, Miotto e Reis (2007), em Santa Catarina; Queiroz (2009) para as espécies da Caatinga; Dantas e Silva (2013) para a Serra Dourada, Goiás; Souza e Silva (2016) para a Floresta Nacional de Silvânia, Goiás; Azevedo e Conceição (2017) para Serra Geral de Licínio de Almeida, Bahia; Correia e Conceição (2017) na Estação Ecológica Raso da Catarina, Bahia; Santos, Souza e Silva (2017) para o estado de Goiás; Oliveira (2017) em Minas Gerais; Silva, Santos e Souza (2018) para a região Centro-Oeste; Santos et al. (2020) para o município de Caetité na Bahia.

2.4 Anatomia como suporte a taxonomia

Numerosos caracteres anatômicos têm apresentado valor sistemático em diferentes táxons, referindo como exemplos, características da epiderme e seus anexos, como os tipos de tricomas e estômatos, além de caracteres do mesofilo (tipos, formas das células, números de camadas), presença de estruturas secretoras e idioblastos cristalíferos, padrões de venação e arranjos do sistema vascular nas folhas e pecíolo (DICKINSON, 2000).

A utilização da anatomia vegetal em sistemática data de 150 anos e tem sido uma ferramenta útil para apoiar a identificação de táxons (METCALFE; CHALK, 1950). Segundo Judd et al. (2009), os caracteres anatômicos podem também contribuir para se propor hipóteses de relações filogenéticas, principalmente os observados em órgãos vegetativos, tais como as folhas, que são anatomicamente variáveis, podendo apresentar padrões específicos para seções, gêneros ou até mesmo família.

Diversos grupos de plantas evoluíram em resposta paralela a um determinado fator ambiental, apresentando caracteres morfológicos semelhantes. Nestes casos a anatomia contribui com a taxonomia destes grupos, uma vez que caracteres anatômicos diagnósticos de uma determinada família são retidos ao longo da evolução e podem ser aplicados para resolver afinidades taxonômicas (CUTLER et al., 2007). Desta forma, a anatomia vegetal tem se revelado como uma importante ferramenta para a taxonomia de Angiospermas, principalmente se as espécies estudadas não estiverem férteis no período da coleta (METCALFE; CHALK, 1950; JUDD et al., 2009; DICKINSON, 2000). Em Leguminosae, devido à sua grande plasticidade morfológica, estudos anatômicos de órgãos vegetativos podem ser utilizados para diferenciar espécies e gêneros, quando os caracteres vegetativos e reprodutivos são indistinguíveis, servindo de subsídio à taxonomia do grupo.

Os estudos de anatomia foliar em *Senna* (*Cassia*) são escassos e pontuais, destacando-se: Kotresha e Seetharam (2000) que realizaram um estudo das epidermes de 19 espécies de *Cassia* da Índia. Pascal, Motte-Florac e McKey (2000), e Melo, Machado e Alves (2010) realizaram estudos anatômicos dos nectários extraflorais em espécies de Caesalpinieae e Mimosoideae, respectivamente. Ogundipe, Kadiri e Adekanmbi (2009) estudaram espécies de *Senna* com propriedades medicinais da Nigéria. Rodrigues et al. (2009) e Srinivasan (2018) descreveram a anatomia foliar de *Senna alata*. Saheed e Illoh (2010) estudaram a anatomia de espécies de *Cassia, Chamaecrista* e *Senna* como um suporte à delimitação genérica. Além disso, Nassar, Ramadan e Ibrahim (2013), e Amponsah et al. (2016) estudaram a anatomia dos órgãos vegetativos e reprodutivos de *Senna occidentalis*. A diversidade de estômatos e tricomas de espécies de *Senna* de Bangladesh foi estudada por Begum, Rahman e Begum (2014). Mais recentemente, Souto, Queiroz e Agra (2021) realizaram uma análise comparativa de quatro espécies de *Senna* ser. *Bacillares* como um suporte à taxonomia do grupo, que apoiaram fortemente a proposição de uma nova espécie.

2.5 Outros estudos em *Senna*

Marazzi et al. (2007) investigou os diferentes padrões do androceu e estigma em *Senna* e suas relações com a assimetria floral no gênero, comparando com a análise filogenética de Marazzi et al. (2006), com o intuito de contribuir para o entendimento da diversidade e evolução floral do grupo. Arogundade, Fatunmise e Bernard (2019) ressaltaram a importância taxonômica de estudos palinológicos na distinção de espécies de *Senna* e de *Cassia*. Apenas as espécies de *Senna* estudadas apresentaram grão de pólen mais avançados, como os tipos tetracolpado, pentacolpado e hexacolpado, enquanto as espécies de *Cassia* possuem tipos de pólen primitivos.

Marazzi e Sanderson (2010) relacionam a evolução dos NEFs em *Senna* com as relações mutualísticas com formigas, uma vez que estas já eram abundantes e podem ter pressionado seletivamente as plantas, contribuído para a origem e continua evolução dos NEFs e diversificação do grupo. Segundo Marazzi et al. (2013, 2019), em *Senna*, os NEFs localizados nas folhas possuem uma variedade de formas: globosa, ovoide, piriforme, clavado e oboclavado. Na série *Bacillares*, os NEFs estão localizados exclusivamente no primeiro par de folíolos ou em ambos os pares. Melo et al. (2010) apontam os nectários extraflorais (número, forma e localização) como um caráter de valor taxonômico na diferenciação de espécies de *Senna*.

Estudos citogenéticos em *Senna* mostram que o número cromossômico básico $x = 14$ é predominante nas espécies do gênero (SOUZA; BENKO-ISEPPON, 2004; CORDEIRO; FÉLIX, 2018), porém outros números cromossômicos são observados n = 11, 12, 13, 28 e 56 (Souza; Benko-Iseppon, 2004; Biondo et al., 2005; RESENDE; DAVIDE; TORRES, 2013; RESENDE et al., 2014; CORDEIRO; FÉLIX, 2018). Tais variações no cariótipo sugerem que eventos de poliploidia contribuem para a diversificação e distribuição de *Senna*. Nas espécies de *Senna* ser. *Bacillares*, o número cromossômico básico é $x = 13$, com exceção de *S. rugosa* em que são observados n = 14, 28 e 56 com prevalência de n = 56 (RESENDE; DAVIDE; TORRES, 2013; RESENDE et al., 2014; CORDEIRO; FÉLIX, 2018). Em relação a posição do centrômero no cromossomo, observa-se a predominância de cromossomos metacêntricos e submetacêntricos (SOUZA; BENKO-ISEPPON, 2004; CORDEIRO; FÉLIX, 2018).

Estudos fitoquímicos em espécies de *Senna* revelaram a presença de diversos compostos bioativos como esteroides, flavonoides, lactonas e triterpenos, entretanto antraquinonas e alcaloide são as classes mais comuns nas espécies do gênero (SILVA et al., 2016). Em *Senna*

cana (Nees & Mart.) H.S. Irwin & Barneby e *S. pendula* (Willd.) H.S. Irwin & Barneby, por exemplo, os compostos observados em maior quantidade foram antraquinonas, flavonoides, taninos, triterpenos e xantonas (MONTEIRO et al., 2018). A atividade biológica de espécies de *Senna* vem sendo avaliada, revelando o potencial medicinal destas espécies, por possuírem atividades antioxidante, anticancerígena, e citotóxica (SILVA et al., 2014, 2016; MAIA et al., 2017, 2018a, 2018b).

3 RESULTADOS

3.1 CAPÍTULO I:

Senna pluribracteata (Leguminosae, Caesalpinioideae), a New Species from Paraíba State, Brazil, with Notes on Leaf Anatomy

Aceito e no prelo em *Systematic Botany*

Senna pluribracteata (Leguminosae, Caesalpinioideae), a New Species from Paraíba State, Brazil, with Notes on Leaf Anatomy

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Abstract —A new species of the genus *Senna* from the Atlantic Forest of Paraíba State, Brazil, is described and illustrated based on a field collection, traditional taxonomic methodologies, and the analysis of *Senna* collections at RB and the main herbaria in northeastern Brazil. Morphologically, ***Senna pluribracteata*** is related to a group of four species of *Senna* sect. *Chamaefistula* ser. *Bacillares*: S. *macranthera, S. pinheiroi, S. rizzinii,* and *S. rugosa,* although ***S. pluribracteata*** has a set of distinctive anatomical characters that differentiate it: two extrafloral nectaries between leaflets in the rachis; large and conspicuous elliptic bracts 7.0–9.0 mm long along the inflorescence peduncle; the epidermis on the abaxial surface is conspicuously and compactly papillose; the rounded leaflet margins have palisade parenchyma near the apex; the mesophyll is dorsi-ventral with a single layer of palisade parenchyma, with isodiametric cells occupying approximately 60% of that structure; the petiole has a somewhat pentagonal shape and is planar adaxially; the rachis is obdeltoid and planar adaxially. Leaf anatomical descriptions and a key to identifying the seven species of *Senna* ser. *Bacillares* found in Paraíba State are provided. The morphological and anatomical affinities of ***S. pluribracteata*** and its allied taxa are discussed.

Keywords- Atlantic Forest, *Cassia,* Fabaceae, *Senna* sect. *Chamaefistula, Senna* ser. *Bacillares*.

Senna was proposed by Miller (1754) and is one of the most representative genera in terms of numbers of species of the Leguminosae, subfamily Caesalpinioideae (approximately 300) (Irwin and Barneby 1982; Queiroz 2009). It was previously recognized as a subgenus of *Cassia* L. (Irwin and Turner 1960), but was segregated from *Cassia* by Irwin and Barneby (1982), who divided *Cassia,* sensu

lato, into three distinct genera: *Cassia* (sensu stricto), *Chamaecrista* Moench, and *Senna*.

Approximately 260 species were recognized by Irwin and Barneby (1982) for *Senna*, which were grouped into six sections [*Astroites* H.S.Irwin and Barneby, *Chamaefistula* (DC. ex Collad.) H.S.Irwin and Barneby, *Paradyction* H.S.Irwin and Barneby, *Peiranisia* (Raf.) H.S.Irwin and Barneby, *Psilorhegma* (Vogel) H.S.Irwin and Barneby, and *Senna* Mill.] and 35 series. Among the proposed sections, *Senna* sect. *Chamaefistula* (DC. ex Collad.) H.S.Irwin & Barneby stands out with approximately 140 species with Neotropical distributions, although a few taxa occur in Africa (with nine species) and three in Asia.

Due to its taxonomic complexity, *Senna* sect. *Chamaefistula* was divided by Irwin and Barneby (1982) into 21 series; the series *Bacillares* (Benth.) H.S.Irwin and Barneby comprises approximately 50 species that occur in different habitats, with some species showing significant morphological diversity (Irwin and Barneby 1982), such as *S. macranthera* (DC. ex Collad.) H.S. Irwin and Barneby. The phylogenetic relationships within the genus *Senna* and the series *Bacillares* were investigated by Marazzi et al. (2006) and emerged supported as a monophyletic group.

According to Irwin and Barneby (1982), *Senna* ser. *Bacillares* species are characterized by having leaves with four leaflets, extrafloral nectaries between the leaflets, anthers firm (ordinarily neither crushed nor crumpled by pressure), and a turgid legume, internally pulpy, and pluriovular, with many seeds oriented transversely and laterally facing the septa.

The series is represented in Brazil by approximately 23 species, seven of which are endemic (Souza and Bortoluzzi 2020). Bentham (1870) described eight species currently belonging to the series *Bacillares* in his treatment of *Cassia* subg.

Senna sect. *Chamaefistula,* in the Flora Brasiliensis (*C. acutisepala* Benth., *C. affinis* Benth., *C. bacillaris* L., *C. chrysocarpa* Desv., *C. macrophylla* Kunth, *C. quinquangulata* Rich., *C. viminea* L., and *C. tenuifolia* Vogel).

During field collections, a specimen of the genus *Senna* with a set of distinctive characters was collected in the Atlantic Forest, identified as a new species, and named *Senna pluribracteata*. It is endemic to the Atlantic Forest of Paraíba State. It is morphologically related to four species of *Senna* sect. *Chamaefistula* ser. *Bacillares*: *S. macranthera*, *S. pinheiroi* H.S. Irwin & Barneby, *S. rizzinii* H.S. Irwin and Barneby, and *S. rugosa* (G. Don) H.S. Irwin & Barneby.

In addition to its external morphology, a leaf anatomical study of the new species was performed, as those studies in *Senna* have been found to be important tools for species differentiation, as reported by Kotresha and Seetharam (2000), Ogundipe et al. (2009), Rodrigues et al. (2009), Nassar et al. (2013), Begum et al. (2014), and Srinivasan (2018).

The new species is described and illustrated here, and its distribution, habitat, conservation status, and morphological and anatomical affinities with allied taxa presented.

MATERIALS AND METHODS

Field expeditions were carried out in Atlantic Forest remnants in northeastern Brazil in the states of Alagoas, Paraíba, Pernambuco, and Rio Grande do Norte.

Collections of the new species were obtained according to appropriate methods of plant taxonomy, as described by Bridson and Forman (1992), and were subsequently deposited in the Prof. Geraldo Mariz Herbarium (UFP) at the Federal University of Pernambuco (UFPE), with duplicates deposited at the Herbarium Prof. Lauro Pires Xavier (JPB), at the Federal University of Paraíba (UFPB). The

description of the new taxon was based on studies of exsiccates of our own collections, using the morphological terminologies found in Irwin and Banerby (1982).

For comparative studies of the new species with related taxa, we also analyzed collections held at the EAN, RB, IPA, JPB, MAC, PEUFR, RB, UFP, and UFRN herbaria (acronyms according to Thiers 2020), as well as at the Sérgio Tavares Herbarium (HST) at the Federal Rural University of Pernambuco (UFRPE – not indexed). Morphological features were analyzed using a stereo-microscope (Leica S8AP0, Switzerland) and documented using a digital camera (Leica DFC295 HD).

Leaf samples were collected from the third to fifth nodes of one adult individual of *Senna pluribracteata*. The leaves were fixed in 50% FAA for 48 h, following Johansen (1940), and then preserved in 70% ethanol.

Anatomical paradermic and transverse sections were made using the second leaf blade below the inflorescence of samples of *Senna pluribracteata* (*Souto et al. 188*), and were prepared for optical microscopy by clarifying them in a 2% sodium hypochlorite solution, washing in distilled water, and neutralizing with 1% acetic acid. The paradermic sections of the leaflet blades (both the adaxial and abaxial surfaces) were stained with 0.25% safranin following Franklin (1945). Transverse sections of the leaflets (mesophyll, margin, midrib), petiole, and rachis were stained with an aqueous solution of Safrablue (Kraus and Arduin 1997). All sections were mounted as semi-permanent slides, analyzed, and photo-micrographed using a light microscope (Leica DM750, Switzerland) using a digital camera (Leica ICC50 HD). The terminology used to characterize the mesophyll and epidermal cell walls followed Metcalfe (1979); the stomata classification followed Dilcher (1974); trichomes are in agreement with Theobald et al. (1979).

TAXONOMIC TREATMENT

Senna pluribracteata F.S. Souto & R.T. Queiroz, sp. nov. TYPE: BRAZIL. Paraíba: Municipality of Sapé, RPPN Fazenda Pacatuba, 7º2'6.80" S, 35º 8 '48.60" W, November 22, 2019, fl. and fr., *F.S. Souto et al.* 188 (holotype: UFP!; isotypes: IPA!, JPB!, K!, RB!).

Senna pluribracteata is morphologically distinguished by having strigose branches, leaves with two extrafloral nectaries between pairs of leaflets (occasionally just above the first pair); and elliptic bracts 7.0–9.0 mm long, arranged along the peduncle. It is related to *S. rizzinii*, *S. pinheiroi*, *S. macranthera*, and *S. rugosa*.

Shrub, ca. 1 m tall, upright. **Stems** not very diffuse, branches cylindrical and strigose; stipules 0.8–1.2 cm long, narrowly triangular, strigose. **Leaves** compound, 6.8–7.8 cm long, completely strigose; petiole 1.6–2.6 cm long, pulvinus 2.0–3.0 mm long; rachis 0.9–1.1 cm long; 2 arrows on each pair of leaflets, 2.0–2.2 mm long, subulate; 4 leaflets, subsessile, acute at the apex, oblique at base, slightly revolute along the margins, chartaceous, adaxial surface dark green, opaque, abaxial surface light green, 1st pair 3.2–3.9 × 1.6–1.9 cm, ovate to elliptic, 2nd pair 4.2–5.0 × 1.6–1.9 cm, elliptic; 2 extrafloral nectaries, claviform, stipitate, somewhat orange, pubescent, between the leaflets on the rachis (occasionally just above the first pair), both located on the leaf rachis, facing the abaxial surface of the leaflets, 3.0–4.0 mm long. **Racemes**, 4.1–9.8 cm long, axillary or terminal; peduncle cylindrical, 3.6–8.5 cm long, strigose; flower bud oblong, 1.0–2.2 × 0.6–0.9 cm, rounded at the apex; bracts 7.0–9.0 × 3.0–4.0 mm, elliptic, acuminate at the apex, foliaceous, strigose, arranged in a spiral along the peduncle. **Flowers** 3–6(–8), grouped at the apex of the inflorescence, 3.0–3.2 cm long; pedicel 1.0–1.5 cm long; calyx with 5 sepals, heteromorphic, the two external sepals large, 0.8–0.9 × 0.4–0.5 cm, the three internal

smaller, 0.6–0.7 × 0.3–0.4 cm, oblong, rounded at the apex, yellowish-green, externally strigose, internally glabrous; corolla with 5 petals, isomorphic, 1.8–2.0 × 1.5–2.2 cm, oblong-obovate, obtuse at apex, unguiculate, yellow, internally glabrous, externally strigillose; fertile stamens 7, yellow, glabrous, anthers oblong, apex curved, 2 pores, sparse trichomes near the apex, 1 center-adaxial filament 2.0–3.0 mm long, anther 6.0–7.0 × 2.0–2.5 mm, the 2 latero-abaxial filaments ca. 3.0 mm long, anthers *ca.* 6.0 × 2.0 mm, the 4 median stamen filaments *ca*. 2.0 mm long, anthers 5.0–5.5 × 1.0–1.5 mm, 3 staminodes, 2 mm long, linear; ovary 11–13.0 × 2.0 mm long, stipitate, velutinous; stylus 4.0–5.0 mm long, arched, glabrous; stigma punctiform. **Pod**, 4.8–5.8 × 0.8–1.5 cm, cylindrical, linear, black at maturity, glossy, strigillose, stipitate, the stipite 1.8–2.9 cm long, gray and strigillose; seeds 4.0–5.5 × 3.0–3.5 mm, ovate, blackish, biseriate, glabrous. Figures 1 and 2.

Distribution and Habitat —*Senna pluribracteata* is endemic to northeastern Brazil (Fig. 3). The species is known from only one collection in the Atlantic Forest, in the municipality of Sapé, Paraíba State, Brazil (Fig. 2), in an area of Tabuleiro Forest, at elevations of from 20-200 m a.s.l., on a slightly undulating landscape, with rainfall rates below 2,000 millimeters per year (Rêgo and Hoeflich 2001). Tabuleiro Forests occupy a coastal strip of tertiary deposits at elevations between 20-200 m a.s.l. The canopy layer does not exceed 30 meters in height, with an understory basically composed of young canopy plants (Rizzini 1997).

The Atlantic Forest is considered one of the world's 34 global biodiversity hotspots, which originally covered an area of approximately 1,227,600 km², although only approximately 7.5% of that original cover remains. Its fragments are distributed along the Brazilian coast between the states of Ceará and Rio Grande do Sul, in addition to the inland states of Minas Gerais and Mato Grosso do Sul (Myers et al.

2000; Stehmann 2009). The northeastern region of that forest holds four of the five centers of biodiversity endemism in Brazil, including the Atlantic Forest remnants to the north of the São Francisco River (the “Pernambuco” and “Brejos Nordestinos” centers that comprise forest fragments between the states of Rio Grande do Norte and Alagoas) (Tabarelli et al. 2006a, 2006b).

Conservation Status —The new species was described based on a single collection, for this reason *S. pluribracteata* should be classified as "Data deficient" (DD), according to the IUCN (2019) criteria.

Etymology — The specific epithet refers to the numbers of bracts and their distributions on the inflorescence peduncle, which represent one of the diagnostic characters of *Senna pluribracteata.*

Taxonomy —*Senna pluribracteata* shows a set of characters that morphologically position it as a member of *Senna* sect. *Chamaefistula* ser. *Bacillares*, and shares several characters with four other species of *Senna* ser. *Bacillares* (*Senna rizzinii* H.S.Irwin & Barneby, *Senna pinheiroi* H.S.Irwin & Barneby, *Senna macranthera* [DC. ex Collad.] H.S.Irwin & Barneby, and *Senna rugosa* [G. Don] H.S. Irwin & Barneby), although it has not been recorded for Paraíba State. Those species are shrubs with narrowly triangular and persistent stipules, inflorescences in racemes, petals unguiculate and yellowish, fruit blackish at maturity, and seeds biseriate. *Senna pluribracteata* can be distinguished from *S. pinheiroi*, however, by having strigose branches, leaflets non-shiny on the adaxial surface, extrafloral nectaries claviform, and heteromorphic sepals (vs. tomentose branches, leaflets shiny on the adaxial surface, extrafloral nectaries narrow-ovoid, and homomorphic sepals in *S. pinheiroi*). The new species, *S. pluribracteata*, can be distinguished from *S. macranthera* and *S. rizzinii* by having larger stipules, 8.0–12.0 mm long, two extrafloral nectaries between

leaflets, one between each pair of leaflets, and bracts 7.0–9.0 mm long, arranged along the peduncle of the inflorescence (vs. smaller stipules [up to 6.0 mm long], one extrafloral nectary between the first pair of leaflets, and smaller bracts [up to 5.0 mm long], at the insertion of the floral pedicel in *S. macranthera* and *S. rizzinii*). *Senna pluribracteata* differs from *S. rugosa*, another allied species that has not been recorded for Paraíba State, by a set of distinctive characters, which include: petiole longer than the leaf rachis (1.6–2.6 cm and 9.0–11.0 mm respectively), claviform and stipitate nectaries, bracts longer (7.0–9.0 mm long) and persistent, and smaller fruits, 4.8–5.8 cm long [vs. petiole smaller than the leaf rachis (0.7–1.2 cm and 15–21 mm long respectively), nectaries ovate and sessile or sub-sessile, bracts smaller (2.0–3.0 mm long) and deciduous, and larger fruits (12.7–16.2 cm long) than seen in *S. rugosa*]. Detailed and comparative information concerning the characters of the five taxa are presented in Table 1.

Leaf Anatomy—The adaxial surface of the leaflet epidermis has straight anticlinal cell walls, with simple, spaced tector trichomes (Fig. 4A), in contrast to the abaxial surface with anticlinal cell walls strongly sinuous, with predominantly paracytic stomata (Fig. 4B), and rare anomotetracytic, and anisocytic stomata. The leaflet is hypostomatic (Fig. 4A, B) with the guard cells at the same level as the epidermal cells.

In cross section, *Senna pluribracteata* shows uniseriate epidermal cells covered by a thin smooth cuticle (Fig. 4C) on the adaxial surface, including on the midrib region, and conspicuously and compactly papillose on the abaxial surface. Simple tector trichomes are present on both surfaces of the leaflet blade (Fig. 4C), although more compact and somewhat uncinate on the abaxial surface (Fig. 4C).

The mesophyll is dorsi-ventral and has a single layer of palisade parenchyma,

with isodiametric cells that occupy approximately 60% of that structure, and 6–7 layers of spongy parenchyma composed of smaller cells (Fig. 4C). The cell layers of the palisade parenchyma are interrupted in the middle of the leaflet margin to the abaxial surface, with spongy parenchyma appearing at the leaf margin. That region has 1–2 layers of typical spongy parenchyma with rounded cells. The leaflet margin is rounded and slightly recurved (Fig. 4D).

The midrib contour is plane-convex, and strongly convex on the abaxial face (Fig. 4E). Epidermal cells, ranging from rounded to nearly rectangular in the midrib region, are of different sizes on the surfaces of the leaflet blade. The cortical region is formed by 1-2 layers of collenchyma adjacent to the epidermis, followed by 7–8 layers of fundamental parenchyma (Fig. 4F). The adaxial surface shows a continuous palisade parenchyma of the mesophyll. The vascular system is composed of a single, central, arc-shaped collateral vascular bundle, surrounded by a non-continuous sheath of 2-3 layers of sclerenchyma cells (Fig. 4E). A few idioblasts containing calcium oxalate (such as druses) were observed, mainly in the phloem and, more sparsely, in the parenchymatic region (Fig. 4F).

The petiole is somewhat pentagonal (Fig. 4G) with rounded epidermal cells smaller than those of the abaxial surface, but with thicker cuticles. The vascular system in the petiole is formed by three main, and two accessory, vascular bundles. All vascular bundles are collateral and are surrounded by a conspicuous sclerenchymatous sheath (Fig. 4G). Medullary parenchyma can be observed in the central portion of the petiole, consisting of rounded cells with thin walls (Fig. 4G); those types of cells can also be observed in the leaf rachis. The anatomical structure of the rachis is similar to that of the petiole, but with a vascular bundle in the central region and three accessories facing the adaxial surface (Fig. 4H).

There have been no previous studies of the leaf anatomy of *S. rizzinii, S. pinheiroi,* or *S. macranthera*. The data presented here are preliminary, and part of a manuscript being finalized by F. Souto (unpubl. data).

The uniseriate epidermis and hypostomatic leaves of *S. pluribracteata,* with guard cells at the same level as the epidermal cells, heterogeneous and dorsi-ventral mesophyll, plane-convex midrib with a single collateral vascular bundle, and somewhat pentagonal petiole, are similar to those seen in *S. rizzinii, S. pinheiroi,* and *S. macranthera*. We observed, however, that *S. pluribracteata* has certain distinctive anatomical characters that clearly differentiate it from the other three related species. The epidermis on the abaxial surface of *Senna pluribracteata* is conspicuously papillose, while very sparsely papillose in *S. rizzinii*, and smooth in *S. pinheiroi* and *S. macranthera*.

The spongy parenchyma in *S. pluribracteata* occupies approximately 60% of the mesophyll, and its large cells also differ from those of *S. rizzinii*, *S. pinheiroi*, and *S. macranthera,* which all have smaller cells with the spongy parenchyma composing between 47 and 53% of the mesophyll.

The rounded leaflet margins of *S. pluribracteata* are similar to those of S. *rizzinii*, although differing by the presence of a heterogeneous parenchyma in the former but a homogeneous parenchyma in the latter. The leaf margins of *S. pluribracteata* also differ from those of *S. pinheiroi*, which are conspicuously acute, and from *S. macranthera* which are irregularly curved; in both of the latter two species, the parenchyma margins are also homogeneous.

The vascular system of the midrib of *S. pluribracteata*, which is formed by a single collateral vascular bundle surrounded by a sheath of sclerenchymatic cells interrupted in the median portion, is similar to that of *S. pinheiroi*, but differs from

those of *S. rizzinii* and *S. macranthera*, which have entire sclerenchymatic sheaths, not interrupted.

The petiole of *S. pluribracteata* have somewhat pentagonal shapes, are planar adaxially, and their vascular systems are composed of five collateral bundles, while the petioles of *S. rizzinii, S. pinheiroi,* and *S. macranthera* are irregularly pentagonal, slightly wavy, concave adaxially, with six collateral bundles.

The rachis of *S. pluribracteata* is obdeltoid and planar adaxially, while elliptic and concave adaxially in *S. macranthera* and *S. rizzinii,* and somewhat obdeltoid, with two adaxial projections, in *S. pinheiroi*.

The differential characteristics observed here in the leaf anatomies of the four species of *Senna* ser. *Bacillares* suggest their usefulness in recognizing that group of *Senna* species.

Discussion of leaf anatomy—The uniseriate epidermis and hypostomatic leaves of *Senna pluribracteata,* with guard cells at the same level as the epidermal cells, are patterns common to all four species of *Senna* ser. *Bacillares* discussed here, and are also present in *S. siamea* (Lam.) Irwin & Barneby (Begum et al. 2014) and in *S. hirsuta* L. and *S. obtusifolia* (L.) Irwin and Barneby (Saheed and Illoh 2010).

The same straight anticlinal cell walls on the adaxial surfaces of *S. pluribracteata, S. rizzinii,* and *S. pinheroi* were observed in other species of *Senna,* including *S. obtusifolia, S. siamea,* and *S. tora* by Kotresha and Seetharam (2000), Begum et al. (2014), and Esievo et al. (2016), as well as in species of other Leguminosae genera such as *Chamaecrista* by Saheed and Illoh (2010) and in *Bauhinia* by Pereira et al. (2018).

A papillose epidermis is not the most common pattern observed in *Senna*, but has been recorded for other species of the genus, including *S. alata* L. and *S.*

podocarpa (Guill. & Perr.) Lock (Ogundipe et al. 2009), and was likewise observed on the pulvinus of *S. rugosa* as described in Rodrigues and Machado (2006). Non-glandular trichomes also were evident in nine species of *Senna*, while uncinate trichomes have only be reported for *S. alata* (Begum et al. 2014).

The presence of more than one type of stomata (mostly paracytic) in the four species studied appears to be a characteristic of the genus *Senna*, having already been recorded for several species of the genus by Kotresha and Seetharam (2000), Ogundipe et al. (2009), Saheed and Illoh (2010), Nassar et al. (2013), Begum et al. (2014), and Esievo et al. (2016), *inter alia*.

The petiole, as observed in transverse sections through the distal end, shows an interrupted ring of bundles accompanied by two or three accessory bundles, and was previously described in the four Leguminosae species by Metcalfe and Chalk (1957). Additionally, the pattern of vascular collateral bundles in the midrib and petiole, common in all of the species studied in this work, constitutes a consistent pattern of the Leguminosae family according to Metcalfe and Chalk (1957), and is not an exclusive character for *Senna*.

Analitical Key—We present here a key to identifying all seven species of *Senna* ser. *Bacillares* found in Paraíba State based on morphological characters, which can be used to support their identifications and for taxonomic studies, as there are large numbers of unidentified or misidentified specimens in many herbaria of Brazil.

KEY TO THE SPECIES OF *SENNA* SER. *BACILLARES* IN PARAÍBA STATE, NORTHEASTERN BRAZIL

1. Stipules falcate; branches glabrous or glabrescent

    2. Stipules 10–12 mm long; extrafloral nectaries 2; apex of the leaflet cuspidate;

tomentose on the abaxial surface; flowers 1.5–1.8 cm long; sepals homomorphic …… *Senna quinquangulata* Rich.) H.S. Irwin & Barneby

2. Stipules 3.0–7.0 mm long; extrafloral nectary 1; leaflet acuminate or obtuse at the apex; glabrous to glabrescent on the abaxial surface; flower 4.2–6.5 cm long; sepals 3, heteromorphic

3. Leaves 12.2–23.2 cm long, leaf rachis 2.2–5.0 cm long; glands conical, acuminate; leaflets concolorous; terminal panicle with extrafloral nectaries on the rachis of the inflorescence; legume flat-compressed, seeds uniseriate ..... *Senna georgica* H.S. Irwin & Barneby

3. Leaves 7.0–8.5 cm long, leaf rachis 0.8–1.3 cm long, glands claviform, apex obtuse; leaflets bifacial; racemes axillary, extrafloral nectaries absent on the inflorescence rachis; legume sub-cylindrical, seeds bisected ..……..…… *Senna splendida* (Vogel) H.S. Irwin & Barneby

1. Stipules narrowly triangular or subulate; branches pubescent, tomentose, or strigose

4. Only one extra-floral nectary on the leaf rachis, between the first pair of leaflets

5. Extra-floral nectary sessile; peduncle 2.4–4.7 cm long; pedicel 2.4–3.0 cm long; petals 1.8–2.0 × 1.0–1.4 cm ……..…… *Senna macranthera* (DC. ex Collad.) H.S. Irwin & Barneby

5. Extrafloral nectary stipitate; peduncle 1.2–1.4 cm long; pedicel 1.7–2.0 cm long; petals 1.0–1.2 × 0.5–0.6 cm …… *Senna rizzinii* H.S. Irwin & Barneby

4. Two extrafloral nectaries on the leaf rachis, between the two leaflet pairs

6. Branches tomentose; stipules 0.3–0.4 cm long; extrafloral nectaries narrow-ovoid, subsessile; bracts lanceolate, deciduous, 3.0–4.0 × 1.0 mm; sepals homomorphic …….. *Senna pinheiroi* H.S. Irwin & Barneby

6. Branches strigose; stipules 1.0–1.2 cm long; extrafloral nectaries claviform, stipulate; bracts ovate to elliptic, persistent, 7.0–9.0 × 3.0–4.0 mm; sepals heteromorphic……. *Senna pluribracteata* F.S. Souto & R.T. Queiroz

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AUTHOR CONTRIBUTIONS

FSS was the main author of the description of the new species and contributed to the collection, analysis and interpretation of the data, and the practical aspects of the anatomy of the species. RTQ contributes to the taxonomic concept of the new species and the *Bacillares* series of the genus *Senna*. MFA contributed to the interpretation and description of the new species, the interpretation and description and discussion of the leaf anatomy, and to the critical review, adding intellectual content to the manuscript. All authors provided critical feedback and helped in the preparation of the manuscript.

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TABLE 1. Distinctive morphological characters of *Senna pluribracteata* and its allied species of the series *Bacillares*.

Character	Species				
	S. pluribracteata	***S. macranthera***	***S. pinheiroi***	***S. rizzinii***	***S. rugosa***
Indument on the branches	Strigose	Tomentose	Tomentose	Tomentose	Tomentose
Stipule length	8.0-12.0 mm	4.0-6.0 mm	3.0-4.0 mm	5.0-6.0 mm	4.0-6.0 mm
Petiole length	1.6-2.6 cm	1.8-2.2 cm	2.0-2.5 cm	1.4-1.8 cm	0.7–1.2 cm
Rachis length	9.0-11.0 mm	5.0-6.0 mm	6.0-8.0 mm	5.0-8.0 mm	15.0-21.0 mm
Numbers of nectaries	Two	Only one	Two	Only one	Two
Nectary shape	Claviform	Fusiform to ovate	Narrow-ovoid	Fusiform to claviform	Ovate
Nectary position	Above the first pair of leaflets and between the second pair	Between the first pair of leaflets	Between the first pair of leaflets	Between the first pair of leaflets	Between the first pair of leaflets
Indument on the adaxial surface of the leaflet	Strigillose	Pubescent	Pubescent	Tomentose	Tomentose
Bract length	7.0-9.0 mm	3.0-5.0 mm	3.0-4.0 mm	3.5-4.0 mm	2.0-3.0 mm
Bract shape	Elliptic	Lanceolate	Lanceolate	Ovate to wide lanceolate	Ovate to elliptic
Bract insertion	At the pedicel and peduncle	At the pedicel	At the pedicel	At the pedicel	At the pedicel
Sepal shape	Heteromorphic	Heteromorphic	Homomorphic	Heteromorphic	Heteromorphic
Length of fruit	4.8-5.8 cm	6.2-10.5 cm	19.3-23.1 cm	5.7-8.5 cm	12.7-16.2 cm

FIGURES CAPTIONS

FIG. 1. *Senna pluribracteata* F.S. Souto & R.T. Queiroz (*Souto et al. 188*). A. Flowering branch. B. Detail of branch stipules. C. Isolated leaflet. D. Detail of the extra-floral nectaries in the leaflet rachis. E. Detail of bracts on the peduncle. F. Isolated flower. G. Mature fruit. H. Isolated seed.

FIG. 2. *Senna pluribracteata* F.S. Souto & R.T. Queiroz (*Souto et al. 188*). A. Isolated flower. B. Detail of bracts on the peduncle. C. Detail of an extra-floral nectary on the 1st pair of leaflets. D. Detail of leaf stipules (black arrow), extra-floral nectary (red arrow) and leaflet arrows (blue arrow). E. Leaf and detail of the acute leaflet apex. F. Mature fruit and detail of an isolated seed.

FIG. 3. Distribution map of *Senna pluribracteata* F.S. Souto & R.T. Queiroz.

FIG. 4. Leaf anatomy of *Senna pluribracteata* F.S. Souto & R.T. Queiroz (*Souto et al. 188*). A. Adaxial surface of a leaflet epidermis. B. Abaxial surface of a leaflet epidermis C. Dorsiventral mesophyll, in cross section. D. Leaflet margin. E. Overview of a midrib, in cross section. F. Detail of the cortical region of the midrib. G. Petiole, in cross section. H. Leaf rachis, in cross section. Legend: (ep) = epidermis, (id) = idioblast, (pap) = epidermal papillae, (ph) = phloem (pm) = medullary parenchyma, (pp) = palisade parenchyma, (pr) = parenchyma, (sch) = sclerenchyma.

Fig 1

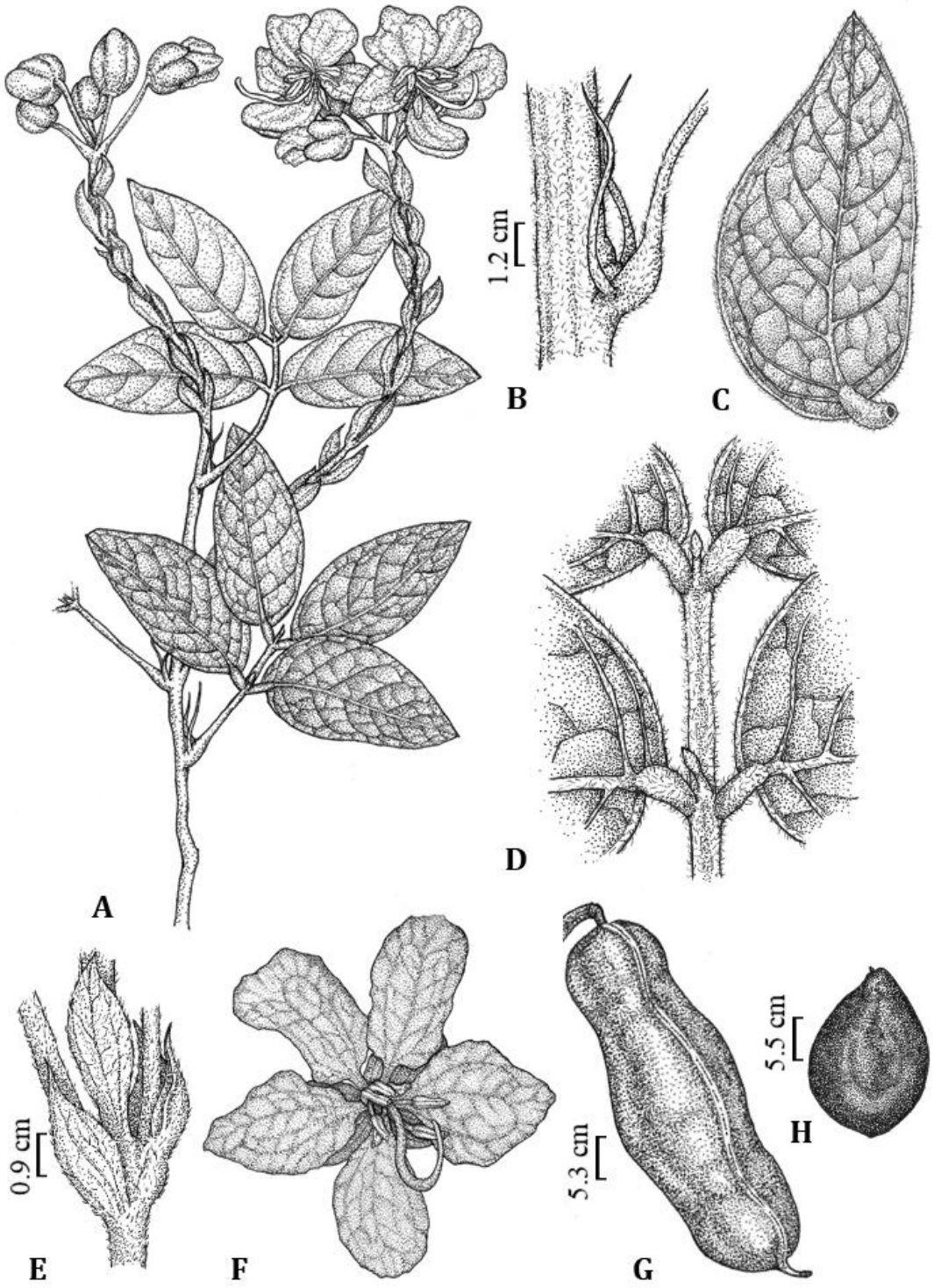


Fig 2

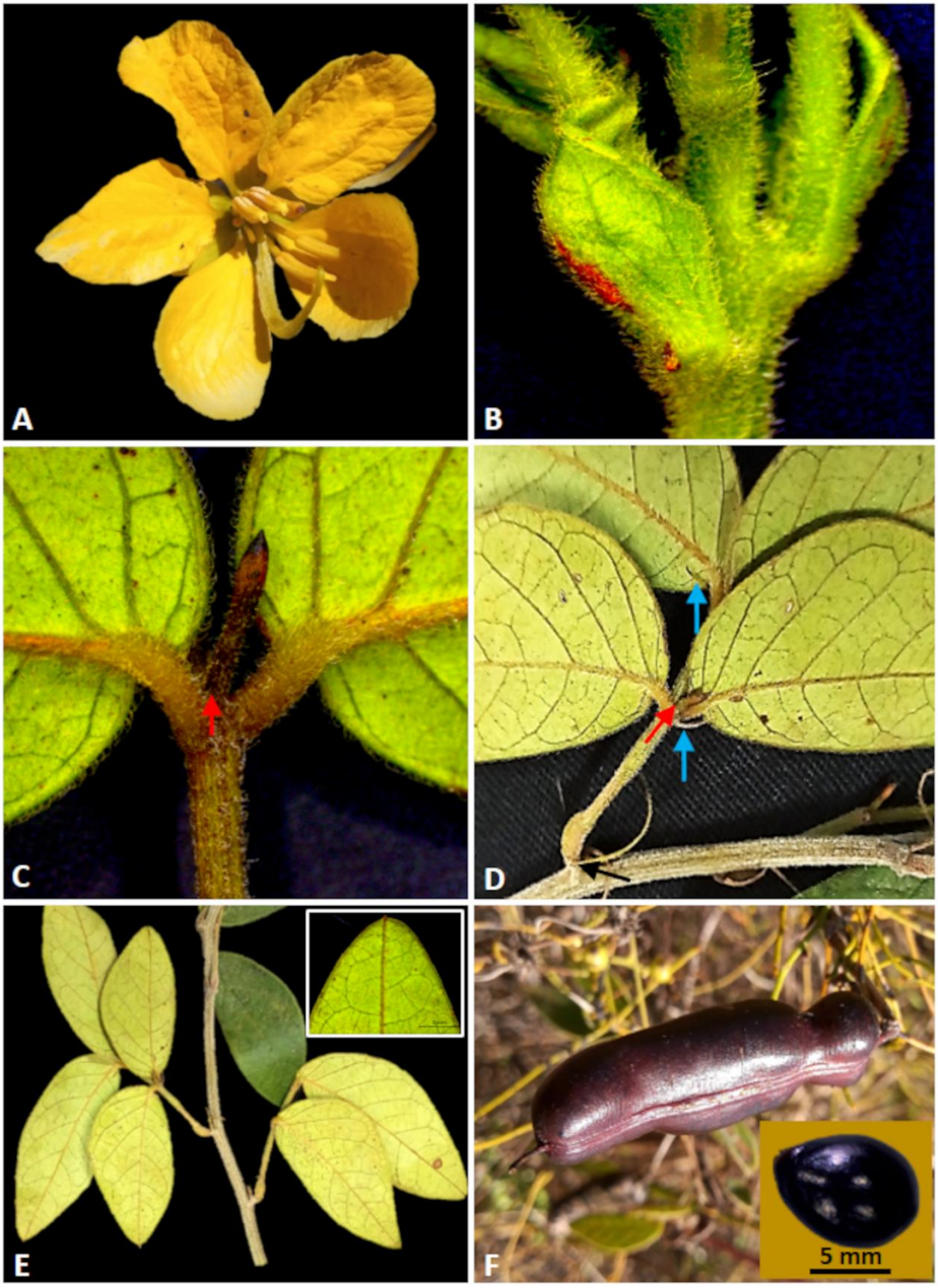


Fig 3

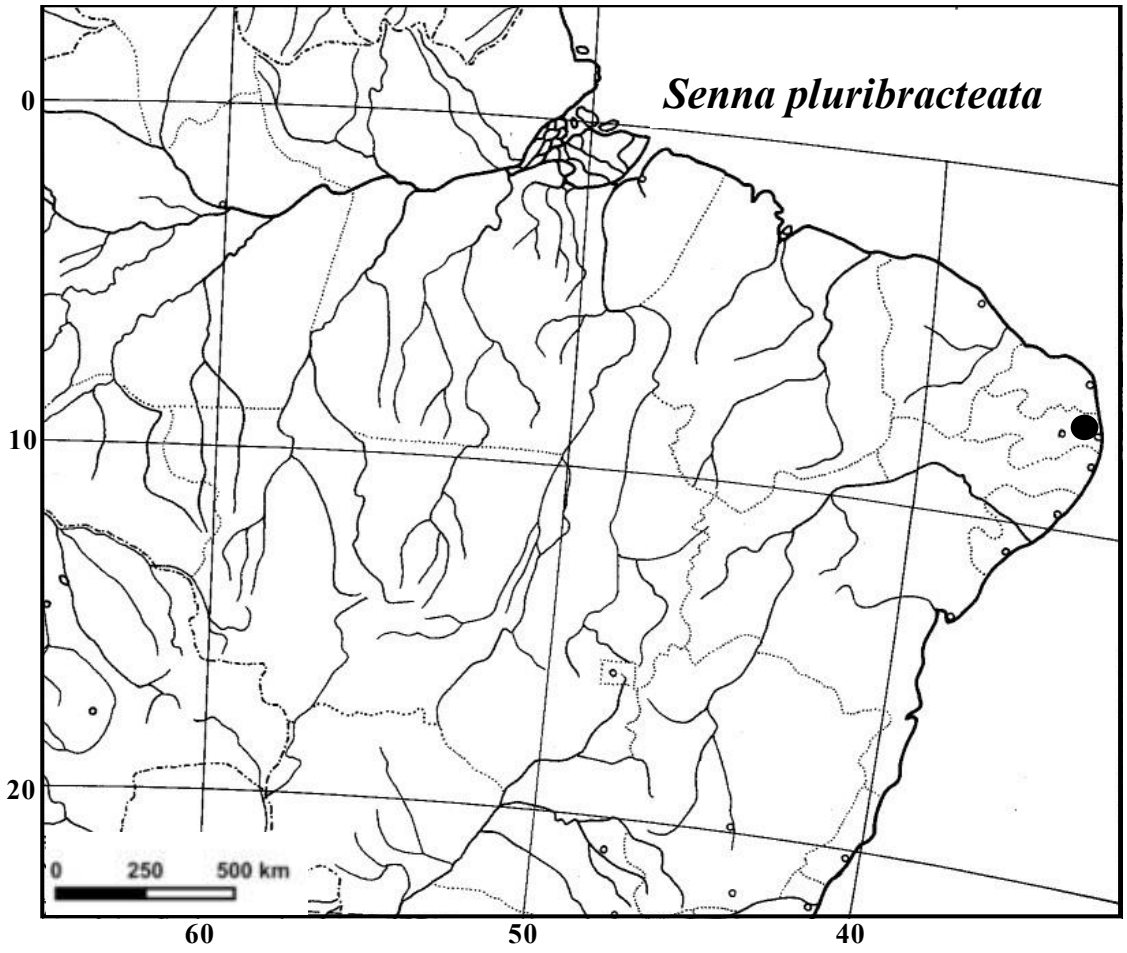
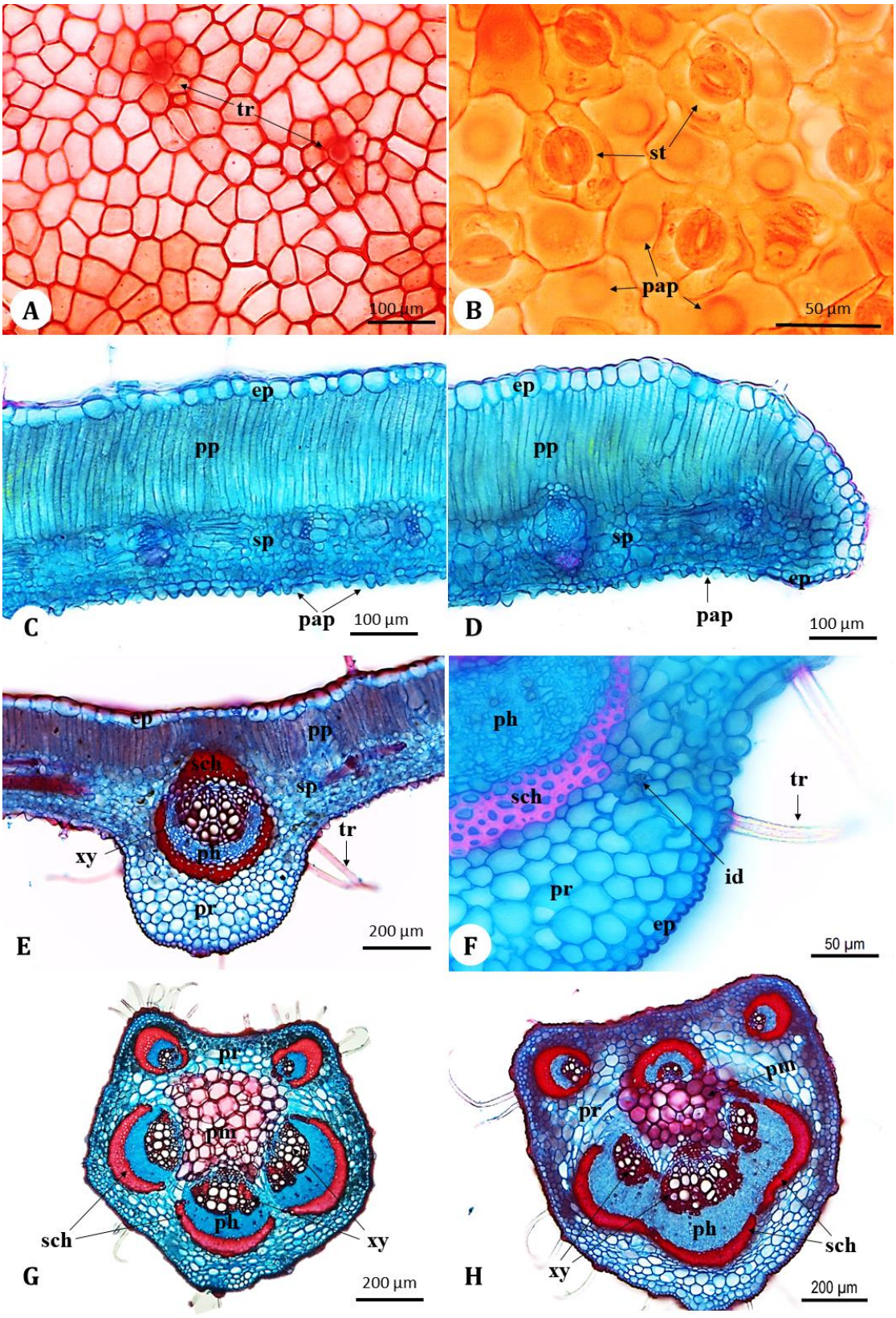


Fig 4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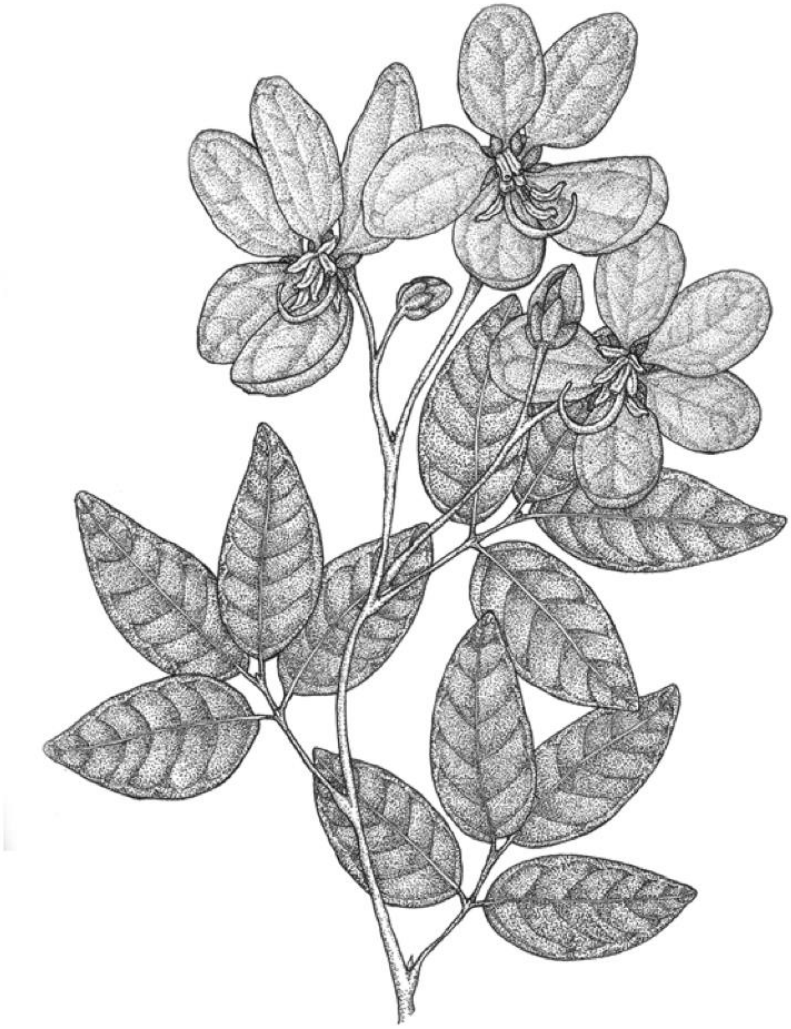
3.2 CAPÍTULO II:

Senna ser. *Bacillares* (Leguminosae, Caesalpinioideae) in the Atlantic Forest north of the São Francisco River, Brazil



A ser submetido à Acta Botanica Brasilica

Senna ser. *Bacillares* (Leguminosae, Caesalpinioideae) in the Atlantic Forest north of the São Francisco River, Brazil

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Abstract

Senna ser. *Bacillares* comprises ca. 50 Neotropical species, occuring in tropical and subtropical areas. Of these, about 23 species occur in Brazil, and seven are endemic. Species of the series *Bacillares* have a wide morphological variety, which can lead to misidentifications. This work was performed in order to provide a taxonomic study of *Senna* ser. *Bacillares* in the Atlantic Forest north of the São Francisco River contributing for its taxonomy, diversity and distribution. Fieldwork was carried out for collecting fresh material, as well as for field observations. All material collected was deposited at UFP and JPB herbaria. In addition, samples of the following herbaria: ALCB, ASE, CEN, EAC, EAN, ESA, F, HST, HUEFS, IAN, IBGE, IPA, JPB, K, MAC, MO, NY, PEUFR, RB, UFG, UFP, UFRN and VIC werw analized. *Senna* ser. *Bacillares* is represented in the study area by ten species, corresponding to 43.4% of the species found in Brazil. Of these, six species are endemic to the Brazilian flora; *Senna pluribracteata* is a new taxon for the country; *Senna georgica* var. *georgica* constitutes a new record for the state of Rio grande do Norte, and *S. angulata* var. *miscadena* is a new record for the Paraíba state. In addition, *S. rizzinii* and *S. rugosa* are new records for the Atlantic Forest, being *S. rizzinii* found in all states of the study area, and *S. rugosa* in Pernambuco state. The results highlight the importance of carrying out regional floristic inventories for the documentation of new species and new occurrences.

Keywords: Caesalpinioideae, *Cassia*, Fabaceae, Brazilian Flora, Taxonomy.

Introduction

Senna Mill. (Leguminosae, Caesalpinioideae) comprises ca. 330 species, of which 280 occur in the Americas, and the rest are distributed in Australia, Africa and/or Madagascar (Marazzi et al. 2006; Queiroz 2009; Marazzi & Sanderson 2010). In Brazil, about 81 species are registered, 30 of which are endemic (Souza & Bortoluzzi 2020). *Senna* was proposed by Miller (1754), having *Senna alexandrina* Mill. as the type species. However, the Miller's concept was not accepted by most of the botanists (Persoon 1805; Colladon 1816; Candolle 1825; Vogel 1837; Bentham 1870, 1871), which adopted the generic concept of Linnaeus (1753), recognizing species of *Senna* as part of *Cassia* L.

Irwin & Barneby (1982) observed the wide diversity of their morphological characters in *Cassia* senso lato, and proposed their segregation in three distinct genera: *Cassia* senso stricto, *Chamaecrista* (L.) Moench and *Senna*. Recently, molecular studies supported *Cassia* segregation (Acharya et al. 2011; Tripathi & Goswami 2011). Marazzi and Sanderson (2010) sugested *Cassia* as the probable sister group of *Senna*, from which it diverged about 49.14 million years ago.

Irwin & Barneby (1982) reported 202 species for *Senna*, which were grouped into six sections: *Psilorhegma* (Vogel) H.S.Irwin & Barneby, *Chamaefistula* (DC. ex Collad.) H.S.Irwin & Barneby, *Senna* Mill., *Peiranisia* (Raf.) H.S.Irwin & Barneby, *Paradyction* H.S.Irwin & Barneby e *Astroites* H.S.Irwin & Barneby. Of these, *Senna* sect. *Chamaefistula* (DC ex Collad.) H.S.Irwin & Barneby is the most representative and taxonomic complex group. The section comprises about 144 species with wide distribution, found in the tropical regions with few species occurring in hot temperate zones.

Senna sect. *Chamaefistula* was divided by Irwin & Barneby (1982) into 21 series, being the *Senna* ser. *Bacillares* (Benth.) H.S.Irwin & Barneby is complex group with approximately

50 species, with great diversity in the Americas, in tropical and subtropical areas, and some species occurring in Asia and Africa. It is represented in Brazil by about 23 species, of which seven are endemic (Souza & Bortoluzzi 2020). According to Irwin & Barneby (1982), the species of the series *Bacillares* are characterized by their leaves with four leaflets with extrafloral nectaries between the leaflets, legume bacoid and internally pulpy, pluriovular, with many seeds oriented transversely and laterally facing the septa. Phylogenetic relationships within the series *Bacillares* were investigated by Marazzi et al. (2006), and the series emerged as a monophyletic group.

Senna can be found in Brazil in different biomes and vegetation formations, however, its greatest relative richness of species is present in the Atlantic Forest (Souza & Bortoluzzi 2020). The Atlantic Forest is a phytogeographic domain that has high rates of endemism, being one of the 34 biodiversity *hotspots* in the world (Myers et al. 2000; Paglia & Pinto 2010). Originally it comprises an area of approximately 1.227.600 km², however, due to its degradation only about 7.5% of its original coverage remains (Myers et al. 2000; Pereira 2009; Stehmann 2009).

In the Northeast region of Brazil, the Atlantic Forest north of the São Francisco River has about 4% of its original vegetation cover, it is fragmented into small stretches of native vegetation, resulting in the isolation of populations and, consequently, the extinction of species (Tabarelli et al. 2006a). The study area comprises the centers of endemism “Pernambuco” and “Brejos Nordestinos”, which comprise areas from Rio Grande do Norte to Alagoas. The area is formed by remnants what corresponding to approximately 4% of the original coverage (Tabarelli et al. 2006a, b). This vegetation is very complex and is strongly influenced by the Amazon and Atlantic Forests of the Southeast and South of Brazil (Veloso et al. 1992; Tabarelli & Santos 2004).

Taxonomic studies with the genus *Senna* in Brazil are scarce, especially involving Atlantic Forest environments in the Northeast region of the country. However, stand out the studies of Lewis (1987) for the state of Bahia, Rodrigues et al. (2005) for the state of Rio Grande do Sul, Queiroz (2009) for the phytogeographic domain of Caatinga, Dantas & Silva (2013) and Souza & Silva (2016) for conservation areas in the state of Goiás, in addition to local studies of Azevedo & Conceição (2017), Correia & Conceição (2017), and Santos et al. (2020) in Bahia. The most comprehensive study for gender in the country is that of Silva et al. (2018) for species occurring in the Midwest region of Brazil.

In view of the significant richness of *Senna* species in the flora of Brazil, and the scarcity of floristic and taxonomic studies with the genus for the Northeast region, especially for the Atlantic Forest, it was carried out a taxonomic study of species of *Senna* ser. *Bacillares* in the Atlantic Forest north of the São Francisco River, contributing to the expansion of knowledge of its taxonomy, diversity and distribution.

Material and methods

In the study area, five field expeditions were carried out, between July to December 2019. Part of the material collected was herborized following the usual techniques in plant taxonomy, as described by Bridson & Forman (1989), and the exsiccates incorporated at the collection of Herbário Prof. Geraldo Mariz (UFP), Federal University of Pernambuco, with duplicates at the Herbário Prof. Lauro Pires Xavier (JPB), of the Federal University of Paraiba. Other part of the material collected was fixed in FAA, for 48 hours, and lately conserved in alcohol 70%, for anatomical and taxonomic studies.

Morphological studies on fresh and fixed material were performed for identifications at species level. We also performed analysis of dry specimens deposited at the herbaria EAN, HST, IPA, JPB, MAC, PEUFR, UFP and UFRN, acronyms according to Thiers (2020), as well

as from herbário Sérgio Tavares (HST), not indexed, at the Federal Rural University of Pernambuco. In addition, we studied images, available online, of specimens deposited at the followig herbaria: ALCB, ASE, CEN, EAC, ESA, F, HUEFS, IAN, IBGE, K, MO, NY, RB, UFG and VIC. The identifications were based on comparing the specimens with the photos of the nomenclatural types available in virtual herbaria, descriptions of protologues, and botanical keys, found in the specialized bibliography (Irwin & Barneby 1982; Lewis 1987; Rodrigues et al. 2005; Queiroz 2009; Dantas & Silva 2013; Souza & Silva 2016; Santos et al. 2017; Silva et al. 2018).

The descriptions were made according to the classic procedures in botanical taxonomy, taking and presenting the extreme measures of length and width of the structures. The nomenclature adopted to indicate the morphological characters follows Radford et al. (1974), Irwin and Barneby (1982), and Harris & Harris (1994), with the exception of the nomenclature of the stigmatic cavity, which is in accordance with Marazzi et al. (2007). The names of the species and their respective authors follow the IPNI (2020).

The geographic distribution of species to Brazil were based on Flora do Brasil (2020). The data of species distribution and phenology for the study area, were inferred from the collections carried out, analysis of the specimens labels, complemented by the information of literature for *Senna*. The vegetation formations and occurrence of *Senna* species, in the study area, are according to IBGE (2012). Conservation status assessments took into account the total species distribution, and follow the guidelines proposed by IUCN (2019), combined with the GeoCAT toll (Bachman et al. 2011). To categorize the status of the species, criterion B (geographic range) was used, specifically criterion B1 which corresponds to Extension of Occurrence (EOO).

The taxonomic treatment is organized in alphabetical order of species, and includes a taxonomic heading, descriptions, material examined for the study area, which is complemented by additional material from locations outside of the study area, information on habitat, distribution, taxonomic notes, phenology, ethnobotanical uses when known, conservation status and illustrations (photograph and/or botanical illustrations) of each species, as well as an analytical key for species identification.

Results and discussion

Senna ser. *Bacillares* is represented in the Atlantic Forest north of the São Francisco River by ten species, corresponding to 43.4% of the species from Brazil. Of these, *Senna angulata* var. *miscadena* (Vogel) H.S.Irwin & Barneby, *S. macranthera* var. *micans* (Nees) H.S.Irwin & Barneby, *S. pinheiroi* H.S.Irwin & Barneby, *S. pluribracteata* F.S.Souto & R.T.Queiroz, *S. rizzinii* H.S.Irwin & Barneby and *S. splendida* var. *gloriosa* H.S.Irwin & Barneby are endemic to Brazil, and *S. pluribracteata* endemic to the Atlantic Forest from Northeast Brazil.

Seven species of *Senna* ser. *Bacillares* were previously cited for the study area in the Flora of Brazil (Souza & Bortoluzzi 2020). However, no vouchers of *Senna bacillaris* (L.f.) H.S.Irwin & Barneby were found for the Atlantic Forest of Pernambuco, for which the species is mentioned in Flora do Brasil (2020). In contrast, *Senna georgica* var. *georgica* H.S.Irwin & Barneby presented a voucher referring to its occurrence in the state of Rio Grande do Norte (IPA 64396). However, after morphological analysis, it was found that the referred specimen belongs to *S. splendida* var. *gloriosa*. Thus, *S. georgica* var. *georgica* is being cited here as a new occurrence for the flora of Rio Grande do Norte state. Among the species recorded in the study area, *Senna pluribracteata* is a new species for sciense (Souto et al. 2021), *S. angulata* var. *miscadena* is a new record for the state of Paraíba. Moreover, *Senna rizzinii* is a new

occurrence for the Atlantic Forest in the states of Alagoas, Pernambuco, Paraíba and Rio Grande do Norte, while *S. rugosa* is a new record for the Atlantic Forest of Pernambuco.

After analysis of specimens deposited at the herbaria, we observed the misidentifications of two species, *Senna affinis* (Benth.) H.S.Irwin & Barneby, for the flora of Pernambuco, and *S. angulata* for the floras of Alagoas and Pernambuco, these specimens belong to *S. georgica* var. *georgica* and *S. chrysocarpa*, respectively. Species of *Senna* ser. *Bacillares* occur on the edges of Ombrophilous Forest, Seasonal Semideciduous Forest, and Brejos de Altitude, as well as anthropized environments and are less frequent in Restinga áreas (coastal scrubs).

Taxonomic treatment

Senna* ser**. ***Bacillares (Benth.) H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 102, 1982.

Shrubs, upright; branches subcylindrical, cylindrical, subangled or angled. Stipules foliaceous, linear, falcate or narrowly-lanceolate, deciduous or persistent. Leaves 4-leaflets; arrow 1, located between the second pair or in each pair of leaflets; 1-2 extrafloral nectaries between the first pair or in both pairs of leaflets; leaflets blade elliptical, oval, obovate, oblong or variations of these, revolute margins, glossy or non-glossy, concolor or discolor. Inflorescences in racemes or panicles, axillary or terminal; bracts foliaceus, persistent or caducous, located at the base of pedicel or along the peduncle. Flowers asymmetric; calyx heteromorphic, sepals yellowish-green, oblong to obovate, glabrous inside; corolla with petals yellow, unguiculate, oblong, obovate or orbicular, obtuse at apex, glabrous inside; androecium with seven fertile stamens (three abaxial and four median stamens), and three staminodes adaxially; anthers with 1-2 pores, curved in the abaxial stamens with elongated beak, straight in the median stamens with short beak; ovary stipitate; stylus short, curved; stigmatic cavity

circular, elliptic or punctiform. Legume bacoid, cylindrical, subcylindrical or linear, compressed or not compressed, valves differing in consistency, color and texture, fleshy endocarp, with seeds separated by transverse and longitudinal septa, late dehiscence through decomposition of the valves. Seeds glabrous, 1-2-seriates. Fig. 1.

Key to the species of *Senna* ser. *Bacillares* of the Atlantic Forest north of the São Francisco River

1. 1-nectary extrafloral on the first pair of leaflets 2

– 2-nectaries extrafloral, between the leaflets 7

2. Stipules caducous; arrow subulate 3

– Stipules persistent; arrow ensiform or linear 4

3. Branches glabrous; extrafloral nectary ovoid, glabrous; leaflets concolor; seeds uniseriate ..... 3. *S. georgica* var. *georgica*

– Branches tomentose; extrafloral nectary globose, sparse-pubescent; leaflets discolor; seeds biseriate .....1. *S. angulata* var. *miscadena*

4. Branches and petiole tomentose or puberulent; leaflets chartaceous; ovary velutinous; fruit up to 10.5 cm long 5

– Branches and petioles glabrous; leaflets membranous; ovary sparse-pubescent; fruit 22.5–24.6 cm long ..... 10. *S. splendida* var. *gloriosa*

5. Branches and petioles tomentose; arrow ensiform; base of the leaflets oblique; bracts with acute apex; fruit ≥5.7 cm long, pubescent or glabrescent 6

– Branches and petioles puberulent; arrow linear; base of the leaflets rounded to slightly oblique; bracts acuminate at the apex; fruit 4.5–5.2 cm long, tomentose ..... 2. *S. chrysocarpa*

6. Extrafloral nectary subsessile; petiole 1.8–2.2 cm long; bracts lanceolate to oblanceolate, caducous; fruit pendulous, pubescent ..... 4. *S. macranthera*

– Extrafloral nectary stipitate; petiole 1.4–1.6 cm long; bracts ovate, persistent; fruit straight, glabrous to glabrescent ..... 8. *S. rizzinii*

7. Branches subcylindrical or cylindrical, tomentose or strigose; stipules linear or narrowly-lanceolate; apex of leaflets acuminate, acute or obtuse; inflorescence in racemes 8

– Branches angled, glabrescent; stipules falcate; apex of leaflets cuspidate; inflorescences in panicles ..... 7. *S. quinquangulata* var. *quinquangulata*

8. Stipules linear, persistent; petiole larger than the rachis (1.6–2.6 cm long and 0.9–1.1 cm long) 9

– Stipules narrowly-lanceolate, caducous; petiole smaller than the rachis (0.7–1.2 cm long and 1.5–2.1 cm long) ..... 9. *S. rugosa*

9. Branches tomentose; nectaries extrafloral conical, subsessile; leaflets glossy on the adaxial surface; bracts lanceolate; sepals homomorphic, acute at the apex ..... 5. *S. pinheiroi*

– Branches strigose; nectaries extrafloral claviform, stipitate; leaflets non-glossy; bracts elliptic; sepals heteromorphic, rounded at the apex ..... 6. *S. pluribracteata*

1. ***Senna angulata*** var. ***miscadena*** (Vogel) H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 177, 1982.

Fig. 2

Shrub, ca. 2.5–3.0 m tall; diffuse branches, cylindrical, tomentose. Stipules caducous. Leaves 9.4–12.6 cm long, petiole 1.7–2.0 cm long, tomentose, pulvinus undifferentiated; rachis 1.0–1.6 cm long; arrow 3.0–3.5 mm long, subulate; 1-nectary extrafloral, 2–3.0 mm long, globose, sessile, blackened, sparse-pubescent, at the first pair of leaflets; petiolule 1.5–2.0 mm long, leaflets 7.5–9.8 × 3.4–3.8 cm, oblong to ovate, obtuse at the apex, oblique at base, non-glossy, discolors, chartaceous, puberulent on the adaxial surface, tomentose on the abaxial surface. Racemes 7.8–8.5 cm long, axillary or terminal; peduncle 2.2–2.4 cm long, cylindrical,

tomentose; flower buds absent; bracts 4.0–5.0 mm long, lanceolate to narrowly-elliptical, acute at the apex, persistent in anthesis, located at the base of the pedicel, pubescent. Flower 5.8–7.2 cm long, pedicel 2.3–3.0 cm long, tomentose; calyx with heteromorphic sepals, 12.0–14.0 × 4.0–5.0 mm, obovate to oblong, rounded at the apex, pubescent externally; corolla with heteromorphic petals, 3.7–4 × 1.8–2.3 cm, obovate to oblong, pubescent externally; 7-stamens fertile, filament pubescent, heteromorphic anthers, oblong to linear, 2-pores, pubescent; abaxial stamens 14.5–19.0 mm long; median stamens 9.0–9.5 mm long, staminodes 4.0 mm long; ovary 2.5–2.8 cm long, velutinous; stylus ca. 2.0 mm long, pubescent; stigmatic cavity elliptic. Fruit 15.1–18.7 cm long, cylindrical, linear, pendulous, brown to blackish, non-glossy, sparse-pubescent, valves chartaceous, not smooth, stipe 6.0–7.0 mm long. Seeds 6.0–7.0 × 4.0 mm, elliptic, blackish, biseriate.

Selected material examined: BRAZIL. Paraíba: Maturéia, Pico do Jabre, 7º15’11”S, 37º23’04”W, 12/IV/2019, fl., *A. Gomes 218*; ibid., 13/V/2019, fl., *A. Gomes 290*; ibid., 7°15’35.99”S, 37°23’9.72”W, 12/VII/2019, fr., *F.S. Souto et al. 166* (JPB, UFP); ibid., 7º15’11”S, 37º23’04”W, 14/VIII/2019, fr., *A. Gomes 373*.

Senna angulata var. *miscadena* is an endemic species of Brazil (Irwin & Barneby 1982), being referred to the states of Bahia, Espirito Santo, Minas Gerais, Rio de Janeiro, Paraná and Santa Catarina, occurring exclusively in the domain of the Atlantic Forest (Souza & Bortoluzzi 2020). The species is here cited as a new record for the state of Paraíba, occurring exclusively in the study area, on the edge of Seasonal Semideciduous Forest (Brejos de Altitude).

This species differs from other species of the genus by its caducous stipules, leaf with undifferentiated pulvine, nectary extrafloral globose, and by the elliptic stigmatic cavity.

It falls into the category of least concern (LC), covering an extent of occurrence of about 817.399.377 km².

It is in flower between April and May, and with fruits from July and August.

2. ***Senna chrysocarpa*** (Desv.) H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 171, 1982.

Fig. 3

Shrub, ca. 1.0–4.0 m tall, upright; branches not very diffuse, subangled, puberulent. Stipules 4.0–6.0 mm long, linear, persistent, pubescent. Leaves 5.0–6.2 cm long, petiole 1.9–3.4 cm long, puberulent, pulvinus 2 mm long; rachis 0.5–0.7 cm long; arrow 1.0–2.0 mm long, linear; 1-nectary extrafloral, 1.2–3.0 mm long, fusiform, stipitate, blackish, glabrous, at the first pair of leaflets; petiolule 2.0–2.5 mm long, leaflets 2.7–5.1 × 1.8–2.2 cm, elliptic to ovate, acute to obtuse at the apex, rounded to slightly oblique at base, non-glossy, discolors, chartaceous, pubescent on both surface. Racemes 4.2–5.0 cm compr., axillary or terminal; peduncle 1.0–1.8 cm long, subcylindrical, tomentose; flower buds ovate to orbicular, rounded at the apex; bracts 3.0–4.0 mm long, widely-lanceolate, acuminate at the apex, persistent in anthesis, located at the base of pedicel, tomentose. Flower 2.5–2.8 cm long, pedicel 1.2–1.5 cm long, tomentose; calyx with heteromorphic sepals, 7.0–10.0 × 6.0–8.0 mm, obovate to oblong, rounded at the apex, tomentose externally; corolla with heteromorphic petals, 14.0–19.0 × 8.0–9.0 mm, obovate to oblong, tomentose externally; 7-stamens fertile, filament glabrous; homomorphic anthers, linear, 2-pores, glabrous, abaxial stamens 10.0–11.0 mm long, stamens median, 7.0–8.0 mm long, staminodes 2.0–3.0 mm long; ovary 1.2–1.3 cm long, velutinous; stylus 2.0–3.0 mm long, glabrous; stigmatic cavity punctiform. Fruit 4.5–5.2 cm long, cylindrical, pendulous, blackish, non-glossy, tomentose, valves subwoody, not smooth, stipe 6.0–8.0 mm. Seeds not seen.

Selected material examined: BRAZIL. Alagoas: Coruripe, Usina Coruripe, Fazenda Progresso, 30/VIII/2001, fl., *M.A.B.I. Machado & I.A. Bayama 45* (MAC); Ibateguara, Coimbra, Grota do Dudé, 12/XI/2001, fl., *M. Oliveira & A. Grilo 661* (MAC); Maceió, Fazenda

Santa Luzia, 30/X/1979, fl., *R.P. Lyra-Lemos & A.I.L. Pinheiro 09* (MAC, NY); Maribondo, Fazenda Boca da Mata, 21/I/2010, fr., *Chagas-Mota 6914* (MAC); Mar Vermelho, Fazenda Canadá, 29/I/2010, fr., *Chagas-Mota 7309* (MAC); Murici, Fazenda Bananeiras, 20/XI/2012, fl., *M.C.S. Mota & E.C.O. Chagas 11810* (MAC, RB); Paripueira, RPPN Placas, 9°27'48.8"S, 35°34'22.7"W, 15/XII/2016, fr., *J.W. Alves-Silva 1637* (MAC); Pilar, Unidade de produção de gás natural/Campo Petrobrás, Mata do Lamão, 9°37'04.0"S, 35°55'18.0", 07/XI/2002, fl., fr., *R.P. Lyra-Lemos et al. 7080* (MAC, UFP); Rio Largo, Área de influência do Pratagy, 11/XI/1999, fl., *R.P. Lyra-Lemos et al. 4400* (ALCB, ESA, HUEFS, MAC); Paraíba: Mamanguape, Reserva Biológica Guaribas, 09/VIII/1999, fl., *C. Schlindwein 945* (UFP); ibid., limite oeste da área II, 6°42'37.0"S, 35°12'42.0"W, 18/VIII/2002, fl., *A.C. Sevilha 2216* (CEN); Pernambuco: Cabo de Santo Agostinho, Área do projeto Suape, 01/XI/1967, fl., A.D. *Andrade-Lima & Medeiros-Costa 63* (F); Maraial, Engenho Curtume, 8º48'S, 35º50"W, 13/X/1996, fl., *G.S. Baracho et al. 176* (UFP); ibid., 08/IX/1996, fl., *J.A. Siqueira-Filho et al. 371* (UFP); Rio Formoso, Horto Florestal de Saltinho, 06/IX/1954, fl., *J.I.A. Falcão et al. 956* (IPA, RB, VIC); ibid., Reserva Biológica Saltinho, 8°43'23.0"S, 35°11'09.0"W, 26/IX/2002, fl., *A.C. Sevilha 2648* (CEN).

Senna chrysocarpa is a South American species, occuring in Bolivia, Brazil, Guyana, French Guiana, Suriname and Venezuela (Irwin & Barneby 1982; Silva et al. 2018). In Brazil it is referred to the states of Alagoas, Amazonas, Amapá, Bahia, Maranhão, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Pará, Pernambuco, Paraná, Rio Grande do Norte, Rondônia, Roraima, and São Paulo, occurring in the domains of the Amazon, Caatinga, Cerrado and Atlantic Forest (Silva et al. 2018; Souza & Bortoluzzi 2020). In the study area it was found in the Atlantic Forest, in states of Alagoas, Paraíba and Pernambuco in all vegetation formations, except in Restinga (coastal scrubs).

Senna chrysocarpa is morphologically related to *S. macranthera* and *S. rizzinii*, however it can be recognized for presenting the branches and petiole puberulent, leaflets with a rounded to slightly oblique at base, and for its small fruits up to 5.2 cm long (*vs*. branches and tomentose petiole, leaflets with oblique base, and for fruits ≥5.7 cm long in *S. macranthera* and *S. rizzinii*).

Senna chrysocarpa is categorized as least concern (LC), covering a range of occurrence of approximately 5.341.120,126 km².

In the study area, it was in flower from July to January and with fruit from November to January.

3. ***Senna georgica*** H.S.Irwin & Barneby var. ***georgica***, Mem. New York Bot. Gard. 35(1): 193, 1982.

Fig. 4

Shrub, ca. 1.5–4.0 m tall, upright or less frequently scandant; branches not very diffuse, cylindrical, glabrous. Stipules 5.0–7.0 mm long, falcate, caducous, glabrous. Leaves 12.2–23.2 cm long, petiole 2.4–4.8 cm long, glabrescent to sparse-pubescent, pulvinus 4.0–5.0 mm long; rachis 2.2–5.0 cm long; arrow 2.0–3.0 mm long, subulate; 1-nectary extrafloral, 4.0–5.0 mm long, ovoid, sessile, brown to blackish, glabrous, at the first pair of leaflets, occasionally in the second pair; petiolule 2.0–3.0 mm long, leaflets 4.2–13.3 × 2.2–8.5 cm, oval-elliptic to widely-elliptic, acuminate at the apex, rounded at base, non-glossy, concolors, membranous, glabrous on the adaxial surface, puberulent on the abaxial surface. Panicle 11.2–14.0 cm long, terminal; peduncle 1.9–2.8 cm long, subcylindrical, sparse-pubescent; flower buds oblong-obovate, rounded at the apex; bracts 2.0–3.0 mm long, linear, acute at the apex, caducous in anthesis, located at the base of the pedicel, glabrous. Flower 4.3–6.4 cm long, pedicel 1.7–4.2 cm long, sparse-pubescent; calyx with heteromorphic sepals, 6.0–18.0 × 4.0–12.0 mm, obovate to

oblong, rounded at the apex, pubescent externally; corolla with heteromorphic petals, 13.0–38.0 × 8.0–20.0 mm, oblong to oblanceolate, pubescent externally; 7-stamens fertile, filament glabrous, heteromorphic anthers, oblongs to linears, 2-pores, glabrous, abaxial stamens 14.0–23.0 mm long, medians stamens 9.0–10.0 mm long, staminodes 3.0 mm long; ovary 2.8–3.5 cm long, velutinous; stylus 2.0–3.0 mm long, sparse-pubescent; stigmatic cavity elliptic. Fruit 23.5–25.4 cm long, linear, compressed, pendulous, blackish, non-glossy, puberulent, chartaceous valves, not smooth, stipe 9.0–10.0 mm long. Seeds 4.0–6.0 x 3.0–4.0 mm, oblongs, browns, uniseriate.

Selected material examined: BRAZIL. Alagoas: Campo Alegre, Mata a dois Km da AL na direção da Cidade, 09/IX/1999, fl., *R.P. Lyra-Lemos et al. 4311* (IPA); Capela, Serra da Lagartixa, 16/X/2010, fl., *Chagas-Mota & J.M. Ferreira 9076* (MAC); Ibateguara, Alto do Guzerá, 27/X/2003, fl., *M. Oliveira 1436* (HUEFS, MAC, UFP); Quebrangulo, Reserva Biológica Pedra Talhada, 18/I/2011, fl., fr., *Chagas-Mota 9876* (MAC); São Miguel dos Campos, Balneário Tipiriça, 9º55'00"S, 36º02'30"W, 18/X/2001, fl., *R.P Lyra-Lemos & F.C. Silva 5851* (MAC); Teotônio Vilela, Usina Seresta, Reserva Madeiras, 03/X/2009, fl., *Chagas-Mota & V.G. Ramalho 5845* (MAC); Paraíba: Areia, Mata do Pau Ferro, 15/IX/1999, fl., *M.S. Pereira 130* (JPB); Cabedelo, Mata do Amém, 20/X/1999, fl., *A.F. Pontes 233* (JPB); João Pessoa, Campus I da UFPB, 7º08'18"S, 34º50'36"W, 26/XI/2015, fl., *L.H.L. Moreira & R.T. Queiroz 84* (JPB); ibid., Bacia Hidrográfica do Rio Timbó, 13/IX/2005, fl., *N.T. Amazonas 57* (JPB); Mamanguape, Rebio Guaribas - Área II, Mata Maranjá, 30/XI/2002, fl., fr., *A.C. Sevilha & G. Pereira-Silva 2585* (CEN, UFG); Rio Tinto, Reserva Biológica Guaribas, 6º48'12"S, 35º05'03"W, 03/XI/2009, fl., fr., *M.E.M. Fortunato & Z.G. Querino* 30 (JPB); Santa Rita, Usina São João, Tibirizinho, 7º57'S, 35º00'W, 31/X/1995, fl., *M.F. Agra et al. 3434* (JPB); Pernambuco: Bonito, Reserva Biológica de Bonito, 16/X/1996, fl., *J.E.G. Lima & L.A.B. Acioli 171* (IPA, PEUFR, UFP); Caruaru, Murici, Brejo dos Cavalos, Parque Ecológico Municipal,

10/X/1994, fl., *S. Mayo & I.M. Andrade 1042* (K); Goiana, Mata da Usina Santa Tereza, Ponta de Pedras, 26/XI/2013, fl., fr., *L.R. Silva 424* (HST, HUEFS, IBGE, RB); Igarassu, após o riacho de Santa Rita, 14/IX/1961, fl., *S. Tavares 818* (HST); ibid., Usina São José, 19/X/2007, fl., fr., *N.A. Albuquerque 512* (IPA); ibid., Mata Piedade, 24/I/2004, fl., *I.M.M. Sá & Silva & M.J. Silva 191* (PEUFR); ibid., Engenho Campinas, 7º47'44.78"S, 35º2'9.06"W, 17/XI/2008, fr., *L.M. Nascimento & G. Batista 752* (UFP); Recife, Campus da UFRPE, 02/III/1989, fl., *L.C. Gomes 51* (PEUFR); São Lourenço da Mata, Estação Ecológica do Tapacura, 19/X/1999, fl., *A.M. Miranda & G. Gamarras 3604* (HST); São Vicente Férrer, Mata do Estado, 25/IV/1999, fr., *E.M.N. Ferraz & A.G. Bispo 684* (HUEFS, PEUFR); Rio Grande do Norte: Baia Formosa, estrada que dá acesso a RPPN Mata Estrela, 6°24'31.7"S, 35°00'26.4"W, 26/IX/2019, fl., *F.S. Souto et al. 182*.

Senna georgica var. *georgica* was registered for Bolivia, Brazil, French Guiana and Paraguay (Irwin & Barneby 1982). In Brazil it occurs in Amazonas, Alagoas, Bahia, Ceará, Distrito Federal, Goiás, Maranhão, Mato Grosso, Mato Grosso do Sul, Pará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Tocantins, in the phytogeographic domains of the Amazon, Caatinga, Cerrado and Atlantic Forest (Dantas & Silva 2013; Santos et al. 2017; Silva et al. 2018). In the study area, it is referred to the Atlantic Forest of all states and their vegetation formations, occurring preferentially at the edge of the forest.

Senna georgica var. *georgica* is easily distinguished from the other species of the series Bacillares found in the study area, however in the herbaria, it is sometimes confused with *S. quinquangulata* var. *quinquangulata*. Characters such one extrafloral nectary, ovoid, leaflets with an acuminate apex, anthers with an apical pore and fruits with uniseriate seeds differ from *S. quinquangulata* var *quinquangulata*, which has two extrafloral nectaries, conical, leaflets with an cuspidate apex, anthers with two apical pores and fruits with biseriate seeds.

The species falls into the category of least concern (LC), covering a wide range of occurrence of about 4.687.267.362 km².

In the study area, it is in flower in March, May, July to January, and it is with fruits in January and from March to May and October.

It is popularly known as “lava-pratos”, the infusion of its leaves is used as a laxative (Silva & Andrade 2005 Agra et al. 2008). Maia et al. (2018) revealed the presence of stilbenes (compound with promising chemopreventive capacity) and naphtapirones in the roots of this species, as well as flavonoids in the leaves and stem barks.

4. ***Senna macranthera*** (DC. ex Collad.) H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 181, 1982.

Fig. 5

Shrub, ca. 1.0–2.0 m tall, upright; branches not very diffuse, cylindrical to subangled, tomentose. Stipules 4–6 mm long, linear, persistent, tomentose. Leaves 4.2–8.1 cm long, petiole 1.8–2.2 cm long, tomentose, pulvinus 1.5–2.0 mm long; rachis 0.5–0.6 cm long; arrow 1.0–1.5 mm long, ensiform; 1-nectary extrafloral, 2.0–3.5 mm long, fusiform to a ovoid, subsessile, orange, pubescent, at the first pair of leaflets; petiolule 2.0 mm long, leaflets 2.5–4,7 × 1.1–1.4 cm, elliptic to oval-elliptic, acute at the apex, strongly oblique base, non-glossy, discolors, chartaceous, pubescent on the adaxial surface, pubescent (var. *pudibunda*) to tomentose (var. *micans*) on the abaxial surface. Panicle 4.3–8.8 cm long, terminal; peduncle 2.4–4.7 cm long, cylindrical, tomentose; flower buds ovate-oblong, rounded at the apex; bracts 3.0–5.0 mm long, lanceolate to oblanceolate, acute at the apex, caducous before anthesis, located at the base of the pedicel, tomentose. Flower 2.6–3.5 cm long, pedicel 2.4–3.0 cm long, tomentose; calyx with heteromorphic sepals, 10.0–12.0 × 5.0–6.0 mm, oblong to obovate, rounded at the apex, pubescent externally; corolla with heteromorphic, 18.0–20.0 × 10.0–14.0 mm, obovate,

pubescent externally; 7-stamens fertile, filament sparse-pubescent, homomorphic anthers, oblongs, 2-pores, glabrous, abaxial stamens 11.5–13.0 mm long, medians stamens 7.0–8.5 mm long, staminodes 2.0–2.5 mm long; ovary 1.0–1.5 cm long, velutinous; stylus 2.0–4.0 mm long, tomentose; stigmatic cavity circular. Fruit 6.2–10.5 cm long, cylindrical, linear, pendulous, blackish, non-glossy, pubescent, chartaceous valves, not smooth, stipe 10.0–12.0 mm long. Seeds 5–6 × 4–5 mm, elliptics, dark brown, biseriate.

Selected material examined: BRAZIL. Alagoas: Quebrangulo, Reserva Biológica de Pedra Talhada, 9º15’22”S, 36º25’41”W, 05/X/2013, fl., *R.P. Lyra-Lemos et al. 13759* (MAC); ibid., 14/IV/2014, fl., *J.S. Correia et al. 121* (MAC); Paraíba: Areia, Mata do Pau Ferro, 15/IX/1999, fl., *M.S. Pereira 139* (JPB); ibid., Fazenda Junco, 27/IV/1989, fl., *L.P. Félix & F.C. Ramalho 1888* (EAN); Maturéia, Pico do Jabre, 7º11’10”S, 37º25’53”W, 12/VII/1997, fl., *M.F. Agra et al. 4109, 4117* (JPB); ibid., 10-15/V/1998, fl., *M.F. Agra & P.C. Silva 5441* (JPB, MO); ibid., 7º15'06"S, 37º22'58"W, 2003, fl., *M.M. Medeiros & A.L. Rangel 17* (JPB); ibid., 10/VI/2004, fl., *L.P. Félix et al. 10440* (EAN); Santa Rita, Curralinho, 05/VII/2012, fl., *T. Leão 999* (UFP); Pernambuco: Alagoinha, Km 8, 16/VIII/1996, fl., fr., *J.E. Gomes de Lima 119* (PEUFR); Altinho, Maciço do Tabocas, 8º33’45”S, 36º33’45”W, 19/I/1996, fl., *J.A. Siqueira-Filho 1521* (UFP); Bonito, Mata da prefeitura, 1990, fr., *V.C. Lima et al. s/n* (IPA); Cabo de Santo Agostinho, Engenho Matapajipe, 17/X/1962, fl., *Andrade Lima 62* (IPA); Goiana, Próximo a Br 101, 12/VII/1985, fl., *R. Pereira 37* (PEUFR); Maraial, Fazenda Céu Azul, 13/X/1957, fl., *Andrade Lima 57* (IPA); Pesqueira, Serra do Ororobá, Fazenda São Francisco, 30/V/1995, fl., *M. Correia 433* (HUEFS, UFP); ibid., Tribo Xucuru, Aldeia Pedra d'água, 27/VI/1995, fl., *V.A. Silva 27* (UFP); Recife, Capoeiras, IX/1937, fl., *Vasconcellos Sobrinho s/n* (IPA); ibid., Dois Irmãos, 01/I/1981, fl., *F. Ehrendorrfer 191* (IPA); Rio Grande do Norte: Natal, Campus universitário da UFRN, Centro de Biociências, 01/X/2004, fl., fr., *R.T. Queiroz 111* (JPB, PEUFR, UFP, UFRN); ibid., Dunas de Mãe Luiza, 06/IX/1953, fl., *S. Tavares 182*

(HST); ibid., Parque Estadual das Dunas de Natal, Bosque dos namorados, 04/XII/2006, fl., *M. Macedo & C. Dantas 04* (EAN).

Senna macranthera is a South American species, occurring in Brazil, Colombia, Ecuador, Peru and Venezuela (Irwin & Barneby 1982; Santos et al. 2017). In Brazil it occurs in Alagoas, Bahia, Ceará, Distrito Federal, Espírito Santo, Goiás, Maranhão, Minas Gerais, Mato Grosso, Paraíba, Pernambuco, Piauí, Paraná, Rio de Janeiro, Rio Grande do Norte, Santa Catarina, Sergipe, and Tocantins, in the domains of the Caatinga, Cerrado and Atlantic Forest (Azevedo & Conceição 2017; Correia & Conceição 2017; Santos et al. 2017). In the study area, it occurs in the Atlantic Forest of all states, inhabiting portions of Sub-Montane and Montane Semideciduous Seasonal Forests, and areas of Dense Lowland Rainforest, and some records in Restinga (coastal scrubs).

It is a polymorphic species, and eigth varieties were recognized by Irwin & Barneby (1982), from which five occur in Brazil, and two were registered in the study area. *Senna macranthera* is related to *S. pluribracteata* and *S. rizzinii*, differing from the former by having 1- nectary extrafloral and caducous bracts, located at the base of the floral pedicel (vs. 2-nectary extrafloral and persistent bracts, located along the peduncle in *S. pluribracteata*). Also, the combination of characters: petiole 1.8–2.2 cm long, adaxial surface of pubescent leaflets, lanceolate to oblanceolate bracts, caducous before anthesis, pubescent fruit differs from *S. rizzinii* (shorter petioles, 1.4–1.6 cm long, adaxial face of the tomentose leaflets, ovate bracts, persistent in anthesis, glabrous to glabrescent fruits).

It falls under the category of least concern (LC), covering a range of occurrence of approximately 8.584.427084 km².

In the study area it is found with flowers practically all year round, except for the months of February and december, and bearing fruit between July and November, in addition to the month of February.

Species popularly known as "aleluia", "bolão-de-ouro", "chuva-de-ouro", "fedegoso", "manduirana" e "pau-fava" (Rodrigues et al. 2005; Tozzi 2016). In folk medicine, the decoction of the fruit fights colds and flu, in addition, extracts from the leaf, root and bark revealed that the species has antioxidant properties (Maia et al. 2017; Neves et al. 2017).

Key for the varieties of *Senna macranthera* of the Atlantic Forest north of the São Francisco River

1. Leaflets 3.5–4.7 cm long, pubescent on the adaxial surface and tomentose o the abaxial surface ..... *S. macranthera* var. *micans*

– Leaflets 2.5–3.2 cm long, pubescent on both surfaces ..... *S. macranthera* var. *pudibunda*

4.1. ***Senna macranthera*** var. ***micans*** (Nees) H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 185, 1982.

Senna macranthera var. *micans* is endemic to Brazil, commonly occurring in areas of Caatinga, and areas of transition, distributed in the states of Alagoas, Bahia, Ceará, Mato Grosso, Mato Grosso do Sul, Paraíba, Pernambuco, Piauí, and Rio Grande do Norte (Irwin & Barneby 1982; Silva et al. 2018; Souza & Bortoluzzi 2020).

4.2. ***Senna macranthera*** var. ***pudibunda*** (Benth.) H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 186, 1982.

Senna macranthera var. *pudibunda* occurring preferentially in Caatinga areas in the states of Alagoas, Bahia, Ceará, Minas Gerais, Paraíba, Pernambuco, Piauí, and Rio Grande do Norte, and in areas of transition between Caatinga and Cerrado (Souza & Bortoluzzi 2020).

5. ***Senna pinheiroi*** H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 180, 1982.

Fig. 6

Shrub, ca. 1.5–2.0 m tall, scandant; branches not very diffuse, subcylindrical, tomentose. Stipules 3.0–4.0 mm long, linears, persistents, tomentose. Leaves 5.2–8.5 cm long, petiole 2.0–2.5 cm long, tomentose, pulvinus 2 mm long; rachis 0.6–1.1 cm long; arrow 2.0 mm long, linear; 2- nectaries extraflorals, 2.0–4.0 mm long, conical, subsessile, yellow to orange, glabrous, between the leaflets; petiolule 2.5–3.0 mm long, leaflets 1.8–7.5 × 1.8–2.6 cm, ovals to elliptic, acuminate at the apex, oblique base, glossy on the adaxial surface, discolors, chartaceous, pubescente on the adaxial surface, tomentose on the abaxial surface. Raceme 4.8–5.5 cm long, axillary; peduncle 1.6–2.5 cm long, cylindrical, tomentose; flower buds oblong-obovate, rounded at the apex; bracts 3.0–4.0 mm long, lanceolate, acuminate at the apex, caducous in anthesis, located at the base of the pedicel, sparse-tomentose. Flower 2.6–5.2 cm long, pedicel 2.0–2.8 cm long, tomentose; calyx with homomorphic sepals, 10.0–11.0 × 4.0–5.0 mm, narrowly-ovate, acute at the apex, tomentose externally; corolla with heteromorphic petals, 14.0–32.0 × 10.0–19.0 mm, orbicular to obovate, pubescent externally; 7-stamens fertile, filament narrowly-pubescent, heteromorphic anthers, oblong to linear, glabrous, abaxial stamens 11.0–15.0 mm long, medians stamens 9.0–10.0 mm long, staminodes 3.0–4.0 mm long; ovary 0.8–1.0 cm long, tomentose; stylus 3.0–4.0 mm long, tomentose; stigmatic cavity punctiform. Fruit 19.3–23.1 cm long, subcylindrical, pendulous, blackish, glossy, sparse-tomentose, chartaceous valves, smooth, stipe 2.0–8.0 mm long. Unobserved seeds.

Selected material examined: BRAZIL. Alagoas: Coruripe, Usina Coruripe, Fazenda Capiatã, 05/V/2005, fl., *R.P. Lyra-Lemos 8668* (MAC); Ibateguara, Serra do Sacramento, 17/V/1984, fl., fr., *M.N.R. Staviski & A.I.L. Pinheiro 740* (MAC); Junqueiro, Km 191 da BR 101, 15/VII/1980, fr., *G.L. Esteves & V.F. Ferreira 499* (MAC); Maceió, Parque Municipal de Maceió, 06/III/1999, fl., *R.P. Lyra-Lemos & I.A. Bayma 4137* (MAC); ibid., Serra da Saudinha, Fazenda Cela, 14/VI/2008, fr., *Chagas-Mota 656* (MAC); Murici, Poço D´Anta, ca. 16/19 km

NNW of Muricí by road. Mata de Muricí, 14/V/2001, fl., *W.W. Thomas et al. 12424* (RB); ibid., Bananeiras, 9º13'47"S, 35º52'78"W, 16/III/2002, fl., *A.M. Carvalho et al. 7123* (MAC); Paraíba: João Pessoa, Campus I da UFPB, 27/VII/1993, fr., *O.T. Moura 1052* (JPB, RB); ibid., Bacia Hidrográfica do Rio Timbó, 28/VI/2006, fl., *N.T. Amazonas 194* (JPB); ibid., Mata Ciliar do Rio Cabelo, 12/V/2011, fl., *L.A. Pereira & E.C.O. Chagas 263* (JPB); Mamanguape, Reserva Biológica Guaribas, Caiana/SEMA II, 05/IV/1989, fl., *L.P. Félix s/n* (JPB); ibid., 24/V/1990, fl., *L.P. Félix & E.S. Santana 3056* (JPB); ibid., Capim Azul, 22/V/1990, fl., fr., *L.P. Félix & E.S. Santana 3009* (EAN, JPB); Rio Tinto, Fragmento de Mata na PB 114, 29/III/2012, fl., *P.C. Gadelha Neto 3250* (JPB, RB); Santa Rita, 12/XI/1991, fl., *M.F. Agra & G. Góis 1541* (JPB); Pernambuco: Goiana, 30/V/1935, *B. Pickel 3863* (IPA); Goiana, Usina N. S. Maravilhas, 23/III/1956, fl., *Andrade-Lima 56/2545* (IPA); Igarassu, Usina São José, 20/V/1960, fl., *Andrade-Lima 60/3464* (IPA); ibid., 7º43'32"S, 34º59'13"W, 17/VII/2007, fl., *A. Alves-Araújo et al. 431* (UFP); ibid., 17/VII/2007, *N.A. Albuquerque et al. 292* (IPA); Maraial, Serra do Urubu, 19/IV/1994, fl., *A.M. Miranda & L.P. Félix 1511* (ASE, PEUFR, RB); Olinda, Praia de Olinda, 03/IV/1948, fl., *C. Leal s/n* (IPA); Recife, Tejipió, Fazenda Modelo, 14/XII/1949, fl., *Andrade-Lima 49/381* (IPA); ibid., Restinga de Piedade, 20/V/1950, fl., *Andrade-Lima 50/474* (IPA).

Senna pinheiroi is an endemic species of Brazil, occurring in Alagoas, Bahia, Paraíba, Pernambuco, Rio de Janeiro and Sergipe, in the phytogeographic domains of the Caatinga and Atlantic Forest (Irwin & Barneby 1982; Souza & Bortoluzzi 2020). In the study area it occurs in the Atlantic Forest of the states of Alagoas, Paraíba and Pernambuco, being frequent in the humid portions of Dense Ombrophilous Forest and Semideciduous Seasonal Lowland Forest, in addition to Restinga, with some records in "Brejos de Altitude".

Senna pinheiroi shares some morphological characters with *S. pluribracteata*, such as: linear stipules, two extrafloral nectaries, leaflets with an oblique base, and raceme-type

inflorescences. However, *S. pinheiroi* can be easily distinguished by presenting tomentose branches, conical extrafloral nectaries, glossy leaflets on the adaxial surface, lanceolate bracts, and heteromorphic calyx (vs. strigose branches, claviform extrafloral nectaries, non-glossy leaflets on the adaxial surface, elliptic bracts, and homomorphic calyx in *S. pluribracteata*).

It is categorized as least concern (LC), covering a range of occurrence of about 126.491.114 km².

Registered with flowers in the study area between February to July and in the months of November and December, and bearing fruit between May and August.

6. ***Senna pluribracteata*** F.S.Souto & R.T.Queiroz, Systematic Botany 46(2): 2021.

Fig. 7

Shrub, ca. 1.0 m tall, upright; branches not very diffuse, cylindrical, strigose. Stipules 8–12 mm long, linear, persistent, strigose. Leaves 6.8–7.8 cm long, petiole 1.6–2.6 cm long, strigose, pulvinus 2.0–3.0 mm long; rachis 0.9–1.1 cm long; arrow 2.0–2.2 mm long, subulate; 2-nectaries extrafloral, 3.0–4.0 mm long, claviform, stipitate, somewhat orange, pubescent, between the leaflets, occasionally at the first pair; petiolule 1.0–1.5 mm long, leaflets 3.2–5.0 × 1.6–1.9 cm, ovate to elliptic, acute at the apex, oblique at base, non-glossy, discolors, chartaceous, strigose on both surfaces. Racemes 4.1–9.8 cm long, axillary or terminal; peduncle 3.6–8.5 cm long, cylindrical, strigose; flower buds oblong, rounded at the apex; bracts 7.0–9.0 mm long, elliptic, acuminate at the apex, persistent in anthesis, located along the peduncle, strigose. Flower 3.0–3.2 cm long, pedicel 1.0–1.5 cm long, strigose; calyx with heteromorphic sepals, 6.0–9.0 × 3.0–5.0 mm, oblong, rounded at the apex, externally strigose; corolla with homomorphic petals, 18.0–20.0 × 15.0–22.0 mm, obovate, externally strigillose; 7-stamens fertile, filament glabrous, heteromorphic anthers, oblong, 2-pores, glabrous, abaxial stamens 8.0–10.0 mm long, medians stamens 7.0–7.5 mm long, staminodes 2.0 mm long; ovary 11.0–

13.0 mm long, velutinous; stylus 4.0–5.0 mm long, glabrous; stigmatic cavity elliptic. Fruit 4.8–5.8 cm long, cylindrical, linear, straight, black at maturity, glossy, strigillose, chartaceous valves, smooth, stipe 4.0–5.0 mm long. Seeds 4.0–5.5 mm long, ovate, blackish, biseriate.

Selected material examined: BRAZIL. Paraíba: Sapé, RPPN Fazenda Pacatuba, 7º2'6.80"S, 35º8'48.60"W, 22/XI/2019, fl., fr., *F.S. Souto et al. 188* (UFP, JPB).

Senna pluribracteata is an endemic species to Northeastern Brazil, only found in an area of Tabuleiro Forest, at altitudes of 20-200 m a.s.l., in the state of Paraíba (Souto et al. 2021).

Morphologically, *S. pluribracteata* is related to *S. macranthera*, *S. pinheiroi* and *S. rizzinii* (taxonomic affinities with the first two species were discussed previously in the taxonomic notes of the respective species). *S. pluribracteata* differs from *S. rizzinii* in that it has strigose branches, two extrafloral nectaries, and elliptic bracts (*vs*. tomentose branches, one extrafloral nectary, and ovate bracts in *S. rizzinii*).

The specie was described based on a single collection, for this reason *S. pluribracteata* should be classified as "Data deficient" (DD), according to the IUCN (2019) criteria.

It was flowered and fructified in November.

7. ***Senna quinquangulata*** (Rich.) H.S.Irwin & Barneby var. ***quinquangulata***, Mem. New York Bot. Gard. 35(1): 153, 1982.

Fig. 8

Shrub, ca. 1.5–4.0 m tall, upright to scandant; branches not very diffuse, angled, glabrescent. Stipules 10.0–12.0 mm long, falcate, caducous, glabrous. Leaves 14.0–18.7 cm long, petiole 4.1–5.0 cm long, pubescent, pulvinus 3–4 mm long; rachis 2.4–3.1 cm long; arrow 2.0–3.0 mm long, elliptic; 2-nectaries extraflorals, 4.0–5.0 mm long, conical, sessile, blackish, glabrous, between the leaflets; petiolule 2.5–3.0 mm long, leaflets 6.4–11.8 × 4.1–6.6 cm,

widely-elliptic to oval-elliptic, cuspidate at the apex, oblique base, non-glossy, discolors, membranous, glabrous on the adaxial surface, pubescent on the abaxial surface. Panicle 14.2–15.7 cm long, terminal; peduncle 1.6–4.2 cm long, subcylindrical, pubescent; flower buds obovate, rounded at the apex; bracts 4–6 mm long, falcate, acute at the apex, caducous in anthesis, located at the base of the pedicel, glabrous. Flower 1.5–1.8 cm long, pedicel 0.9–1.1 cm long, pubescent; calyx with homomorphic sepals, 7–8 × 3–4 mm, oblongs, rounded at the apex, pubescent externally; corolla with homomorphic petals, 12–14 × 6–7 mm, obovate, pubescent externally; 7-stamens fertile, filament glabrous, homomorphic anthers, oblongs, 2-pores, glabrous, abaxial stamens 11–12 mm long, medians stamens 8–10 mm long, staminodes 1.0–1.5 mm long; ovary 1.8–2.3 cm long, velutinous; stylus 4–5 mm long, narrowly-velutinous; stigmatic cavity elliptic. Fruit 14.6–30.2 cm long, subcylindrical, flat, pendulous, blackish, non-glossy, glabrous, woody valves, not smooth, stipe 2–5 mm long. Seeds 4–5 × 3 mm, oblongs, blackish, biseriate

Selected material examined: BRAZIL. Alagoas: Barra de Santo Antônio, Fazenda Santa Rosa, 08/III/1982, fl., *M.N.R. Staviski & R.P. Lyra-Lemos 872* (MAC); Capela, Serra da Lagartixa, 05/VI/2009, fl., fr., *Chagas-Mota & A.I.L. Pinheiro 3967* (MAC); Ibateguara, Usina Serra Grande, Mata Petrópolis, 8º58’32”S, 35º55’46”W, 14/III/2010, fl., *F. Cavalcante & M.C.S. Mota 395* (MAC); Maceió, Usina Cachoeira, Fazenda Boa Vista, 9º38’59”S, 35º42’32”W, 15/X/2004, fr., *A.C. Martins-Monteiro et al. 118* (MAC); Murici, Serra do Ouro, 9º14’74”S, 35º50’59”W, 15/III/2002, fl., *R. Lemos et al. 6295* (MAC); Pilar, Fazenda Lamarão, 9º38’S, 35º54’W, 09/VIII/2001, fl., *R.P. Lyra-Lemos et al. 5737* (MAC); Rio Largo, Usina Leão, 28/IX/2006, fr., *P.A.F. Rios et al. 90* (MAC); Satuba, Reserva do Catolé, 22/IX/2006, fl., fr., *P.A.F. Rios et al. 03* (MAC); Viçosa, Fazenda Jussara, 28/I/2010, fr., Chagas-Mota 7177 (MAC); Paraíba: Areia, Mata do Pau Ferro, 28/VIII/1980, fl., *Andrade-Lima et al. 156* (EAN); ibid., 17/X/1988, fl., *L.P. Félix & G.V. Dornelas 1418* (EAN); ibid., 6º58’12”S, 35º42’15”W,

03/VIII/2018, fl., *J.M.P. Cordeiro 1373* (EAN); João Pessoa, 15º BIMTz, 7º06'54"S, 34º51'47"W, 11/VI/2010, fl., L.*A.F. Vieira et al. 21* (JPB); Mamanguape, Cabeça de Boi, SEMA II, 06/III/1990, fl., *L.P Félix & E.S. Santana 2772* (EAN, JPB); Rio Tinto, Fragmento na PB 114, 6º46'28"S, 35º06'26"W, 29/III/2012, fl., *P.C. Gadelha Neto 3249* (JPB); Pernambuco: Bonito, Reserva Municipal de Bonito, 21/V/1996, fr., *L.F. Silva et al. 239* (IPA); Cabo de Santo Agostinho, Gurjaú/Mata do Cuxio, 8º13'37.8"S, 35º04'10.8"W, 05/II/2003, fl., *J.B.S. Oliveira et al. 09* (UFP); Goiana, RPPN Fazenda Tabatinga, 04/III/2010, fl., *D. Cavalcanti & B.S. Amorim 170* (UFP); Igarassu, Mata de Cruzinha, 7º42'22.4"S, 34º57'47.8"W, 26/XI/2009, fl., fr., *J.D. Garcia 1336, 1338* (UFP, IPA); Jaqueira, RPPN Frei Caneca, Mata do Cruzeiro, 8º43'12.4"S, 35º50'40.0"W, 16/III/2003, fl., *A. Viana 273* (UFP); Maraial, Lagoa dos Gatos, Serra do Urubu, 19/IV/1994, fl., fr., *A.M. Miranda & L.P. Félix 1528* (HST, PEUFR); Recife, Dois Irmãos - Campus UFRPE, 22/IV/1992, fl., *L.C. Gomes 199* (PEUFR); ibid., Mata de Dois Irmãos, 28/VIII/1949, fl., *Andrade Lima 49-283* (IPA); ibid., Santuário dos Três Reinos, 07º57'44.9"S, 34º56'20.2"W, 04/II/2014, fl., *L.A. Silva et al. 46* (UFP).

Senna quinquangulata var. *quinquangulata* presents distribution from Mexico to Bolivia (Irwin & Barneby 1982). It is registered in Brazil in the followig states: Acre, Alagoas, Amazonas, Amapá, Bahia, Ceará, Maranhão, Mato Grosso, Pará, Paraíba, Pernambuco, Rio de Janeiro, Rondônia and Roraima. It occurs in the domains of the Amazon, Caatinga, and Atlantic Forest (Silva et al. 2018; Souza & Bortoluzzi 2020). In the study area it occurs in the Atlantic Forest of the states of Alagoas, Paraíba and Pernambuco, frequent in the humid portions of Dense Ombrophilous Forest, and in Restinga, with some records in "Brejos de Altitude".

The taxonomic affinities of *S. quinquangulata* var. *quinquangulata* were discussed in the notes of *S. georgica* var. *georgica.*

The species falls into the category of least concern (LC), covering a range of occurrence of approximately 24.614.405.178 km².

It was in flower from January to November, and fructified in April and November.

This species is popularly known as “fedegoso-grande”, “lava-pratos” or “mamangá”, which its seeds and roots are used for psychoactive purposes (Otsuka et al. 2010).

8. ***Senna rizzinii*** H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 174, 1982.

Fig. 9

Shrub, 1.0–2.0 m tall, upright; branches not very diffuse, cylindrical, tomentose. Stipules 5.0–6.0 mm long, linears, persistents, tomentose. Leaves 4.7–5.0 cm long, petiole 1.4–1.6 cm long, tomentose, pulvinus 1.0–1.5 mm long, rachis 0.5–0.8 cm long; arrow 1.5–2.0 mm long, ensiform; 1-nectary extrafloral, 2.0 mm long, fusiform to conical, stipitate, blackish, sparse-pubescent, at the first pair of leaflets; petiolule 1.0–1.5 mm long, leaflets 1.8–4.4 × 1.0–1.7 cm long, ovate to ovate-elliptic, acute to obtuse at the apex, oblique base, non-glossy, discolors, chartaceous, pubescente on the adaxial surface, tomentose on the abaxial surface. Raceme 4.5–5.0 cm long, axillary; peduncle 1.2–1.4 cm long, cylindrical, tomentose; flower buds oblong, rounded at the apex; bracts 4.0 mm long, ovate, acute at the apex, persistent, located at the base of the pedicel, sparse-tomentose. Flower 2.6–3.3 cm long, pedicel 1.6–1.8 cm long, tomentose; calyx with heteromorphic sepals, 6.0–8.0 × 3.0–4.0 mm, obovate to oblongs, rounded at the apex, pubescent externally; corolla with heteromorphic, 10.0–12.0 × 5.0 mm, oblongs to obovate, sparse-pubescent externally; 7-stamens fertile, filament sparse-pubescent, homomorphic anthers, oblong-linears, 2-pores, glabrous, abaxial stamens 9.0–11.0 mm long, medians stamens 7.0–9.0 mm long, staminodes 2.0 mm long; ovary 1.8–2.0 cm long, velutinous; stylus 2.0–3.0 mm long, tomentose; stigmatic cavity circular. Fruit 5.7–8.5 cm long,

cylindrical, straight, blackish, glossy, glabrous to glabrescent, chartaceous valves, smooth, stipe 3.0–6.0 mm long. Unobserved seeds.

Selected material examined: BRAZIL. Alagoas: Mata Grande, subida para a Serra do Ouro, 9º70'89"S, 37º42'33"W, 25/VIII/2007, fl., *R.P. Lyra-Lemos et al. 10514* (MAC); ibid., estrada de Mata Grande para Stª Cruz, 9º7'51.8"S, 37º45'05"W, fl., 26/VIII/2007, *R.P. Lyra-Lemos et al. 10567, 10589* (MAC); São Miguel, 3 km depois do entroncamento da Al-101 com Al-201, 25/VIII/1988, fl., *M.N.R. Staviski 867* (K, MAC); Paraíba: Areia, 24/IX/1958, fl., fr., *J.C. Moraes 1574* (EAN); ibid., CCA, 17/VI/1986, fl., *L.P. Félix & G.V. Dornelas 163* (EAN); ibid., Mata do Pau Ferro, 24/IX/1987, fl., *F.C. Ramalho et al. 17* (EAN); ibid., Jardim Cidade Universitária, 6º58'43.04"S, 35º42'40.76"W, 04/X/2016, fl., fr., *P.C. Gadelha Neto 4041* (EAN); Mamanguape, Reserva Florestal do INCRA, 26/X/1982, fl., *C.A.B. Miranda et al. 165* (JPB); ibid., Estação Ecológica de Mamanguape, 06/VII/1988, fl., *C.A.B. Miranda & L.P. Félix s/n* (JPB); ibid., Cabeça de Boi, Sema II, 31/VIII/1989, fl., *L.P. Félix & E.S. Santana 2189* (EAN, JPB); ibid., Trilha do Poste de Cimento, 6º42'37"S, 35º11'43"W, 12/VIII/2011, fl., *R.A. Pontes & R.C. Duré 727* (JPB); Maturéia, Pico do Jabre, 30/VI/1979, fl., fr., *A. Fernandes s/n* (HUEFS, UFRN); ibid., 7º11'10"S, 37º25'53"W, 18/V/2002, fl., *M.F. Agra et al. 5905* (HUEFS, JPB); Pernambuco: Garanhuns, PE-218, 06/II/1998, fr., *P. Silva et al. 41* (UFP); Jataúba, Fazenda Balame, 28/VII/1995, fl., *F.B.P. Moura 246* (MAC); Pesqueira, Serra do Ororobá, Faz da Fazenda São Francisco, 27/VI/1995, fl., *M. Correira 265* (HUEFS, UFP); ibid., 28/IX/1995, fl., fr., *M. Correira 367* (HUEFS, UFP); ibid., 16/VIII/1996, fl., *J.E. Gomes de Lima 124* (PEUFR); Rio Grande do Norte: Baía Formosa, 20/XI/1984, fl., *A.D.R. Flor & A. Roberto 181* (IPA, UFRN); Tibau do Sul, Santuário Ecológico de Pipa, 06/VIII/1999, fl., *Y. Arns 220* (IPA); Natal, 29/VIII/1992, fl., *L.P. Félix 5181* (EAN); ibid., Parque da Cidade, 27/VI/2007, fl., *R. Sena et al. 182* (HUEFS, UFRN).

Senna rizzinii is an endemic species to Brazil, occurring throughout the Northeast region in the domains of Caatinga and Cerrado, with some records in coastal dunes (Irwin & Barneby 1982; Queiroz 2009; Azevedo & Conceição 2017; Souza & Bortoluzzi 2020). In the study area it was registered for the Atlantic Forest of all states, being more common in areas of Seasonal Semideciduous Forest and Dense Ombrophylous Forest, both Sub-montana and Montana ("Brejos de Altitude"), and in portions of Lowland Forests (Tabuleiros).

It is morphologically related to *S. macranthera* and *S. pluribracteata*, in which their affinities were discussed in the taxonomic notes of the respective species.

Senna rizzinii falls into the category of least concern (LC), covering an extent of occurrence of about 745.692.370 km².

In the study area it was recorded with flowers from May to November and with fruits from September to February.

9. ***Senna rugosa*** (G. Don) H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 188, 1982.

Fig. 10

Shrub, ca. 3.0 m tall, upright; branches diffuse, cylindrical, tomentose. Stipules 4.0–6.0 mm long, narrowly-lanceolate, caducous, glabrous. Leaves 10.4–17.2 cm long; petiole 0.7–1.2 cm long, tomentose, pulvinus 3.0 mm long; rachis 1.5–2.1 cm long; arrow 3.0 mm long, linear; 2-nectaries extraflorals, 2.0–3.0 mm long, ovoid, sessile, blackish, sparse-tomentose, between the leaflets; petiolule 2.0–2.5 mm long, leaflets 3.1–11.5 × 1.6–3.8 cm, elliptics to oblongs, obtuse at the apex, oblique base, non-glossy, discolors, coriaceus, pubescent on the adaxial surface, tomentose on the abaxial surface. Raceme 17.8–18.4 cm long, axillary to terminal; peduncle 2.8–3.2 cm long, cylindrical, tomentose; flower buds unobserved; bracts 2.0–3.0 mm long, ovate to elliptic, acut at the apex, caducous in anthesis, located at the base of the pedicel,

tomentose. Flower 4.7–6.2 cm long, pedicel 3.2–3.8 cm long, tomentose; calyx with heteromorphic sepals, 6.0–8.0 × 3.0–4.0 mm, obovate to oblong, obtuse at the apex, tomentose externally; corolla with heteromorphic petals, 10.0–29.0 × 10.0–17.0 mm, orbicular to obovate, narrowly-tomentose externally; 7-stamens fertile, filament narrowly-pubescent, heteromorphic anthers, oblongs to linears, 2-pores, glabrous, abaxial stamens 11.0–18.0 mm long, medians stamens 8.0–9.0 mm long, staminodes 2.5–3.0 mm long; ovary 1.2 cm long, velutinous, stylus 3.0–4.0 mm long, glabrous, stigmatic cavity punctiform. Fruit 12.7–16.2 cm long, cylindrical, pendulous, blackish, glossy, glabrous, valves leathery, not smooth, stipe 5.0–7.0 mm long. Seeds 4.0–6.0 × 4.5–5.0 mm, oblong, blackish, biseriate.

Selected material examined: BRAZIL. Pernambuco: Caruaru, Parque Ecológico Municipal, 8°18’36.0”S, 36°00’00”W, 25/II/1994, fl., fr., *M.B. Costa e Silva et al. s/n* (PEUFR); *ibid*., 25/V/1995, fr., *M.C. Tschá et al. 91* (PEUFR); *ibid*., 01/VI/1995, fl., *M.R.C. Sales de Melo 43* (PEUFR); ibid., 01/VI/1995, fl., *F.M. Villarouco et al. 63* (PEUFR!).

Additional material examined: BRAZIL. Bahia, São Desidério, Sítio Rio Grande, Barragem Rio das Fêmeas, 12°26’30.0”S, 45°09’50.0”W, 12/VI/2008, fl., fr., *M. Oliveira 3451* (UFP).

Senna rugosa is an endemic species of South America occurring in Bolivia, Brazil and Paraguay (Irwin & Barneby 1982). In Brazil it was registered from North to South in the states of Bahia, Ceará, Distrito Federal, Goiás, Maranhão, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Pará, Pernambuco, Piauí, Paraná, Rondônia, São Paulo and Tocantins, with wide distribution in the Cerrado, between altitudes of 300-1.500 meters, and less frequently in the Amazon, Caatinga, and Atlantic Forest domains (Dantas & Silva 2013; Souza & Bortoluzzi 2020). It occurs in the study area in the Atlantic Forest of Pernambuco in an area of Seasonal Semideciduous Forest (“Brejos de Altitude”).

It can be distinguished from the other *Senna* species occurring in the study area by its smaller petiole than the rachis (0.7–1.2 cm long vs. 1.5–2.1 cm long), coriaceus leaflets, and ovate to elliptic bracts, caducous at the anthesis.

Senna rugosa falls into the category of least concern (LC), covering a range of occurrence of approximately 4.108.946.796 km².

It was registered in flowers from February to June.

In folk medicine, the leaf extracts are used to heal wounds, and also have anti-bacterial properties (Fenner et al. 2006). The roots are used as a dewormer, as a decoction or infusion (Rodrigues & Carvalho 2001).

10. ***Senna splendida*** var. ***gloriosa*** H.S.Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 192, 1982.

Fig. 11

Shrub, ca. 1.0–3.0 m tall, upright; branches not very diffuse, cylindrical, glabrous. Stipules 4.0–7.0 mm long, falcate, persistents, glabrous. Leaves 7.0–8.5 cm long, petiole 1.4–2.5 cm long, glabrous, pulvinus 3.0–4.0 mm long; rachis 0.8–1.3 cm long; arrow 2.0 mm long, linear; 1-nectary extrafloral, 2.0–3.0 mm long, conical, sessile, greenish, glabrous, at the first pair of leaflets; petiolule 2.0 mm long, leaflets 3.2–6.9 × 1.9–3.1 cm, oblongs, elliptics to narrowly-elliptics, obtuse at the apex, rounded to discreetly oblique base, non-glossy, discolors, membranous, glabrous on both surfaces. Raceme 8.5–10.8 cm long, axillary; peduncle 4.2–6.0 cm long, cylindrical, glabrous; flower buds oblong, rounded at the apex; bracts 8.0–9.0 mm long, ovate to ovate-lanceolate, acute at the apex, caducous in anthesis, located at the base of the pedicel, glabrous. Flower 4.2–6.5 cm long, pedicel 2.0–2.6 cm long, glabrous; calyx with heteromorphic sepals, 12.0–25.0 × 5.0–10.0 mm, oblongs to ovals, acute at the apex, glabrous externally; corolla with heteromorphic, 20.0–44.0 × 13.0–28.0 mm, oblongs to oblong-

obovates, glabrous externally; 7-stamens fertile, filament glabrous, heteromorphic anthers, linear to oblong, 2-pores, glabrous, abaxial stamens 18.0–28.0 mm long, medians stamens 10.0–12.0 mm long, staminodes 4.0–6.0 mm long; ovary 2.7–4.0 cm long, sparse-pubescent; stylus 2.0–3.0 mm long, pubescent, stigmatic cavity elliptic. Fruit 22.5–24.6 cm long, subcylindrical, pendulous, dark brown, non-glossy, glabrous, leathery valves, smooth, stipe 9.0–11.0 mm long. Seeds 5.0 × 4.0 mm long, oblongs, blackish, biseriate.

Selected material examined: BRAZIL. Alagoas: Coruripe, Poxim, 18/VIII/2011, fl., *Chagas-Mota et al. 10901* (MAC); Maravilha, Serra da Caiçara, 9º14’20”S, 37º13’04”W, 23/III/2006, fr., *R.P. Lyra-Lemos et al. 9256* (MAC); Marechal Deodoro Sítio Beira Mar, 25/VIII/1997, fl., fr., *M.N.R. Staviski et al. 1047* (MAC); Mucuri, 24/VIII/1999, fl., fr., *R.P. Lyra-Lemos & I.A. Bayma 4211* (MAC); Penedo, Buçu em direção a Penedo, 29/VII/1981, fl., *G.L. Esteves 802* (MAC); Piaçabuçu, Jacozinho em direção a Penedo, 22/IX/1987, fl., *M.N.R. Staviski et al. 996* (EAC, ESA, MAC, RB); ibid., Ponta da Terra, 03/IX/1987, fl., fr., *R.P. Lyra-Lemos et al. 1301* (MAC); Paraíba: Mamanguape, Cabeça de Boi, 31/VIII/1989, fl., *L.P. Félix & E.S. Santana 2153* (EAN, JPB); ibid., ASPLAN, Camaratuba, 11/X/2009, fr., *D.B.O. Abreu et al. 17* (EAN); Maturéia, Pico do Jabre, 29/VII/1991, fl., *L.P. Félix & S.F. Vasquez 4088* (EAN); ibid, 30/X/1997, fl., *M.F. Agra & Sr. Paulo 4811* (JPB, MO); ibid., 12/VII/2019, fl., *F.S. Souto et al. 165* (UFP, JPB); Pernambuco: Goiana, Capaeira, IX/1937, fl., *Vasconcelos Sobrinho s/n* (IPA); Recife, 13/IX/1960, fl., *P. Miranda s/n* (PEUFR); ibid., Derbi, IX/1970, fl., *I.C. Leão 80* (UFP, PEUFR,); ibid., Cidade universitária, Campus da UFPE, 02/XI/1985, fl., *L.A. Amazonas et al. 02* (IPA); Rio Grande do Norte: Baia Formosa, margem da estrada que dá acesso a RPPN Mata Estrela, 26/IX/2019, fl., fr., *F.S. Souto et al. 183*; Extremoz, Genipabu, estrada para praia de Genipabu, 08/VIII/2008, fl., H. *C. Lima & R. D. Ribeiro 7058* (HUEFS, RB); Natal, Dunas de Mãe Luiza, 06/IX/1953, fl., *S. Tavares 186* (IPA, UFP); ibid., UFRN, Centro de Biociências, 11/VI/2002, fl., fr., *I. Loiola et al. 696* (JPB, UFP, UFRN); ibid., Parque

das Dunas, Trilha da Geologia, 29/VII/1999, fl., fr., *L.A. Cestaro 99* (UFRN); ibid., Bosque dos Namorados, 04/XII/2006, fr., *C. Dantas & M. Macedo 04* (UFRN); Nísia Floresta, 12/X/2016, fl., fr., *T.W. Alves 01* (UFRN); Parnamirim, Mata do Jequi, 28/XI/2007, fl., fr., *M.L. Mota et al. 04* (UFRN); Tibau do Sul, Santuário Ecológico de Pipa, 06/VIII/1999, fl., *Y. Arns 218* (IPA).

Senna splendida is native of Brazil, Paraguay and Uruguay, and introduced in Africa and Asia (Irwin & Barneby 1982; Silva et al. 2018). Irwin & Barneby (1982) recognized two varieties, being *S. splendida* var. *gloriosa* endemic to Brazil and registered in the states of Alagoas, Bahia, Ceará, Goiás, Minas Gerais, Paraíba, Pernambuco and Rio Grande do Norte, in areas of Caatinga, Cerrado and Atlantic Forest (Queiroz 2009; Santos et al. 2017; Souza & Bortoluzzi 2020). In the study area, it was registered for the Atlantic Forest of all states, occurring in all vegetal formations.

Senna splendida var. *gloriosa* is easily recognized and distinguished from others, for being a glabrous plant, except the ovary, in addition to its falcate and persistente stipules, leaflets elliptic, oblong or narrowly-ovate.

The species is categorized as of least concern (LC), covering a wide range of occurrences ca. 19.016.539.470 km².

It was recorded in flower from May to November, and with fruits from June to September.

Species popularly known as “canafístula”, “fedegoso-grande” and “feijão-brabo”. In folk medicine its leaves are used to accelerate menstrual flow, as an infusion (Rodrigues & Carvalho 2001; Agra et al. 2008). Leaf extracts revealed the presence of different secondary compounds (anthraquinones, flavonoids, phenolics, steroids, tannins, triterpenoids, xanthones and glycosides), while the flowers extracts have showed antioxidant activity (Silva et al. 2014; Maia et al. 2017).

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List of specimens analyzed

Abreu DBO. 17 (10). **Agra MF.** s.n. (EAC 7073) (5), 1541 (5), 1942 (8), 1949 (8), 1991 (4), 3434 (3), 4109 (4), 4117 (4), 4208 (4), 4523 (4) 4559 (4), 4811 (10), 5112 (4), 5208 (4), 5231 (4), 5441 (4), 5905 (8). **Aguiar AJC.** 101 (8). **Albuquerque NA.** 292 (5), 512 (3). **Alves H.** s.n. (UFP 3871) (5). **Alves PB.** 53 (2), 89 (7), 167 (5). **Alves TW.** 01 (10). **Alves-Araújo A.** 431 (5), 670 (3). **Alves-Silva** JW. 1637 (2). **Alvino LD.** 40 (4). **Amazonas LA.** 02 (10). **Amazonas NT.** 57 (3), 194 (5). **Andrade Lima D.** 49-283 (7), 49-381 (5), 50-474 (5), 56-2545 (5), 57 (4), 60-3464 (5), 62 (4), 63 (2), 156 (7). **Araújo GB.** 87 (7), 367 (5). **Araújo SF.** 196 (2). **Arns Y.** 220 (8), 246 (10). **Baracho GS.** 176 (2). **Barbeiro SMC.** 2354 (5). **Barbosa E.** 58 (5). **Barbosa MR.** 1366 (3), 2446 (5). **Barreto R.** 83 (7). **Bayma IA.** 08 (5), 553 (2). **Bezerra GJ.** 46 (3). **Bispo Júnior VS.** 07 (3). **Botter M.** s.n. (PEUFR 21590) (3). **Cabral MCC.** 05 (7). **Camarotti F.** 06 (8), 31 (3). **Canejo FWG.** 01 (10). **Cardoso VGR.** 03 (2). Caroline BF. s.n. (UFRN 15647) (10). **Carvalho AM.** 7123 (5). **Castro ASF.** 47 (3), 48 (3). **Cavalcante F.** 135 (7), 395 (7). **Cavalcanti D.** 118 (5), 170 (7), 230 (5), 341 (5). **Cervi AC.** 7359 (2). **Cestaro LA.** 99 (10). **Chagas ECO.** 100 (3). **Chagas-Mota** 656 (5), 1075 (7), 1778 (5), 1779 (2), 2231 (3), 2248 (2), 2507 (2), 2515 (5), 3200 (2), 3353 (3), 3631 (2), 3803 (3), 3967 (7), 4014 (3), 4072 (7), 4418 (5), 4905 (3), 4959 (2), 5240 (7), 5303 (2), 5668 (2), 5709 (7), 5748 (3), 5845 (3), 5867 (7), 5971 (2), 6011 (3), 6162 (2), 6169 (3), 6914 (2), 7177 (7),

7309 (2), 9076 (3), 9167 (2), 9218 (3), 9350 (3), 9876 (3), 10901 (10). **Cordeiro JMP.** 1373 (7). **Correia JS.**121 (4). **Correia M.** 234 (4), 265 (8), 367 (8), 433 (4), 454 (4). **Costa A.** s.n. (MAC 21693) (2). **Costa-Araújo MH.** 10 (10). **Costa e Silva M.B.** s.n. (PEUFR 18360) (9). **Cunha E.** s.n. (JPB 26576) (4). **Dantas C.** 04 (10). **Dávila N.** 6621 (10). **Dornelas NF.** 15 (4). **Duarte J.** 27 (2). **Ehrendorrfer F.** 191 (4). **Esteves GL.** 499 (5), 593 (2), 672 (10), 802 (10), 1673 (7), 1849 (10), 1889 (10). **Falcão BPS.** 28 (7), 37 (2), 81 (2). **Falcão JIA.** 956 (2), 1160 (7). **Félix LP.** s.n. (JPB 9352, 14678), 163 (8), 1418 (7), 1581 (5), 1888 (4), 2153 (10), 2189 (8), 2606 (8), 2772 (7), 3009 (5), 3056 (5), 4001 (5), 4088 (10), 5181 (8), 10440 (4). **Fernandes A.** s.n. (UFRN 5707, 6888) (8), s.n. (HUEFS 140460) (8), s.n. (HUEFS 140463) (8), s.n. (EAC 6905) (8), s.n. (EAC 11988) (4). **Ferraz EMN.** 361 (3), 425 (3) 684 (3). **Flor ADR.** 181 (8). **Fortunato MEM.** 30 (3). **Gadelha Neto PC.** 68 (3), 259 (3), 2429 (8), 3091 (10), 3092 (5), 3247 (3), 3249 (7), 3250 (5), 4041 (8). **Garcia JD.** 1336 (7), 1338 (7). **Gimenes M.** s.n (HUEFS 44781). **Gomes A.** 218, 290, 373 (1). **Gomes de Lima JE.** s.n. (HST 7020) (7), 119 (4), 124 (8), 163 (7), 164 (7), 171 (3), 192 (3). **Gomes LC.** 51 (3), 199 (7), 247 (3). **Gomes SP.** 399 (7). **Guedes E.P.** 58 (7). **Guedes ML.** 2090 (7), 2311 (7). **Leal C.** s.n. (IPA 12276). **Leão IC.** 80 (10). **Leão T.** 999 (4), 1004 (3). **Lemos R.** 6295 (7), 6509 (7). **Lima HC.** 7058 (10). **Lima IB.** 219 (5), 855 (8). **Lima JE.** 03 (10). **Lins e Silva ACB.** 307 (3). **Locatelli E.** s.n. (UFP 39595) (4). **Loiola I.** 696 (10). **Lucena MFA.** 324 (3). **Lyra-Lemos RP.** 08 (2), 09 (2), 110 (2), 240 (7), 326 (10), 412 (7), 760 (2), 1301 (10), 1498 (10), 1549 (10), 2549 (2), 2774 (5), 3760 (7), 4137 (5), 4211 (10), 4217 (10), 4311 (3), 4400 (2), 5267 (2), 5737 (7), 5851 (3), 5912 (3), 7080 (2), 7111 (2), 7710 (7), 8075 (2), 8101 (2), 8668 (5), 9256 (10), 9550 (5), 9629 (5), 9631 (7), 9994 (2), 10514 (8), 10567 (8), 10589 (8), 11009 (7), 11174 (5), 12306 (3), 13759 (4). **Macedo M.** 04 (4). **Machado MABI.** 45 (2). **Marinho AM.** s.n. (UFRN 4262) (4). **Marques JS.** 313 (7). **Martins MLL.** 346 (10). **Martins-Monteiro AC.** 106 (2), 118 (7). **Martins P.** s.n. (EAC 6931, HUEFS 139378) (3). **Mayo S.** 1042 (3). **Medeiros MM.** 17 (4), 53 (4). **Melquiades A.**

44 (7), 218 (7). **Miranda AM.** s.n. (HST 5915) (7), s.n. (PEUFR 15081) (7), 272 (5), 703 (7), 1511 (5), 1528 (7), 3604 (3), 6499 (7). **Miranda CAB.** s.n. (JPB 8000) (8), s.n. (EAN 6334) (10), s.n. (EAN 16860) (10), 165 (8). **Modesto C.** s.n. (IPA 12007) (3). **Montenegro NF.** 76 (3). **Moraes JC.** 1574 (8). **Moreira IS.** 165 (10). **Moreira LHL.** 84 (3). **Moreira VP.** 20 (10). **Mota MCS.** 11579 (5), 11810 (2). **Mota ML.** 04 (10). **Moura ACA.** 110 (5). **Moura F.** 208 (4), 246 (8). **Moura FBP.** 246 (8). **Moura EO.** 13 (10), 26 (10). **Moura OT.** 1052 (5). **Nascimento IS.** s.n. (JPB 26568) (3). **Nascimento LM.** 752 (3). **Nunes E.** s.n. (EAC 21409) (8). **Oliveira JBS.** 09 (7), 75 (5). **Oliveira M.** 203 (7), 661 (2), 1436 (3), 1517 (3), 3451 (9). **Oliveira LB.** 67 (4). **Pereira LA.** 263 (5). **Pereira MS.** 130 (3), 139 (4). **Pereira OJ.** 7909 (2). **Pereira R.** 37 (4), 212 (7). **Pickel B.** 3863 (5). **Pinheiro AIL.** 195 (7), 447 (2), 470 (7), 475 (7), 668 (2), 697 (5), 774 (7). **Pinheiro PM.** 106 (3). **Pontes AF.** 233 (3). **Pontes RA.** 727 (8). **Pontual I.** s.n. (PEUFR 1819). **Portela V.** s.n. (UFP 23148). **Queiroz RT.** 111 (4). **Ramalho FC.** 17 (8). **Rios PAF.** 03 (7), 90 (7). **Rodrigues MN.** 1973 (10), 2041 (10), 2095 (2), 2107 (5), 2145 (2). **Rodrigues NM.** 1729 (10). **Roque AA.** 1649 (10), 2532 (10). **Sá e Silva IMM.** 191 (3), 193 (3). **Sales de Melo MRC.** 43 (9). **Sarmento AC.** 887 (2). **Schlindwein C.** 945 (2). **Sena R.** 182 (8). **Sevilha AC.** 2216 (2), 2317 (3), 2585 (3), 2648 (2). **Silva DC.** s.n. (UFP 10021) (3). **Silva EA.** 01 (10). **Silva JWA.** 898 (7). **Silva LA.** 46 (7). **Silva LF.** 239 (7). **Silva LR.** 424 (3). **Silva P.** 41 (8). **Silva SI.** s.n. (UFP 10818) (3). **Silva VA.** 27 (4). **Silva WO.** s.n. (UFRN 17535). **Siqueira Filho JA.** 371 (2), 1521 (4). **Soares ML.** 132 (4). **Sobrinho MS.** 428 (4). **Sousa MA.** 1061 (5). **Sousa-Novais R.** 76 (7). **Souto FS.** 158 (4), 159 (4), 160 (4), 163 (8), 164 (8), 165 (10), 166 (1), 174 (3), 175 (3), 178 (7), 182 (3), 183 (10), 188 (6). **Staviski MNR.** 80 (2), 410 (2), 740 (5), 867 (10), 872 (7), 996 (10), 1047 (10). **Tavares S.** 182 (4), 186 (10), 557 (3), 818 (3). **Teixeira G.** 2587 (3). **Thomas WW.** 12424 (5), 13157 (2). **Tschá MC.** 91 (9), 831 (7). **Vasconcelos JCM.** 340 (10), 888 (10). **Vasconcelos Sobrinho** 582

(10). **Versieux LM.** 531 (10). **Viana A.** 273 (7). **Vieira LAF.** 21. **Villarouco FM.** 63 (9). **Wurdack JJ.** 147 (10). **Xavier LP.** s.n. (JPB 224) (10), s.n. (JPB 1798) (10).

Legends:

Figure 1. Morphological characterization of *Senna* ser. *Bacillares*: **A.** Shrub habit in *S. macranthera*. **B.** Leaves 4-leaflets in *S. pinheiroi*. **C.** One extrafloral nectary in *S. splendida* var. *gloriosa*. **D.** Two extrafloral nectaries in *S. pluribracteata*. **E.** Bacoid legume in *S. rizzinii*. **F.** Seeds uniseriate in *S. georgica* var. *georgica*. **G.** Seeds bisseriates in *S. pluribracteata*. (Photos: b, e-f: R.T. Queiroz; a, c-d, g: F.S. Souto).

Caracterização morfológica de Senna ser. Bacillares: A. Shrub habit. B. Folhas tetrafolioladas. C. One extrafloral nectary in S. splendida var. gloriosa. D. Two extrafloral nectaries in S. pluribracteata. E. Legume bacoid in S. rizzinii. F. Seeds uniseriate in S. georgica var. georgica. G. Seeds bisseriates in S. pluribracteata. (Potos: b, e-f: R.T. Queiroz; a, c-d, g: F.S. Souto).

Figure 2. *S. angulata* var. *miscadena* (Vogel) H.S.Irwin & Barneby: **A.** Flowering branch. **B.** Detail of extrafloral nectary. **C.** Bract detail. **D.** Fruit isolated. **E.** Seed isolated.

Figure 3. *S. chrysocarpa* (Desv.) H.S.Irwin & Barneby: **A.** Flowering branch. **B.** Detail of extrafloral nectary. **C.** Bract detail. **D.** Fruit isolated.

Figure 4. *S. georgica* var. *georgica* H.S.Irwin & Barneby: **A.** Flowering branch. **B.** Leaf. **C.** Detail of extrafloral nectary. **D.** Heteromorphic calyx; **E.** Flower; **F.** Seeds. (Photos: R.T. Queiroz).

Figure 5. *S. macranthera* (DC. ex Collad.) H.S.Irwin & Barneby: **A.** Shrub habit. **B.** Leaf **C.** Detail of extrafloral nectary. **D.** Bracts. **E.** Flower. **F.** Fruit. (Photos: F.S. Souto).

Figure 6. *S. pinheiroi* H.S.Irwin & Barneby: **A.** Flower. **B.** Panicle. **C.** Stipules. **D.** Detail of extrafloral nectaries. **E.** Leaf. (Photos: R.T. Queiroz).

Figure 7. *S. pluribracteata* F.S.Souto & R.T.Queiroz: **A.** Flowering branch. **B.** Stipules. **C.** Detail of extrafloral nectaries. **D.** Bracts. **E.** Flower. **F.** Fruit.

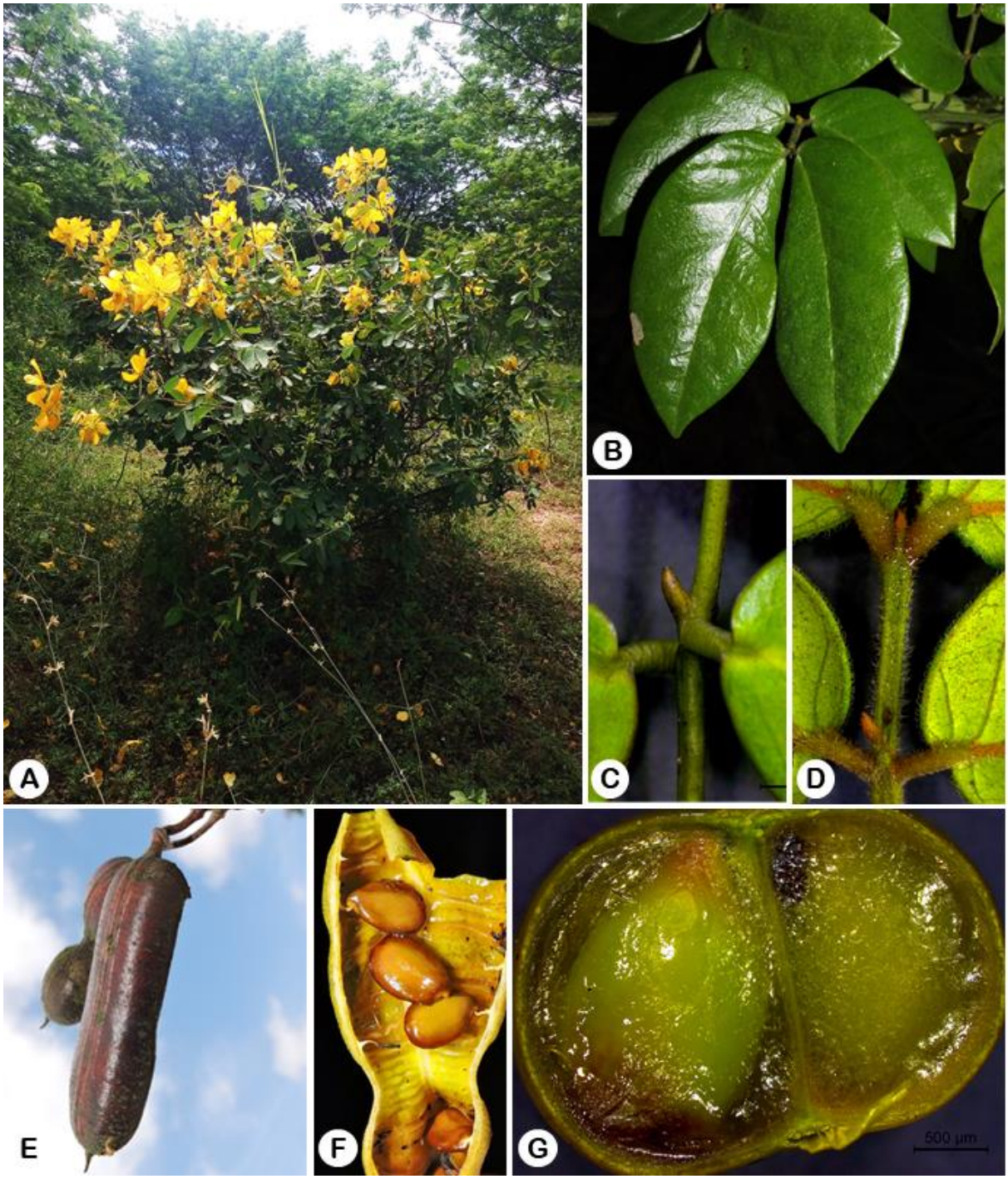
Figure 8. *S. quinquangulata* var. *quinquangulata* (Rich.) H.S.Irwin & Barneby: **A.** Flowering branch. **B.** Detail of extrafloral nectaries. **C.** Fruit isolated.

Figure 9. *S. rizzinii* H.S.Irwin & Barneby: **A.** Leaf. **B.** Detail of extrafloral nectary. **C.** Leaflet. **D.** Flower. **E.** Fruit. (Photos: R.T. Queiroz).

Figure 10. *S. rugosa* (G.Don) H.S.Irwin & Barneby: **A.** Flowering branch. **B.** Detail of extrafloral nectaries. **C.** Androecium. **D.** Fruit isolated.

Figure 11. *S. splendida* var. *gloriosa* (Vogel) H.S.Irwin & Barneby: **A.** Shrub habit. **B.** Leaf. **C.** Stipules. **D.** Detail of extrafloral nectary. **E.** Flower. **F.** Fruit. **G.** Seeds. (Photos: F.S. Souto).

1 Figure 1.



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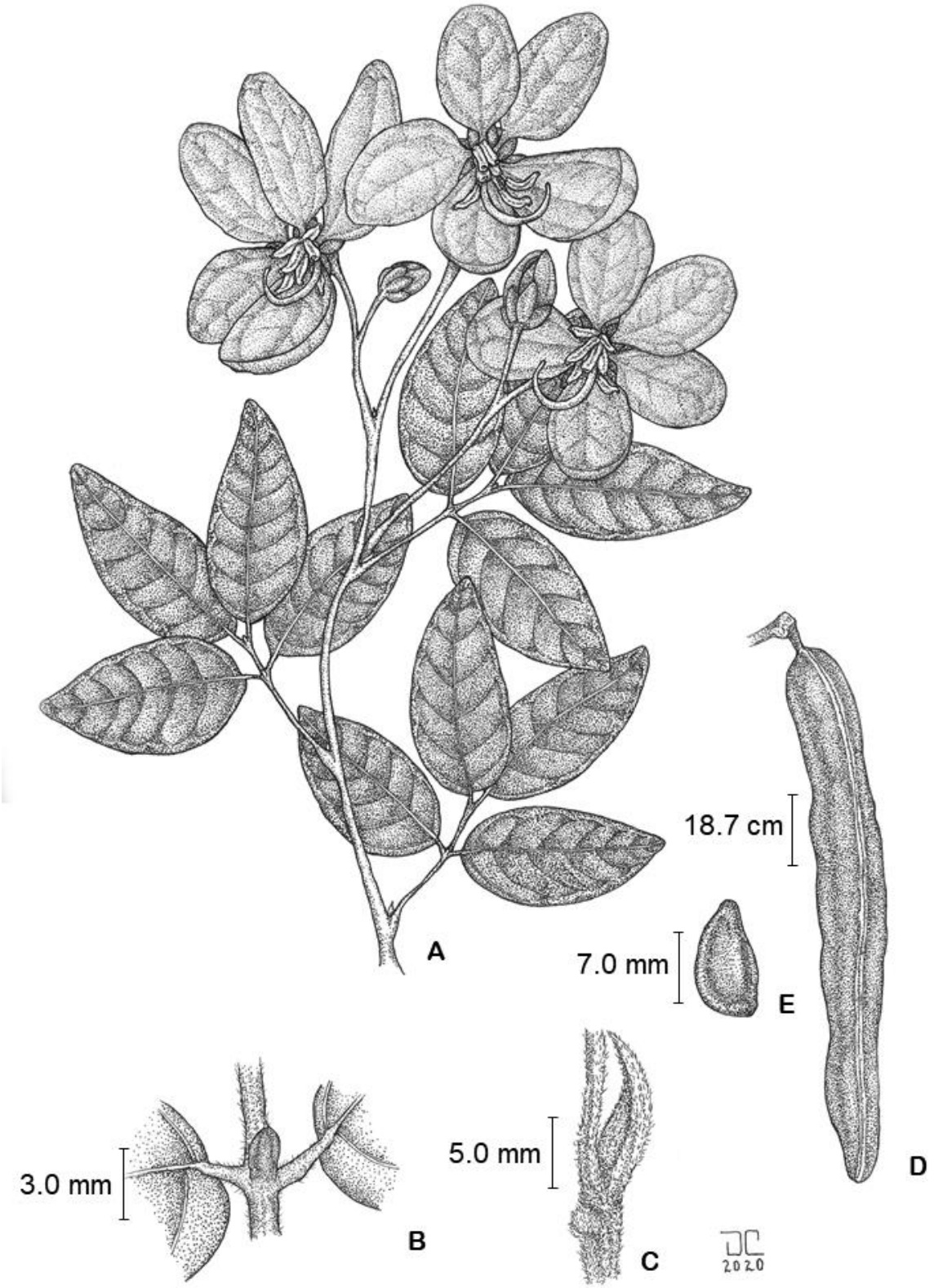

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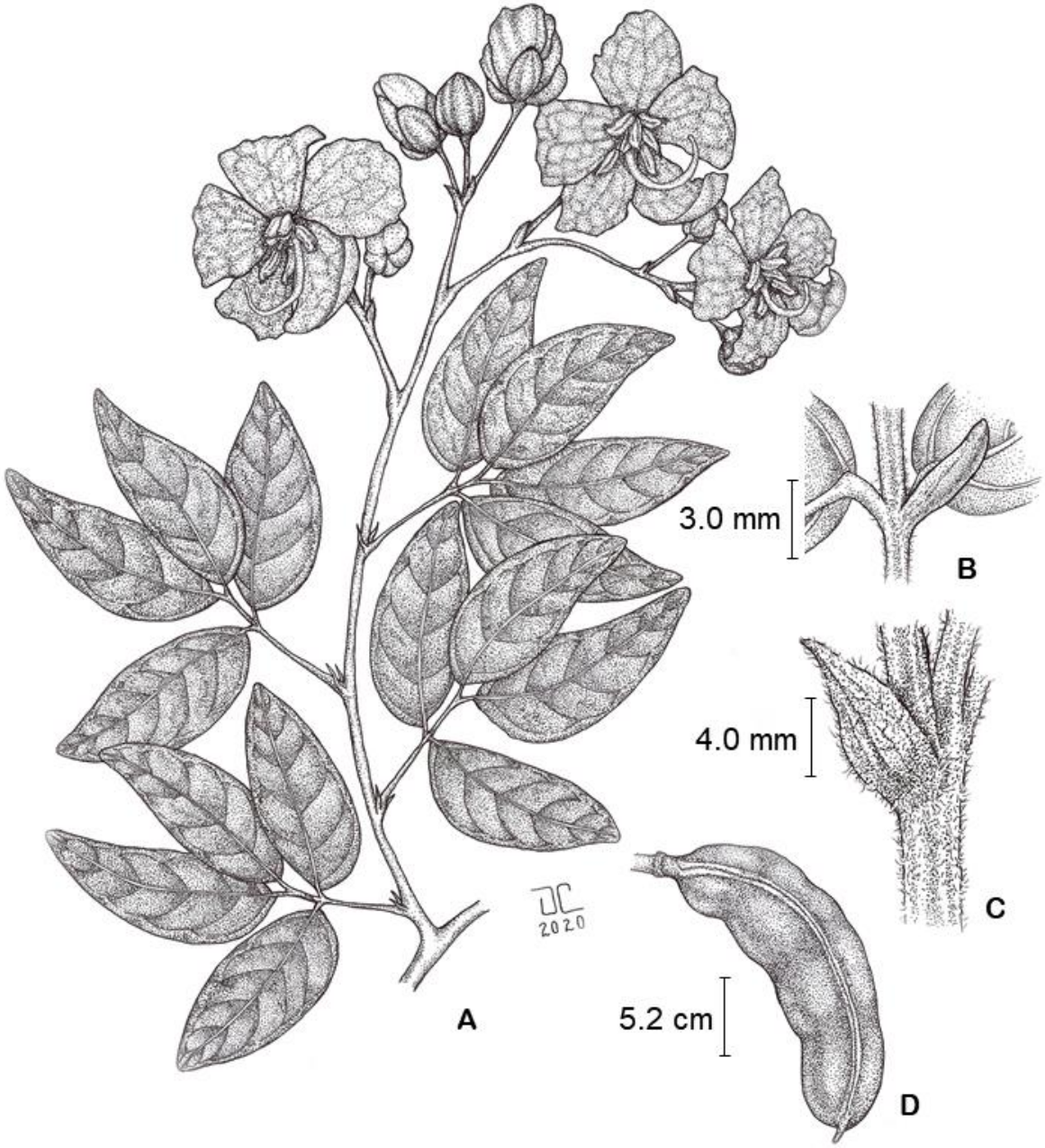

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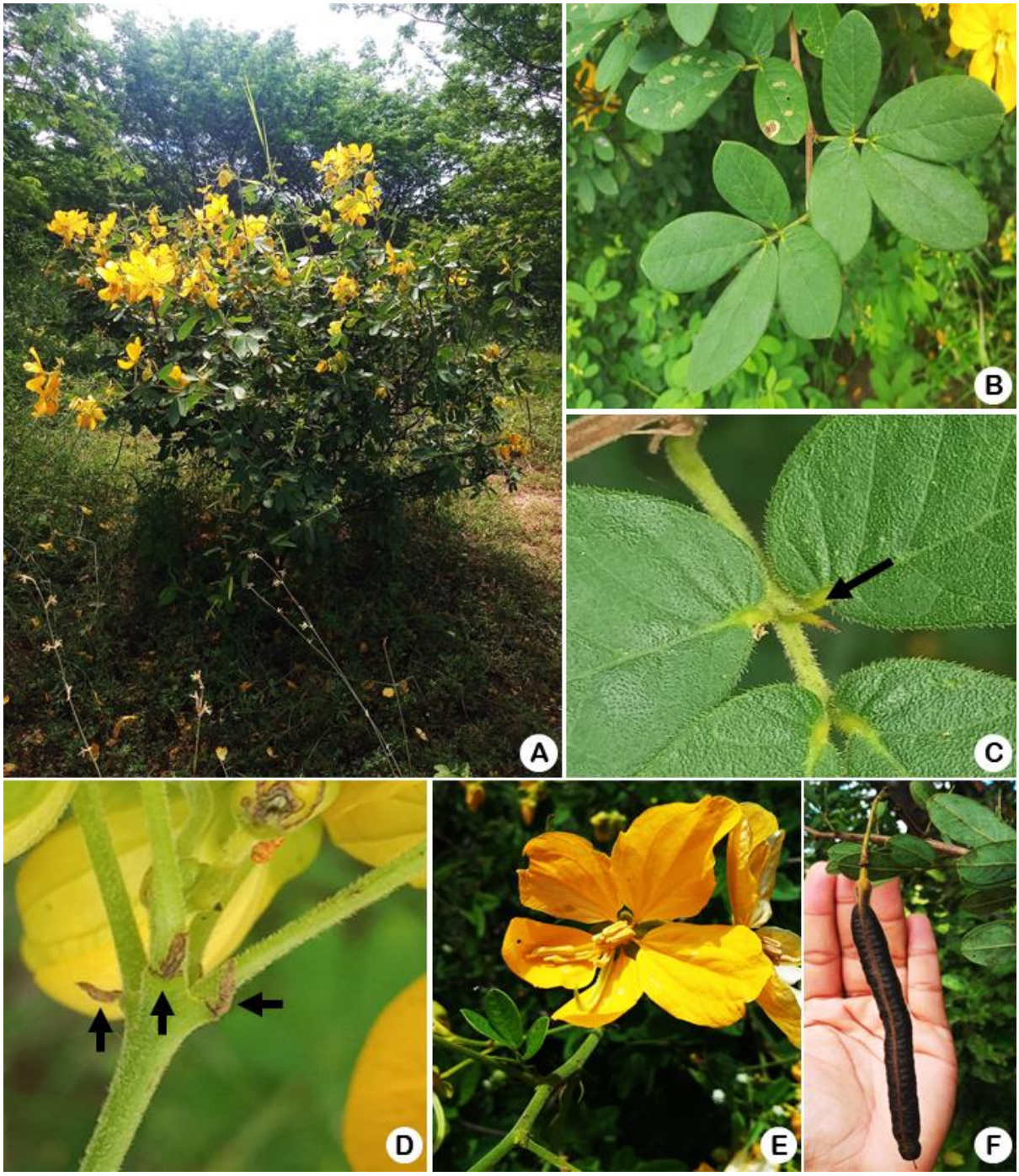
Figure 4.

Figure 5.



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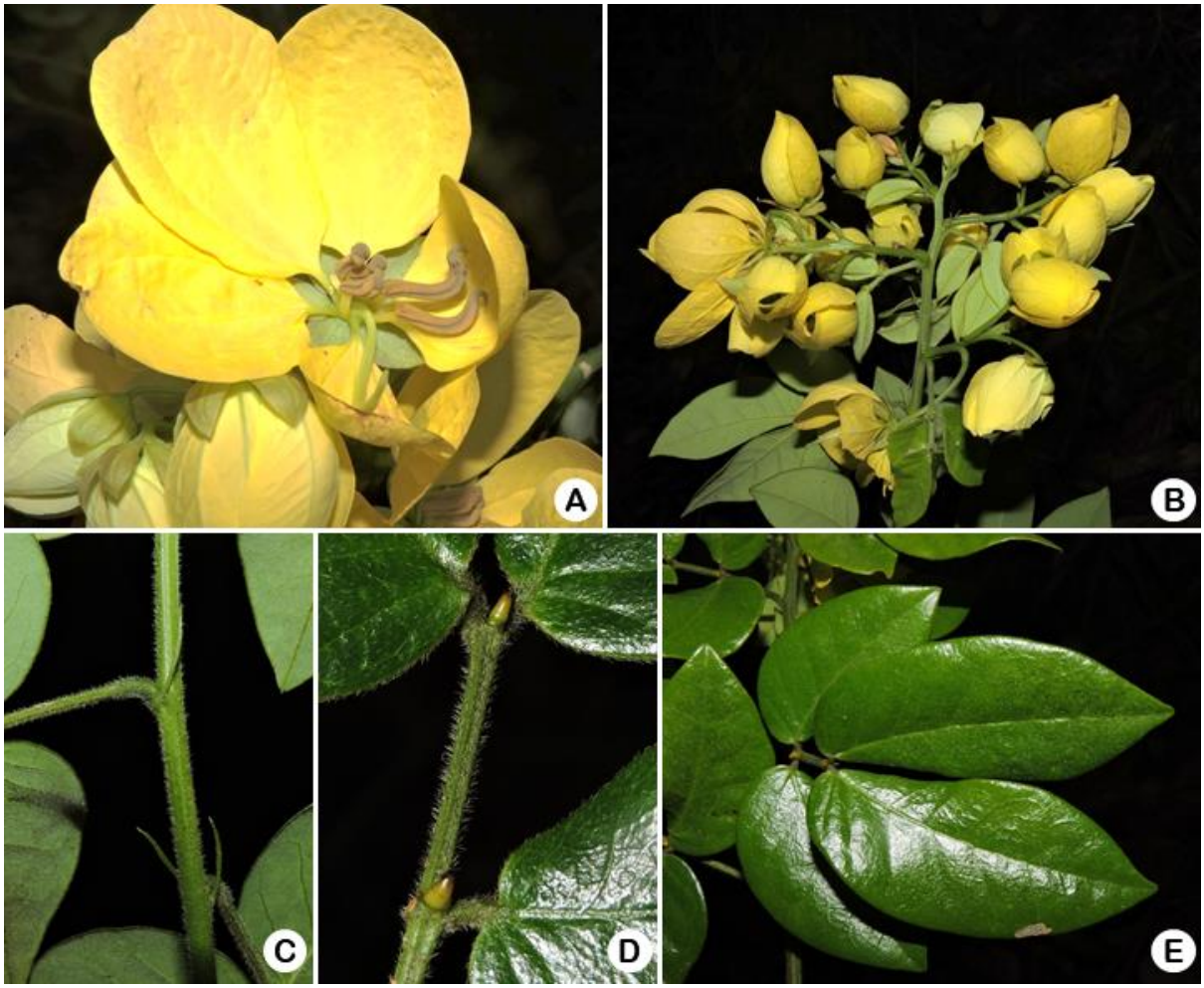

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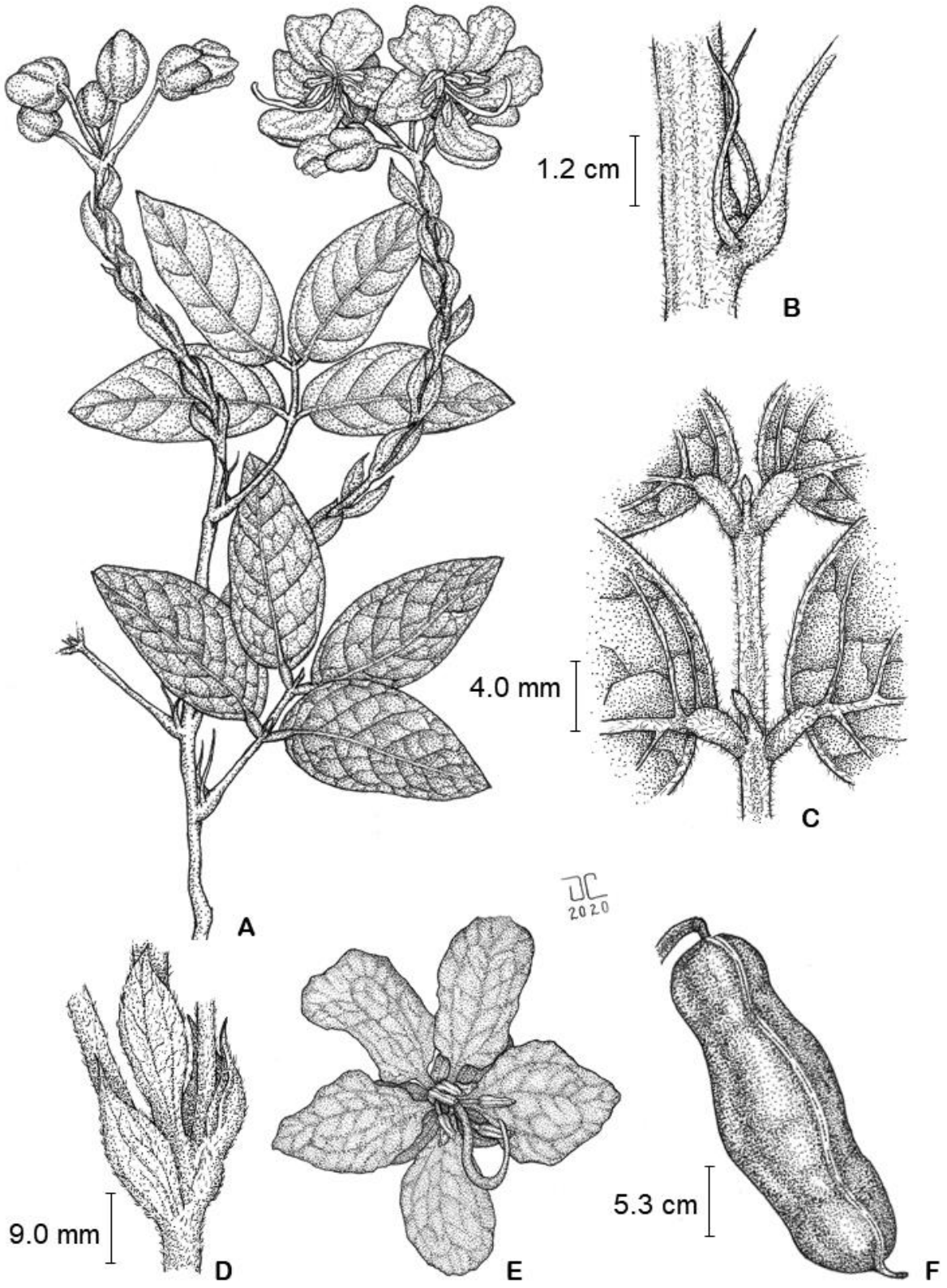

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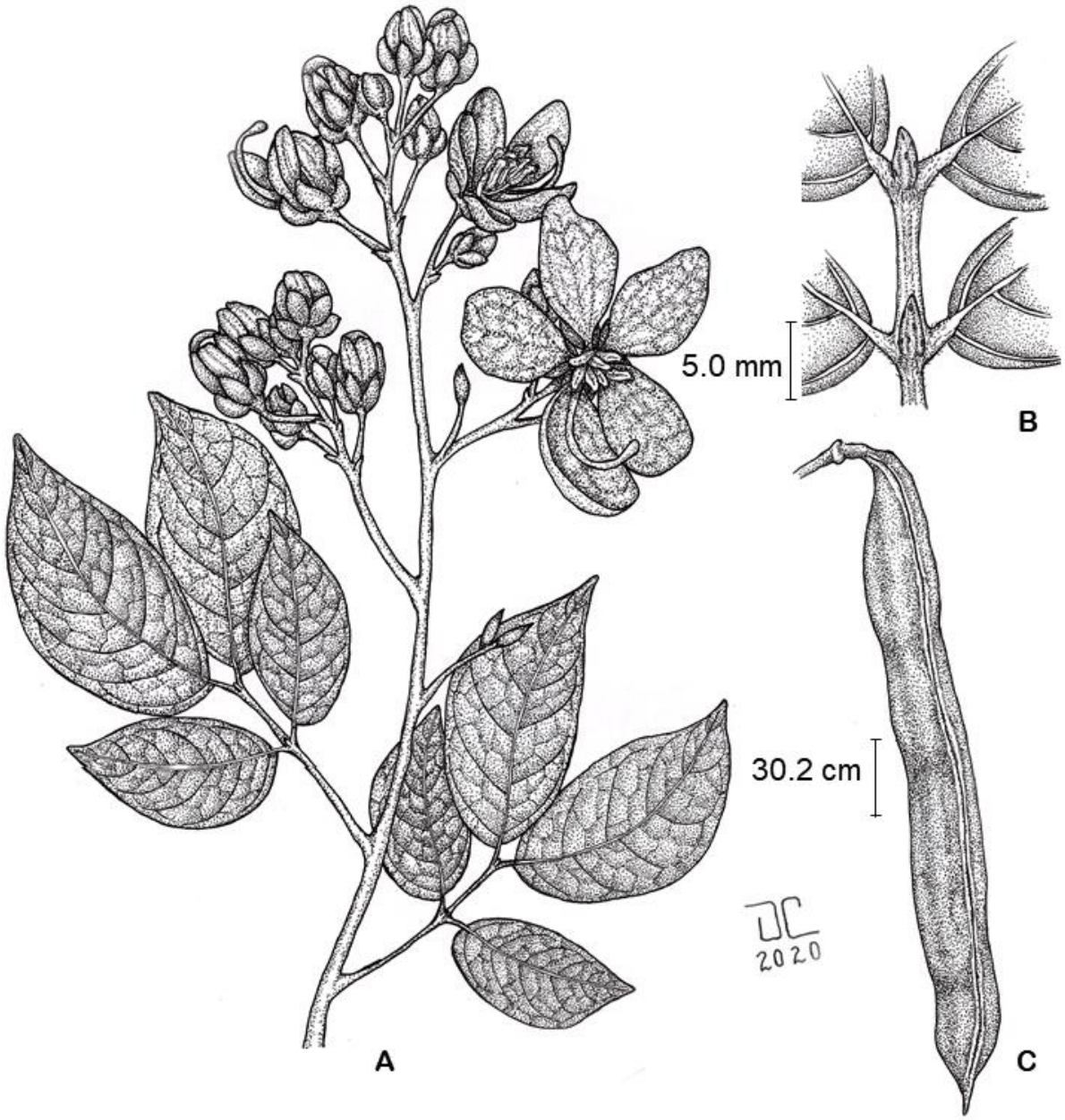

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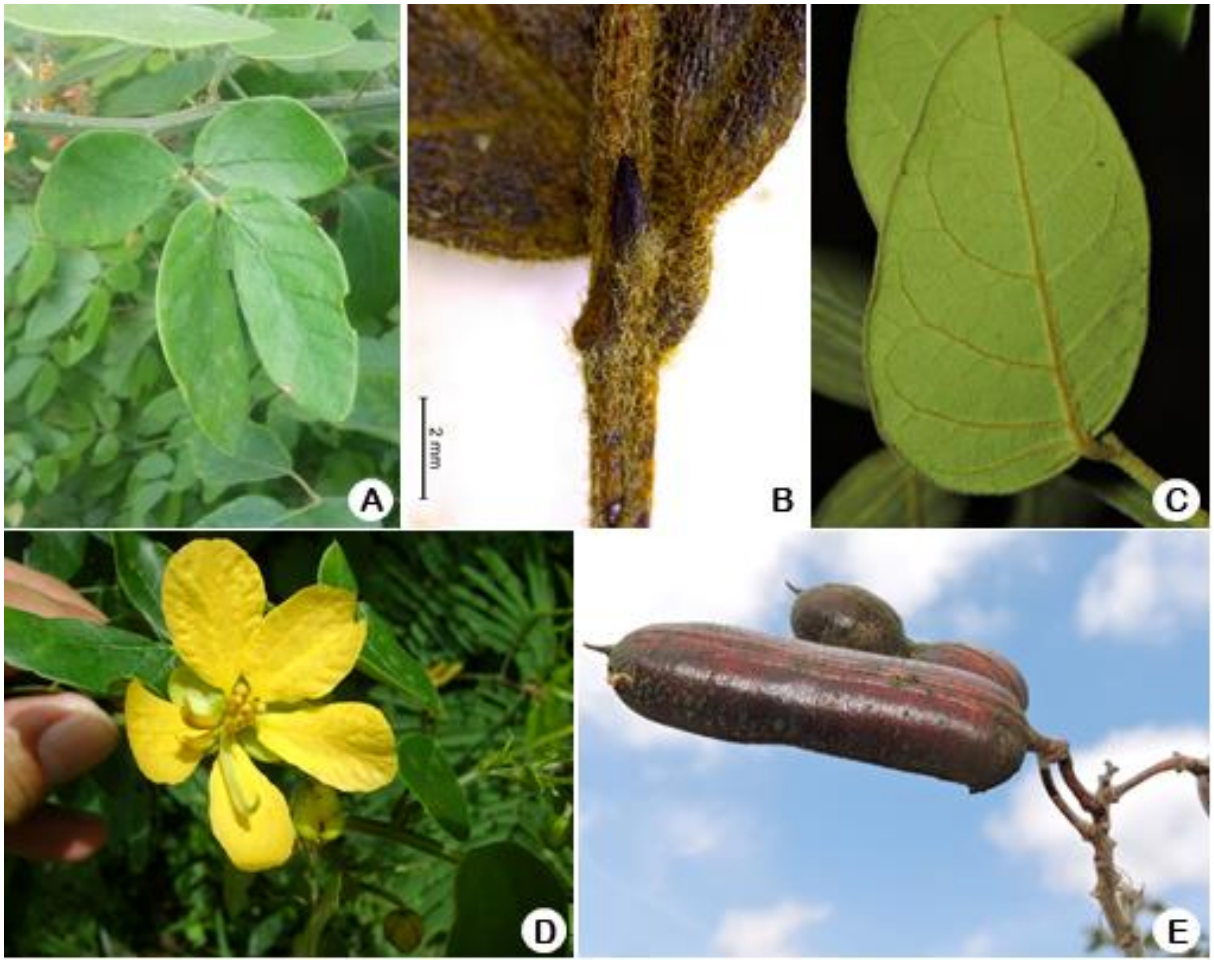
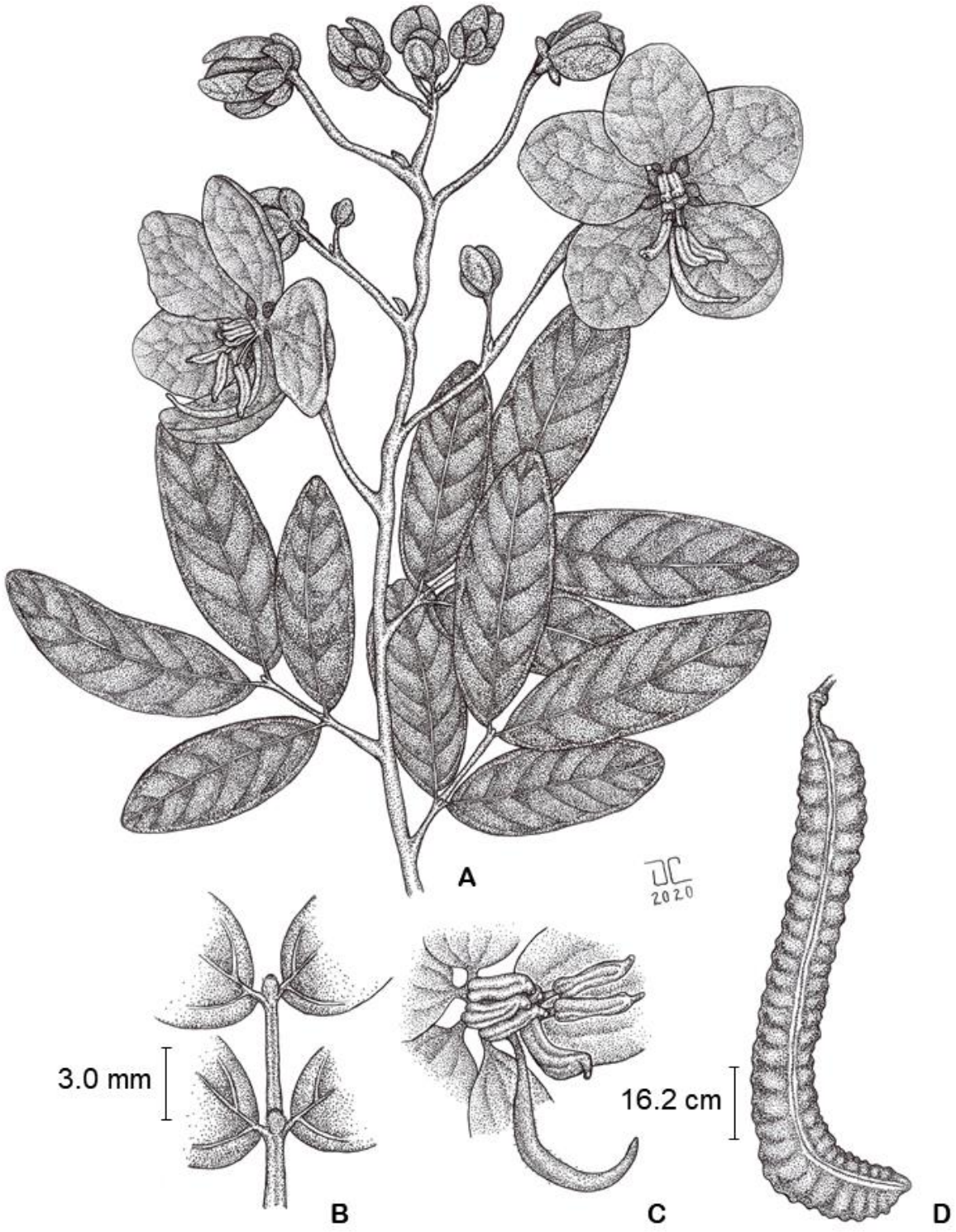


Figure 10.



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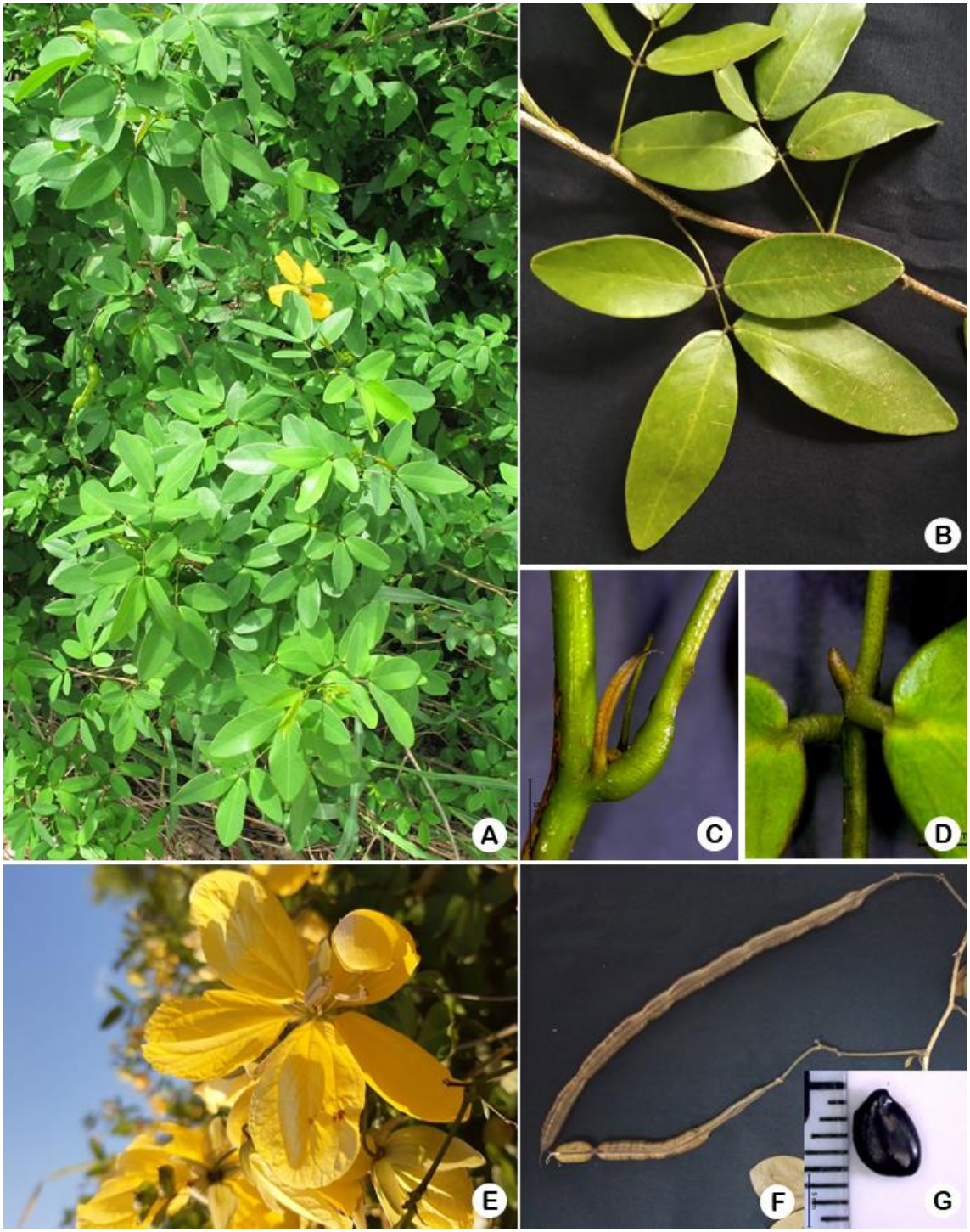
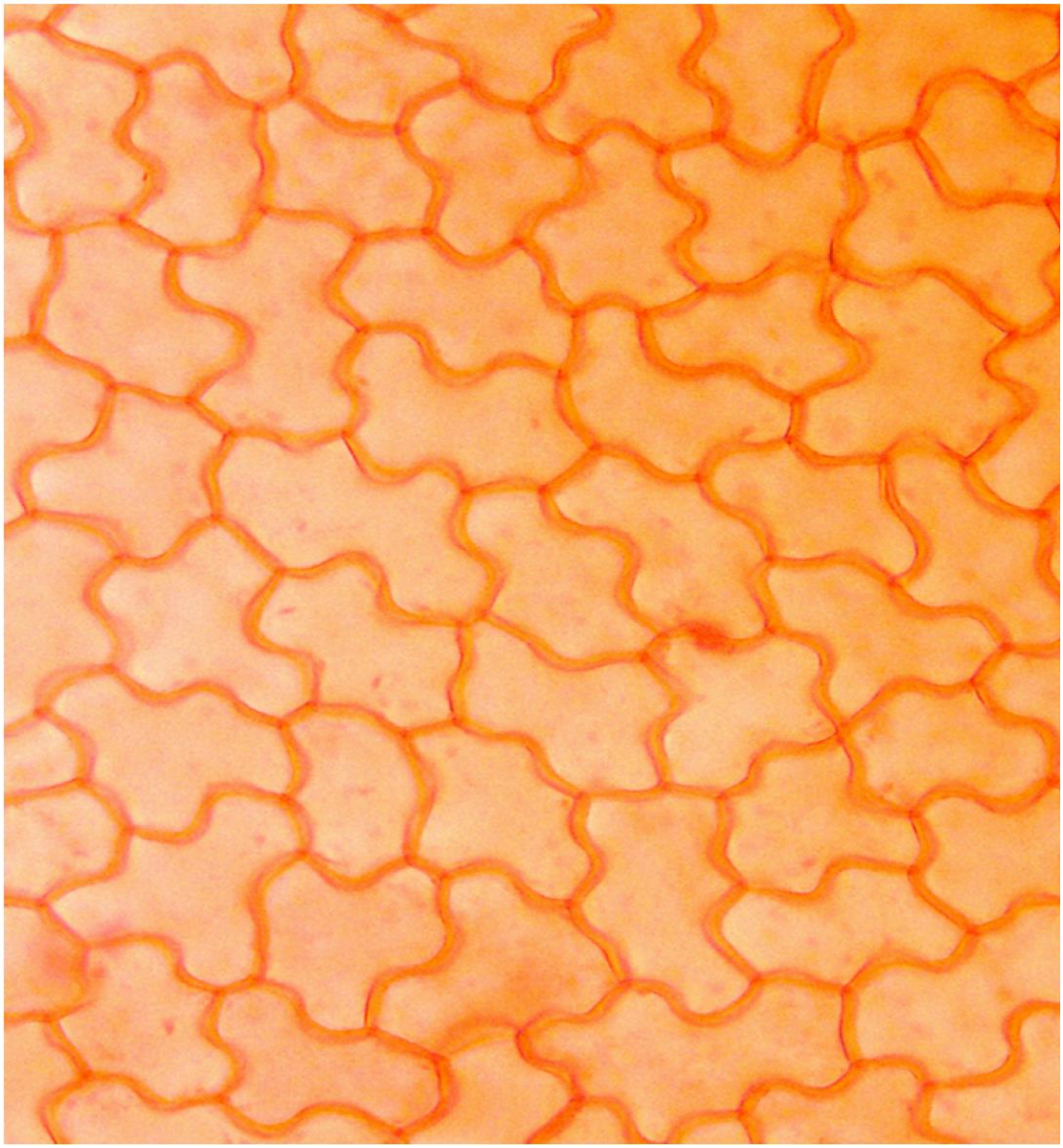


3.3 Capítulo III:

Leaf Anatomy of Ten Species of *Senna* series *Bacillares* and Their Taxonomic Significance



A ser submetido à Microscopy Research and Technique

Leaf anatomy of ten species of *Senna* series *Bacillares* and their taxonomic significance

Leaf anatomy of *Senna* series *Bacillares*

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Abstract

Senna ser. *Bacillares* comprises about 50 species, of these, 23 are found in Brazil. In this work an anatomical study was performed using multiple microscopic techniques on the leaves of ten species of *Senna* ser. *Bacillares*, in order to identify both qualitative and quantitative features of leaf anatomy, as a differential parameter to support its taxonomy. All species showed hypostomatic leaflets, uniseriate epidermis, dorsiventral mesophyll, and plane-convex midrib with 1-vascular bundle, and collateral vascular system. Moreover, different types of cuticle and epicuticular waxes were observed: membranous platelets, platelets, crusts, fissurate layer, and rosettes. Trichomes simple, unicellular, and multicellular were present on the leaf epidermis of most species. Stomata anisocytic, anomocytic, anomotetracytic, and paracytic were observed, being the anomotetracytic type not previously mentioned for *Senna*. Four different patterns of leaflets edge were observed (acute, rounded, recurved and truncate), the type truncate was exclusive to *S. angulata*. The vascular bundles varied in shapes and in number in the petiole and leaf rachis, and were the most distinctive characters to separate the species studied. Inorganic idioblasts as crystals sand, druses, prismatic crystals, and spherical crystals were present on petiole and rachis. Spherical crystals and crystals sand are being reported for the first time in *Senna*. The set of different characters observed on the leaflet epidermis and its attachments, together with the anatomy of leaflet edges, petiole and leaf rachis provided an additional subsidy, which is useful for the taxonomy of *Senna* ser. *Bacillares* studied here, as well as for the genus.

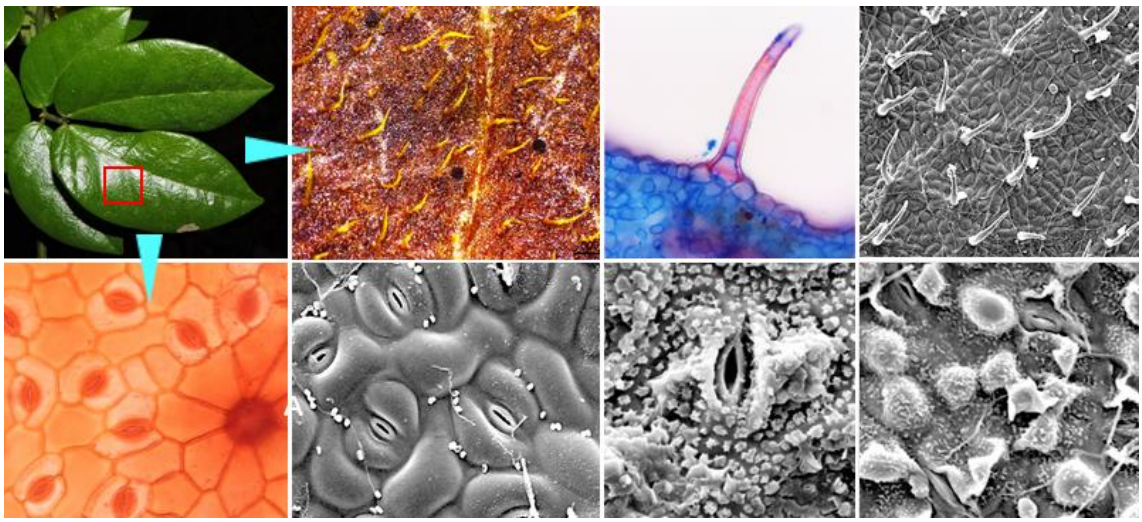
KEYWORDS

Cassia, Fabaceae, Leguminosae, Micromorphology, *Senna* sect. *Chamaefistula*.

RESEARCH HIGHLIGHTS

- Anatomical studies using multiple microscopy techniques revealed distinctive characters between *Senna* species.
- Characters of the epicuticular waxes, petiole, and leaf rachis proved to be an additional tool to *Senna* taxonomy.

GRAPHICAL ABSTRACT



1 | INTRODUCTION

The genus *Senna* Mill. (Leguminosae, Caesalpinioideae) comprises about 330 species with pantropical distribution (Queiroz, 2009; Marazzi & Sanderson, 2010), and center of diversity in Americas (Irwin & Barneby, 1982). Species of *Senna* are easily recognized for having extrafloral nectaries on the leaves, bracteoles absent, relatively large flowers with yellow petals, and anthers with poricidal dehiscence (Queiroz, 2009).

Senna is quite taxonomically complex and was divided infragenerically in six sections and 35 series by Irwin and Barneby (1982). *Senna* ser. *Bacillares* (Benth.) H.S. Irwin & Barneby, belonging to the section *Chamaefistula*, comprises about 50 species with wide distribuition in Americas, of these, 23 are found in Brazil (Irwin & Barneby, 1982; Souza & Bortoluzzi 2020). They can be recognized for their 4-leaflets leaves with

extrafloral nectaries between the leaflets, and bacoid pluriovulate legume with seeds transversely oriented (Irwin & Barneby, 1982). Phylogenetic studies indicate *Senna* ser. *Bacillares* as a monophyletic group (Marazzi, Endress, Queiroz, & Conti, 2006).

Plant anatomy has proved to be an important tool for the taxonomy of angiosperms, especially if the species studied are not fertile during the collection period (Metcalfe & Chalk, 1950; Dickison, 1975; Judd, Campell, Kellogg, Stevens, & Donoghue, 2009). In Leguminosae, due to their morphological plasticity, anatomical studies of vegetative organs showed great potential in differentiating genera and species, supporting the group's taxonomy (Crow, Stirton, & Cutler, 1997; Coutinho, Francino, & Meira, 2013; Coutinho, Rando, Conceição, & Meira, 2016; Nemoto, Ohashi, & Wu, 2016; Pereira, Costa-Silva, Felix, & Agra, 2018; Seixas, Fortuna-Perez, & Rodrigues, 2019). In addition, several anatomical characters (cuticle, epidermis and its attachments, trichomes, mesophyll, vascular system of the midrib and petiole) have contributed to elucidate systematic and phylogenetic relationships in different groups of plants (Dickison, 2000).

Studies of leaf anatomy in *Senna*, although scarce, are considered an additional taxonomic tool in the differentiation of species of the genus (Kotresha & Seetharam, 2000; Ogundipe, Kadiri, & Adekanmbi, 2009; Rodrigues, Souza-Filho, Ferreira, Ilkiu-Borges, & Gurgel, 2009; Saheed & Illoh, 2010; Nassar, Ramadan, & Ibrahim, 2013; Begum, Rahman, & Begum, 2014; Amponsah, Mensah, Ampofo, Bekoe, Sarpong, & Jibira, 2016; Souto, Queiroz, & Agra, 2021).

In view of the above, an anatomical study was carried out in the leaves of ten species of *Senna* ser. *Bacillares*, using multiple microscopic techniques, to identify qualitative and quantitative characteristics that provide differential parameters to support its taxonomy.

2 | MATERIAL AND METHODS

2.1 | Plant material and species identifications

The plant collecting and field observations were carried out for taxonomic and anatomical studies. Part of the plant material was dried and pressed following the usual techniques for plant taxonomy (Bridson & Forman, 1992), and the exsicates were deposited at the Herbarium UFP, and duplicates at the Herbarium JPB. Moreover, we proceeded analysis of herbaria specimens of UFP, PEUFR, IPA, JPB, EAN, MAC e UFRN, acronyms according to Thiers (2020), and also of the Herbarium Prof. Sérgio Tavares (HST) of Universidade Federal Rural de Pernambuco, not indexed.

Leaf samples also were collected for the anatomical studies from the third to the fifth nodes, fixed in FAA (50%) for 24-48 hours, and stored in alcohol 70%, according to Johansen (1940). In addition, leaflet samples from dried specimens were also analysed (Table1). They were rehydrated and, subsequently, stored in alcohol (70%) according to Smith and Smith (1942).

The identification of all species (Table 1) were made with the support of diagnosis, descriptions, and analytical keys found in the specialized bibliography for *Senna* (Vogel, 1837; Bentham, 1870, 1871; Irwin & Barneby, 1982; Lewis, 1987; Souza & Silva, 2016; Tozzi, 2016; Azevedo & Conceição, 2017; Correia & Conceição, 2017; Santos, Oliveira, Queiroz, & Silva, 2020), and was complemented by the analysis of the types displayed in national and foreign virtual herbaria (E, F, K, NY, RB, and W).

2.2 | Cuticle, epicuticular waxes, indument, trichomes, trichomatic index, and leaflet epidermis

For SEM examinations, dried leaflets fragments, approximately 1 cm^2, were attached to aluminum stubs using double-faced adhesive tape, metallized with gold, and examined in

both surfaces them using SEM (JEOL JSM-5600) at 15 KV. The epicuticular waxes terminology follow Barthlott (1994) and Barthlott et al. (1998).

The leaflet indument and trichomes were studied and micrographed under stereo microscopy (SM), Leica S8AP, coupled with video camera (Leica DFC295). Trichomes index were based on three fields of each sample, for a total of 15 (n = 15), using light microscopy. The quantitative analyses were performed using Anati Quanti software (Aguiar, Sant'anna-Santos, Azevedo, & Ferreira, 2007) and statistical analyzes using PAST software, version 1.0. Univariate ANOVA was used as a variance analysis test, with statistical significance determined by the Tukey method ($p < 0.05$).

Leaflet epidermal samples were obtained by freehand paradermic sections on the adaxial and abaxial surfaces, from five specimens (when disponible). Subsequently, the sections were clarified in sodium hypochlorite (2%), rinsed in distilled water and neutralized with acetic acid (2%), and stained with Safranin (Kraus & Arduin, 1997). The sections were mounted in glycerinated gelatin (50%) and, subsequently, analyzed and micrographed under light microscopy (LM), Leica DM750, coupled with video camera (Leica ICC50 HD). The epidermis patterns are according to Fahn (1974). The terminologies for indument and trichomes classifications follows Harris and Harris (1994) and Theobald, Krahulik, and Rollins, (1979), respectively.

2.3 | Stomatal type and stomatal index and density

The stomatal patterns were classified according to Dilcher (1974), after freehand paradermic sections of the epidermis leaflets. Quantitative and statistical analyzes for stomatal index and density followed the same procedures as for trichomatic indexes.

2.4 | Mesophyll, edges and midrib of leaflets, and petiole and leaf rachis

Freehand transverse sections were performed in leaflets blades, midrib, and edges, and also in the petiole and leaf rachis, of ten *Senna* species. The cuts were clarified with

sodium hypochlorite, neutralized with acetic acid (2%), rinsed in distilled water and stained with Safrablue. The leaf sections were mounted in glycerin gelatine (50%), analyzed and photographed under light microscopy (LM), Leica DM750, coupled with video camera (Leica ICC50 HD).

3 | RESULTS

3.1 | Epicuticular waxes and cuticle

Different types of epicuticular waxes were observed on leaflet epidermal surfaces, most of them on a single phylloplane. Epicuticular waxes as granules were observed on the both surface of five species (Table 2): *S. angulata* (Figure 1a,b), *S. pinheiroi* (Figure 2a,b), *S. pluribracteata* (Figure 2c,d), *S. quinquangulata* (Figure 2e,f), and *S. rugosa* (Figure 3c,d); and on the adaxial surface of four species (Table 2): *S. chrysocarpa* (Figure 1c), *S. macranthera* (Figure 1e), *S. rizzinii* (Figure 3a), and *S. splendida* (Figure 3e).

Epicuticular waxes as platelets were recorded on the adaxial surfaces of six species: *S. angulata* (Figure 1a), *S. chrysocarpa* (Figure 1c), *S. macranthera* (Figure 1e), *S. quinquangulata* (Figure 2e), and *S. splendida* (Figure 3e); and on both surface of two species: *S. pinheiroi* (Figure 2a,b) and *S. pluribracteata* (Figure 2c,d). Microplatelets as rosettes types were observed on the abaxial surfaces of *S. chrysocarpa* (Figure 1b), *S. pluribracteata* (Figure 2d), *S. rizzinii* (Figure 3b), and on both surfaces of *S. georgica* and *S. splendida* (Figure 3e,f). Microplatelets were observed on the abaxial surface of their convex cells (papillae) in *S. chrysocarpa* (Figure 1d), *S. pluribracteata* (Figure 2d), *S. quinquangulata*, and *S. rizzinii*. Membraneous platelets were observed exclusively on both surfaces of *S. rizzinii* (Figure 3a,b).

The type of epicuticular waxes as crusts were observed on the leaflet epidermis of the five species (Table 2): on the abaxial surface of *S. angulata* (Figure 1b), and *S. pluribracteata* (Figure 2d); on the adaxial surface of *S. quinquangulata* (Figure 2e), and

S. rizzinii (Figure 3a); and on both surfaces of leaflet epidermis of *S. splendida* (Figure 3e,f). Fissured layers were recorded on the adaxial surface of *S. chrysocarpa* (Figure 1c). Groups of massive rodlets type epicuticular waxes were observed only on the adaxial surface of *S. splendida* (Figure 3e).

The species studied showed three types of cuticle on the leaflet epidermis: smooth, rugose and striate (Table 2). The smooth cuticle epidermis was observed on the adaxial surfaces of eight species: *S. angulata* (Figure 1a), *S. chrysocarpa* (Figure 1c), *S. georgica*, *S. macranthera* (Figure 1e), *S. pinheiroi* (Figure 2a), *S. quinquangulata* (Figure 2e), *S. rizzinii* (Figure 3a), and *S. splendida* (Figure 3e). The rugose type was observed on the adaxial surfaces of *S. pluribracteata* (Figure 2c) and *S. rugosa* (Figure 3c), as well as on the abaxial surfaces of *S. angulata* (Figure 1b), *S. georgica*, *S. macranthera* (Figure 1f), *S. pinheiroi* (Figure 2b), *S. rugosa* (Figure 3d), and *S. splendida* (Figure 3f). Striate cuticle was observed only on the midrib of abaxial surface of *S. macranthera* (Figure 1f).

In addition, double structured plant surfaces with convex cell shapes (papillae), and superimposed three-dimensional epicuticular waxes on the abaxial leaflet surface were observed in *S. chrysocarpa* (Figure 1d), *S. pluribracteata*, with microplatelets (Figure 2d), *S. quinquangulata* (Figure 2f), and *S. rizzinii* (Figure 1b). Some species presented their cuticle completely covered by epicuticular waxes, as was observed on the abaxial surface of *S. chrysocarpa* (Figure 1d), *S. pluribracteata* (Figure 2d), and *S. rugosa* (Figure 3d), as well as on both surfaces of *S. georgica*, with microplatelets, and *S. splendida* with a cluster of microcrusts (Figure 3e,f).

3.2 | Leaflet indument, type of trichomes and trichomatic indexes

On the adaxial surface, the indument pubescent was predominant, and observed in five species (Table 3): *S. chrysocarpa* (Figure 4a), *S. macranthera* (Figure 4b), *S. pinheiroi*, *S. rizzinii* (Figure 4c), and *S. rugosa* (Figure 4d). The types puberulent and strigose were

observed in one species each: *S. angulata* (Figure 4e) and *S. pluribracteata* (Figure 4f), respectively. Three species showed glabrous leaflets: *S. georgica*, *S. quinquangulata* (Figure 4g), and *S. splendida* (Figures 4h and 5h), is the last glabrous on both surfaces.

On the abaxial surface, the indumentum of tomentose type was observed in five species (Table 3): *S. angulata* (Figure 5a), *S. macranthera*, *S. pinheiroi* (Figure 5b), *S. rizzinii* (Figure 5c), and *S. rugosa* (Figure 5d). Pubescent leaves were recorded in two species, *S. chrysocarpa* and *S. quinquangulata* (Figure 5e). The types puberulent and strigose were observed on the abaxial surface of one species each, *S. georgica* (Figure 5f), and *S. pluribracteata* (Figure 5g), respectively.

Trichomes were observed on the midrib on both surfaces of eight species: *S. angulata*, *S. chrysocarpa* (Figure 6a,b), *S. macranthera*, *S. pinheiroi*, *S. pluribracteata*, *S. quinquangulata*, *S. rizzinii*, and *S. rugosa*. In *S. georgica* (Figure 6c, d), the trichomes are present only on the midrib on the abaxial surface. The leaflets with ciliate margin are predominant and found in six species: *S. angulata*, *S. chrysocarpa* (Figure 6g) *S. macranthera*, *S. pluribracteata* (Figure 6h), *S. rizzinii*, and *S. rugosa*. In *S. georgica* (Figure 6i) and *S. quinquangulata* were observed sparse trichomes on the edges of leaflets.

The species studied showed two types of simple trichomes, one unicellular type and another multicellular type (Table 3), which were observed on both surfaces of seven species: *S. angulata* (Figure 7a), *S. chrysocarpa* (Figure 7b), *S. macranthera* (Figure 7c), *S. pinheiroi* (Figure 11i), *S. pluribracteata* (Figure 11b), *S. rizzinii* (Figure 11g), and *S. rugosa* (Figure 11d). Two species (*S. georgica* [Figure 7d], and *S. quinquangulata* [Figure 11c]) are glabrous on their adaxial surfaces, and only one species, *S. splendida* (Figure 11j), is completely glabrous on both surfaces. In addition, most multicellular trichomes have a papillary dome on their surfaces, and it was observed on the adaxial surface of *S.*

pinheroi (Figure 2a), and also on both surfaces of *S. chrysocarpa* (Figure 1c,d), *S. macranthera* (Figure 1e,f), *S. pluribracteata* (Figure 2c,d), *S. rizzinii* (Figure 3a,b), and *S. rugosa* (Figure 3c,d). This type of trichome also was observed on the abaxial surface of *S. angulata* (Figure 1b), and *S. quinquangulata* (Figure 2f).

The trichomatic indexes on the adaxial surfces of all studied species were smaller than on the abaxial surfaces, and varied from 1.78%, in *S. pinheiroi,* to 3.05%, in *S. angulata* (Table 3, Figure 8a). Species with closer indeces on the adaxial surfaces were *S. pinheiroi* and *S. chrysocarpa* with 1.78% and 1.87%, respectively. On the abaxial surfaces the trichomatic indexes varied from 1.63% in *S. rizzinii* to 10.31% in *S. quinquangulata* (Table 3, Figure 8b). Closer indexes on the abaxial surfaces were observed in *S. chrysocarpa* and *S. angulata* with values of 2.69% and 2.73%, respectively (Figure 8b).

3.3 | Leaflet epidermal cell walls

In frontal view, the *Senna* species studied showed three patterns of contour of the epidermis anticlinal walls, on the adaxial surface: straight to curved, curved and sinuous (Table 4). In adaxial surface the pattern straight to curved was predominant and observed in five species, *S. chrysocarpa* (Figure 9a), *S. pluribracteata* (Figure 9b), *S. quinquangulata* (Figure 9c), *S. rizzinii* (Figure 9d), and *S. rugosa* (Figure 9e). The sinuous anticlinical walls pattern were registered in four species: *S. angulata* (Figure 9f), *S. georgica* (Figure 9g), *S. macranthera* (Figure 9h), and *S. splendida* (Figure 9i). The curved pattern was an exclusive character observed on the adaxial surface of *S. pinheiroi* (Figure 9j).

With respect to the abaxial surface, the sinuous pattern was observed in four species, *S. georgica* (Figure 10a), *S. macranthera* (Figure 10b), *S. rizzinii* (Figure 10c), and *S. splendida* (Figure 10d). The straight to curved anticlinical walls pattern was

recorded in four species, *S. angulata* (Figure 10e), *S. pinheiroi* (Figure 10f), *S. quinquangulata* (Figure 10g), and *S. rugosa* (Figure 10h). The curved to sinuous pattern was observed only in two species, *S. chrysocarpa* (Figure 10i), and *S. pluribracteata* (Figure 10j).

In cross-section, all species have uniseriate epidermis on both surfaces (Figure 11), including the midrib, petiole and leaf rachis. In all species, epidermal cells are rounded on the adaxial surface (Figure 11). The epidermis on the abaxial surface is conspicuously papillous in four species (Table 4): *S. chrysocarpa* (Figure 11a), *S. pluribracteata.* (Figure 11b), *S. quinquangulata* (Figure 11c), and *S. rugosa* (Figure 11d). Epidermis sparsely papillous was observed in three species (Table 4): *S. angulata* (Figure 11e), *S. georgica* (Figure 11f), and *S. rizzinii* (Figure 11g). The pattern smooth was observed in three species (Table 4): *S. macranthera* (Figure 11h), *S. pinheiroi* (Figure 11i), and *S. splendida* (Figure 11j).

3.4 | Types of stomata, stomatal indexes and densities

The leaflets of all species are hypostomatic, with four different types of stomata: anisocytic, anomocytic, anomotetracytic and paracytic (Table 4). The paracytic (Figure 10) and anisocytic types (Figure 10a,b,c,e,f,g,h,i) were found in all species, being predominant the type paracytic. Anomotetracytic stomata were present in nine species: *S. angulata*, *S. chrysocarpa*, *S. georgica*, *S. macranthera*, *S. pinheiroi*, *S. pluribracteata* (Figure 10j), *S. rizzinii*, *S. rugosa* and *S. splendida* (Figure 10d). The type anomocytic was observed in five species: *S. angulata* (Figure 10e), *S. georgica*, *S. macranthera*, *S. pinheiroi* (Figure 10f), and *S. quinquangulata*. In all species, stomata are observed at the level of epidermal cells.

The stomatic indexes varied from 13.19% in *S. chrysocarpa*, to 20.97% in *S. angulata* (Table 4, Figure 12a). *Senna pinheiroi* (18.32%) and *S. macranthera* (18.79%),

and *S. pluribracteata* (17.55%) and *S. splendida* (17.79%) that showed the closest indices (Figure 12a). The stomatic densities varied beetween species, and the lowest index, 1.01 est/mm², was observed in *S. pinheiroi*, and the highest in *S. quinquangulata* with 2.47 est/mm² (Table 4, Figure 12b). Two species, *S. pluribracteata* and *S. georgica*, showed closer densities, 1.50 e 1.59 est/mm², respectively (Figure 12b).

3.5 | Leaflet mesophyll, and leaflet margins

All studied species showed dorsiventral mesophyll with uniseriate palisade parenchyma (Figure 11), and spongy parenchyma that varies from 4-7-seriates (Table 5). The pattern 5-6-seriate was predominant, and observed in six species, *S. angulata* (Figure 11e), *S. chrysocarpa* (Figure 11a), *S. macranthera* (Figure 11h), *S. pinheiroi* (Figure 11i), *S. quinquangulata* (Figure 11c), and *S. rizzinii* (Figure 11g). The 6-7-seriates pattern was recorded in three species, *S. georgica* (Figure 11f), *S. pluribracteata* (Figure 11b), and *S. rugosa* (Figure 11d). The parenchyma 4-5-seriate was an exclusive character of *S. splendida* (Figure 11j).

Proportion between palisade and spongy parenchymas in the mesophyll was different in the species studied (Table 5). The greater proportion of spongy parenchyma was observed in the mesophyll of *S. quinquangulata* and *S. rugosa* (61.9% and 61.8%, respectively), while in *S. rizzinii* the values are closer, the spongy parenchyma comprises 52.8% and the palisade 47.2% of the mesophyll. Seven species showed palisade parenchyma significantly larger than the spongy one (Table 5): *S. angulata* (Figure 11e), *S. chrysocarpa* (Figure 11a), *S. georgica* (Figure 11f), *S. macranthera* (Figure 11h), *S. pinheiroi* (Figure 11i), *S. pluribracteata* (Figure 11b), and *S. splendida* (Figure 11j).

Three types of inorganic idioblasts were observed in the mesophyll of the studied species: druses, prismatic crystals and spherical crystals (Table 5). Druses were observed in mesophyll of eight species: *S. chrysocarpa*, *S. georgica* (Figure 11f), *S. pinheiroi*

(Figure 11i), *S. pluribracteata* (Figure 11b), *S. quinquangulata* (Figure 11c), *S. rizzinii*, *S. rugosa*, and *S. splendida*. Prismatic crystals were observed in the mesophyll of eight species: *S. angulata* (Figure 11e), *S. georgica*, *S. macranthera* (Figure 11h), *S. pinheiroi*, *S. pluribracteata*, *S. quinquangulata*, *S. rizzinii*, and *S. rugosa*. Spherical crystal-type of idioblasts were observed in seven species: *S. angulata*, *S. chrysocarpa* (Figure 11a), *S. pinheiroi*, *S. pluribracteata, S. quinquangulata*, *S. rizzinii* (Figure 11g), and *S. splendida* (Figure 11j).

The leaflet margins of the studied species showed different shapes (Table 5, Figure 13). The rounded pattern was predominant and observed in four species, *S. chrysocarpa* (Figure 13a), *S. pluribracteata* (Figure 13b), *S. quinquangulata* (Figure 13c), and *S. rizzinii* (Figure 13d). The recurved margin was observed in three species: *S. georgica* (Figure 13e), *S. macranthera* (Figure 13f), and *S. rugosa* (Figure 13g). The pattern acute was observed in *S. pinheiroi* (Figure 13h), and *S. splendida* (Figure 13i), while the truncate margin was an exclusive character of *S. angulata* (Figure 13j). All species showed a vascular bundle near to the margin (Figure 13). The continuous palisade parenchyma is observed only at the margin of *S. pluribracteata* (Figure 13b).

3.6 | Midrib

The median portion of the midrib of all species studied, in cross-section, has a plane-convex outline (Table 6, Figure 14). Adjacent to the epidermis, on the adaxial surface, the presence of a continuous palisade parenchyma that was observed in four species, *S. chrysocarpa* (Figure 14a), *S. pinheiroi* (Figure 14b), *S. pluribracteata* (Figure 14c), and *S. rizzinii* (Figure 14d), while in the other species the palisade parenchyma is interrupted by a fundamental parenchyma (Figure 14e–j).

On the abaxial surface, the cortical region is formed by an angular collenchyma, 1-2-seriate, followed by the fundamental parenchyma in eight species: *S. chrysocarpa*

(Figure 14a), *S. macranthera* (Figure 14i), *S. pinheiroi* (Figure 14b), *S. pluribracteata* (Figure 14c), *S. quinquangulata* (Figure 14f), *S. rizzinii* (Figure 14d), *S. rugosa* (Figure 14g), and *S. splendida* (Figure 14j). In *Senna angulata* (Figure 14h) and *S. georgica* (Figure 14e) the cortical portion is formed only by the fundamental parenchyma.

The vascular system, in all species, is formed by a single central bundle of the collateral type, in the arch shape (Figure 14). In three species, small bundles of phloem were observed in the adaxial surface: *S. georgica* (Figure 14e), *S. quinquangulata* (Figure 14f), and *S. rugosa* (Figure 14g). A continuous sheath of sclerenchyma that was adjacent to the vascular system was observed in six species: *S. angulata* (Figure 14h), *S. chrysocarpa* (Figure 14a), *S. georgica* (Figure 14e), *S. pinheiroi* (Figure 14b), *S. quinquangulata* (Figure 14f), and *S. rugosa* (Figure 14g), while in the other species, such as *S. macranthera* (Figure 14i), *S. pluribracteata* (Figure 14c), *S. rizzinii* (Figure 14d), and *S. splendida* (Figure 14j), a discontinuous sclerenchyma sheath was observed.

With respect to the presence of idioblasts, two types of inorganic idioblasts, as druses and prismatic crystals were observed in the midrib of all studied species (Table 6). Druses were present in the fundamental parenchyma and phloem area (Figure 14a,c,d,f,g,j), while prismatic crystals were observed near to the sclerenchyma sheaths (Figure 14a,h). Idioblasts as spherical crystals were observed in two species: in the fundamental parenchyma of *S. georgica* (Figure 14e), and also *S. macranthera*.

3.7 | Petiole

The petiole, in cross section, showed three patterns of shape: pentagonal, rectangular and semicircular (Table 7, Figure 15). The pentagonal pattern was observed in *S. pluribracteata* (Figure 15a); the pentagonal pattern slightly concave adaxially was observed in three species: *S. georgica* (Figure 15b), *S. macranthera* (Figure 15c), and *S. quinquangulata* (Figure 15d); the pentagonal pattern slightly wavy and concave adaxially

was observed in *S. rizzinii* (Figure 15e); the pentagonal-sinuous pattern, concave adaxially, was present in *S. chrysocarpa* (Figure 15f), and *S. pinheiroi* (Figure 15g). The rectangular pattern convex abaxially was observed in two species: *S. angulata* (Figure 15h) and *S. rugosa* (Figure 15i). The semicircular shape was an exclusive character of *S. splendida* (Figure 15j).

Adjacent to the epidermis, the cortex is formed by 1-2 seriate angular collenchyma, followed by the fundamental parenchyma in seven species: *S. chrysocarpa* (Figure 15f), *S. georgica* (Figure 15b), *S. pinheiroi* (Figure 15g), *S. pluribracteata* (Figure 15a), *S. quinquangulata* (Figure 15d), *S. rizzinii* (Figure 15e), and *S. splendida* (Figure 15j). In the other species the cortex is constituted only by the fundamental parenchyma.

The vascular system is collateral (Figure 15), a characteristic of the family, varying in number of bundles of central and accessories facing to adaxial surface were observed. Four central bundles and two accessories were observed in six species: *S. chrysocarpa* (Figure 15f), *S. macranthera* (Figure 15c), *S. pinheiroi* (Figure 15g), *S. rizzinii* (Figure 15e), *S. rugosa* (Figure 15i), and *S. splendida* (Figure 15j); four central bundles and four accessories are seen in *S. angulata* (Figure 15h); three central bundles and two accessories are recorded in *S. pluribracteata* (Figure 15a); five central bundles and two accessories are seen in *S. quinquangulata* (Figure 15d); six central bundles and three accessories are recorded in *S. georgica* (Figure 15b).

Discontinuous sclerenchyma sheaths surround the vascular bundles in nine species: *S. angulata* (Figure 15h), *S. chrysocarpa* (Figure 15f), *S. georgica* (Figure 15b), *S. macranthera* (Figure 15c), *S. pinheiroi* (Figure 15g), *S. pluribracteata* (Figure 15a), *S. rizzinii* (Figure 15e), *S. rugosa* (Figure 15i), and *S. splendida* (Figure 15j). In *S. quinquangulata* (Figure 15d), the vascular sheaths are surrounded by continuous bundles of sclerenchyma. In all species the central portion of the petiole showed a medullary

parenchyma, with anisodiametric cells, having circular shape and thin cell walls (Figure 15).

Two types of inorganic idioblasts are observed in the petiole of all studied species: druses and prismatic crystals (Table 7). Druses were observed in the medullary parenchyma and phloem (Figure 15a,e), while prismatic crystals occurs associated with sclerenchyma. Spherical crystals-like idioblasts were observed in the medullary parenchyma of *S. rizzinii*, and in the fundamental parenchyma of *S. splendida*. The crystals sand type was observed in the cortical region of *S. angulata* and *S. pluribracteata*.

3.8 | Leaf rachis

The leaf rachis, in transverse section, showed six shape patterns: rounded, elliptic, obdeltoid, pentagonal, semicircular, and triangular (Table 8, Figure 16). The circular pattern was a character exclusive of *S. splendida* (Figure 16a); the pattern eliptic and concave on the adaxial surface was observed in two species: *S. macranthera* (Figure 16b), and *S. rizzinii* (Figure 16c); the pentagonal pattern was common to *S. pluribracteata* (Figure 16d), and *S. rugosa* (Figure 16e); the obdeltoid pattern with two adaxial projections was observed in *S. pinheiroi* (Figure 16f), and *S. quinquangulata* (Figure 16g); the semicircular pattern with adaxial projections was present in *S. angulata* (Figure 16h) and *S. georgica* (Figure 16i); the triangular shape with adaxia projections was a character distinctive to *S. chrysocarpa* (Figure 16j).

The vascular system of the leaf rachis is similar to the petiole and midrib, of the collateral type (Figure 16), which varies in number of central and accessories bundles facing to adaxial surface (Table 8). Four central bundles and two accessories were predominant, observed in six species: *S. chrysocarpa* (Figure 16j), *S. macranthera* (Figure 16b), *S. pluribracteata* (Figure 16d), *S. quinquangulata* (Figure 16g), *S. rizzinii* (Figure 16c), and *S. rugosa* (Figure 16e). Four central bundles and four accessories, were

distinctive to *S. georgica* (Figure 16i). Three central bundles and two accessories were exclusive to *S. pinheiroi* (Figure 16f). The central bundle as circle, and two accessories were seen in *S. angulata* (Figure 16h), and *S. splendida* (Figure 16a).

The vascular bundles are surrounded by a continuous sclerenchyma sheaths in five species: *S. angulata* (Figure 16h), *S. georgica* (Figure 16i), *S. quinquangulata* (Figure 16g), *S. rugosa* (Figure 16e), and *S. splendida* (Figure 16a), while the type discontinuous was observed in the other species. The rachis has a medullary parenchymatic area similar to that observed in the petiole (Figure 16).

Inorganic idioblasts like druses, prismatic crystals and crystals sand (Table 8) were observed. Druses were present in the phloem area, and in the parenchimas fundamental, medullar, and cortical of all the species studied. Idioblasts of the prismatic crystals type are associated with sclerenchyma sheaths of all species, and also in the medullar parenchyma of *S. chrysocarpa,* and *S. macranthera*. Crystals sand were observed in the cortical and medullar parenchymas of *S. angulata* and *S. pluribracteata*.

4 | DISCUSSION

According to Barthlott et al. (1998), epicuticular waxes have a great micromorphological diversity and are taxonomically useful in the characterization of many plant families. However, few epidermal studies have been carried out on the leaves of *Senna* species, and the occurrence of epicuticular waxes as granules and plates were previously reported for *S. alata* (L.) Roxb. by Rodrigues et al. (2009), and the platlets types were reported for *Cassia fistula* L. Khan and Zaki (2019), a genus morphologically and phylogenetically related to *Senna.* In this work we are reporting for the first time the presence of microplatelets, membraneous platelets and fissured layers in *Senna* species. The epicuticular waxes as rosettes, considered as 'Fabales-type' wax were also present in four species in our work, which corroborate with Barthlott et al. (1998).

The indument of the species of *Senna* ser. *Bacillares* studied here followed the pattern observed by Irwin and Barneby (1982) in the review of the genus for America. However, different indument were observed besides those reported by these authors for the adaxial surface of *S. pinheiroi* and for the abaxial surface of *S. georgica*, *S. macranthera*, *S. pinheiroi*, *S. rizzinii*, and *S. rugosa*. This divergence may occur due to the use of a different methodology.

Simple single-celled trichomes were previously reported by Metcalfe and Chalk (1950) for *Senna* species (*Cassia*), and corroborated by Ogundipe et al. (2009) and Begum et al. (2014), with multicellular glandular trichomes still being observed on the abaxial surface of *S. hirsuta* (L.) H.S. Irwin & Barneby and *S. occidentalis* (L.) Link, a character not observed in the species of this study. Simple multicellular trichomes uniseriate are also observed in other species of *Senna* (*Cassia*), such as *S. siamea* (Lam.) H.S. Irwin & Barneby and *S. spectabilis* (DC.) H.S. Irwin & Barneby (Kotresha & Seetharam, 2000). In *Mimosa* L. (Caesalpinioideae), through micromorphological study, two basic types of trichomes were differentiated: glandular and non-glandular, the first, sessile or stipulated and the last, branched or unbranched (Santos-Silva, Tozzi, Simon, Urquiza, & Morales, 2013). The absence of trichomes has a taxonomic value in the recognition of *S. splendida*.

From an ecological point of view, Johnson (1975) suggests that the occurrence of trichomes and their density may be influenced by metabolic processes resulting from seasonal variations in the environment, such as water availability. Matos, Venzon, Freitas, Rezende, & Schoereder (2009) observed that the increase in the density of trichomes in *Capsicum* spp. which acted as a limiting factor in its predation by mites, acting as a morphological defense of the plant against its natural predators.

Regarding the distribution of stomata, the hypoestomatic pattern is the most frequent in the subfamily Caesalpinioideae (Metcalfe & Chalk, 1950), corroborating the observations obtained in the studied *Senna* species. However, amphistomatic leaflets have been observed in *Senna* species occurring in Nigeria (Ogundipe et al., 2009) and Bangladesh, with the exception of *S. siamea* (Lam.) H.S. Irwin & Barneby (Begum et al., 2014). Cutler, Botha, Stevenson, and William (2007) suggest that plants that grow in tropical forests have stomata restricted to the abaxial surface, since the water supply is stable.

Stomatal analysis performed according to the classification proposed by Dilcher (1974) revealed the occurrence of types of anisocytic, anomocytic and paracitic stomata, previously observed in *Senna* species (Kotresha & Seetharam, 2000; Ogundipe et al., 2009; Begum et al., 2014). However, the presence of anomotetracytic stomata in *Senna* species is being mentioned here for the first time for the genus. Sultana, Ahmad, Zafar, Khan, and Arshad (2012), also report the occurrence of diacytic stomata in *S. obtusifolia* (L.) H.S. Irwin & Barneby, a character not observed in the studied species. According to Metcalfe and Chalk (1950), different types of stomata occur on the same leaf surface, due to the arrangement and variable number of subsidiary cells.

Regarding the epidermal analyzes, different patterns of contour of the anticline walls were observed, corroborating with previous reports by Metcalfe and Chalk (1950). On the adaxial surface, there was a predominance of straight anticline walls, as observed in *S. chrysocarpa* and *S. quinquangulata*, for example, being a pattern common to other species of the genus, such as *S. alata* and *S. hirsuta* (L.) H.S. Irwin & Barneby (Begum et al., 2014), and in *S. occidentalis* and *S. reticulata* (Willd.) H.S. Irwin & Barneby (Prata-Alonso, Mendonça, & Alonso, 2015). Regarding the abaxial surface, most species had sinuous walls, such as *S. macranthera* and *S. splendida*. Kotresha and Seetharam (2000)

observed in a study with species of *Cassia* L. sensus lato (including *Senna*), that the sinuous pattern is the rarest on the abaxial surface of the studied species, occurring only in *Cassia occidentalis* L. (*S. occidentalis*), the straight pattern predominating.

The significance of the contour patterns of the anticline walls of epidermal cells, generate different interpretations between different authors. According to Wilkinson (1979), this character has ecological value, being influenced by the growth of the plant under strong or weak solar incidence, tending to be sinuous in plants growing shaded and straight when exposed to the sun. On the other hand, Mantovani, Gomes, Gomes, and Vieira (1995) observed straight anticline walls in Rubiaceae species, although the plants are growing in shade, suggesting that this character may be influenced by genetic factors. Authors such as Barthlott (1981), and Fontenelle, Costa, and Machado (1994), propose that the contour of the anticline walls is related to gene control and not to luminosity, being a character of important taxonomic value.

A papillose epidermis is not a common pattern observed in *Senna* species, but it was previously registered in species of the genus, including *S. alata* and *S. podocarpa* (Guill. & Perr.) Lock (Ogundipe et al., 2009), and in species of the genus *Chamaecrista* (L.) Moench (Francino, Coutinho, Dalvi, Azevedo, Conceição, & Meira, 2015; Coutinho et al., 2016), related morphologically to *Senn*a, both belonging to Cassiinae subtribe. According to Dickison (2000), epidermal papillae function as a mechanical barrier to fungi. On the other hand, Mantovani et al. (1995) suggests that the papillae convert light stimuli, being important in photosynthesis.

The dorsiventral mesophile with single-palisade parenchyma observed in all studied species, according to Metcalfe and Chalk (1950), is a common characteristic of *Senna* (*Cassia*) species. This character was also observed in other species of the genus, such as *S. occidentalis* (*Cassia occidentalis*) (Nassar et al., 2013; Amponsah et al., 2016)

and *S. alata* (*Cassia alata* L.) (Srinivasan, 2018). Mauseth (1998) suggests that most plants have a palisade parenchyma that is only one layer thick, but species exposed to intense sunlight may be three to four layers thick. Regarding the spongy parenchyma, Metcalfe and Chalk (1950) report that it is difficult to establish an exact number of spongy parenchyma strata for each species, since this is a variant character in the same individual. The proportion between the mesophile parenchyma showed to be relevant in the recognition of *S. rizzinii*, since both parenchyma present values close to 50%.

The shape of the edges showed taxonomic relevance in the recognition of *S. angulata*, whose species has a truncated border. This character is configured as a diagnosis for the identification of species of other genera of Leguminosae, such as *Bauhinia* L. and *Schnella* Raddi (Pereira et al., 2018), as well as for Rubiaceae species (Mantovani et al., 1995).

Rodrigues et al. (2009) and Nassar et al. (2013) reported the occurrence of a collateral vascular bundle in the median portion of the midrib in *S. alata* and *S. occidentalis*, respectively, corroborating what was observed in the studied *Senna* species and in species of the genera *Chamaecrista* (Francino et al., 2015) and *Bauhinia* (Pereira et al., 2018). According to Dickson (2000), the vascular system of most plants is formed by collateral bundles, with the xylem organized internally and the phloem externally.

The presence of a continuous palisade parenchyma on the adaxial surface of the midrib was a character previously observed in 49 species of *Chamaecrista* (Francino et al., 2015), but not previously registered for *Senna* species. The presence of sclerenchyma involving the vascular system of the midrib is a common feature of Leguminosae species as already observed in *Albizia* Durazz. (Miranda et al., 2009), *Bauhinia* and *Schnella* (Pereira et al., 2018), and *Psoralea* L. (Crow et al., 1997). According to Dickson (2000),

because it is a tissue made up of lignified cells, the sclerenchyma gives support and protection to the plant, and can occur alone or grouped in bundles.

The anatomy of the petiole has been identified as the most variable and important characters in the delimitation of species and generic groupings by several taxonomists (Deghan, 1982; Martínez-Cabrera, Terrazas, & Ochoterena, 2009; Talip, Cutler, Puad, Ismail, Ruzi, & Juhari, 2017; Song & Hong, 2018; Seixas et al., 2019), including supporting the delimitation of new *Senna* species (Souto et al., 2021). Metcalfe and Chalk (1950) drew attention to the potential of studying the anatomy of petiole as a support for the taxonomy of Caesalpinioideae (Leguminosae), as well as for other families such as Solanaceae and Bignoniaceae. The presence of adaxial accessory bundles facing the adaxial surface in the petiole is a common feature in species of *Senna* (Ogundipe et al., 2009), and in other Leguminosae genera, such as, for example, *Bauhinia* (Rezende, Cardoso, & Vannucci, 1994; Pereira et al., 2018), and *Eriosema* (DC.) Desv (Seixas et al., 2019), and also observed in the leaf rachis.

The anatomy of the rachis had not been previously investigated in *Senna* species. Characters such as the shape and number of vascular bundles showed a taxonomic value in the delimitation of species, as observed in the anatomy of the petiole. In *Chamaecrista*, for example, the anatomy of petiole and leaf rachis has been important for the support and delimitation of new species (Silva, Souza, & Alonso, 2019; Matos, Souza, Santos, & Silva, 2020).

Druse-type inorganic idioblasts and prismatic crystals were previously observed in *Senna* species (Rodrigues et al., 2009; Saheed & Illoh, 2010), as they were recorded here for all studied species. Metcalfe and Chalk (1950) reported the occurrence of solitary crystals and grouped everywhere in Caesalpinioideae, serving to differentiate them from

Papilionoideae species that present crystals almost always solitary. Spherical crystals and crystals sand are reported here, for the first time, for *Senna* species.

According to Alamgir (2017), prismatic crystals are important in the diagnosis of plant drugs present in *Senna* species. Several functions have been attributed to idioblasts such as a product of metabolism, which in excess can be toxic to plants. Crystals can act to remove excess calcium from the plant, but they can also work to protect against herbivores, as they cause a burning sensation in the predator's mouth, causing animals not to forage certain plants (Franceschi & Horner, 1980).

5 | CONCLUSIONS

The leaf anatomy of ten species of *Senna* ser. *Bacillares* showed a set of characters useful to distinguish taxonomically the species studied. Different types of epicuticular waxes on the leaf epidermis of the species studied here, and even within species, with syntopism, showed relative taxonomic importance to separate the species of *Senna* studied here, and was very distinctive for characterizing *S. splendida*. The contour of the anticline walls, especially on the adaxial surface for the recognition of *S. pinheiroi*, in addition to the morphology of the indument on both surfaces of the leaflets, important in the recognition of *S. angulata*, *S. georgica*, *S. pluribracteata*, and *S. splendida*. The shape of the truncate edge was taxonomically relevant for the the separation of *S. angulate* from the other species of the series *Bacillares*.

The anatomical characters of the petiole and leaf rachis were the most important for the differentiation of the studied species, with emphasis on the format and the number of central and accessories vascular bundles, which were useful in the recognition of *S. chrysocarpa*, *S. georgica*, *S. pluribracteata*, and *S. splendida*. The set of different characters observed on the leaf epidermis and its attachments, together with the anatomy

of leaflet edges, petiole and leaf rachis provided an additional subsidy, useful for the taxonomy of species of *Senna* ser. *Bacillaries* studied here, as well as for the genus *Senna*.

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Legends:

Figure 1 Cuticles and epicuticular waxes on both surface of the leaflets of species of *Senna* ser. *Bacillares*, by SEM: (a-b) *S. angulata* (*F.S. Souto et al. 166*): (a) adaxial surface, (b) abaxial surface, (c-d) *S. chrysocarpa* (*V.G.R. Cardoso 03*): (c) adaxial surface, (d) abaxial surface, (e-f) *S. macranthera* (*R.T. Queiroz 111*): (e) adaxial surface, (f) abaxial surface. Legends: blue arrow, granules; green arrow, crusts; purple arrow, microplatelets; red arrow, platelets; rose arrow, fissured layers; str, striate. Scale bars: (c, d) = 50 µm, (a, b) = 100 µm, (e, f) = 300 µm.

Figure 2 Cuticles and epicuticular waxes on both surface of the leaflets of species of *Senna* ser. *Bacillares*, by SEM: (a-b) *S. pinheiroi* (*L.A. Pereira & E.C.O. Chagas 263*): (a) adaxial surface, (b) abaxial surface, (c-d) *S. pluribracteata* (*F.S. Souto et al. 188*): (c) adaxial surface, (d) abaxial surface, (e-f) *S. quinquangulata* (*L.C. Gomes 199*): (e) adaxial surface, (f) abaxial surface. Legends: blue arrow, granules; green arrow, crusts; purple arrow, microplatelets; red arrow, platelets. Scale bars: (a, e, f) = 100 µm, (b, c, d) = 300 µm.

Figure 3 Cuticles and epicuticular waxes on both surface of the leaflets of species of *Senna* ser. *Bacillares*, by SEM: (a-b) *S. rizzinii* (*R.T. Queiroz 93*): (a) adaxial surface, (b) abaxial surface, (c-d) *S. rugosa* (*M. Oliveira 3451*): (c) adaxial surface, (d) abaxial surface, (e-f) *S. splendida* (*I. Loiola 696*): (e) adaxial surface, (f) abaxial surface. Legends: blue arrow, granules; green arrow, crusts; orange arrow, rodlets; red arrow, platelets; white arrow, rosettes; yellow arrow, membraneous platelets. Scale bars: (a) = 50 µm, (e, f) = 40 µm, (d) = 100 µm, (b, c) = 300 µm.

Figure 4 Indument on the adaxial surface of the leaflets of species of *Senna* ser. *Bacillares*, by SM: (a) *S. chrysocarpa* (*V.G.R. Cardoso 03*), (b) *S. macranthera* (*R.T. Queiroz 111*), (c) *S. rizzinii* (*R.T. Queiroz 93*), (d) *S. rugosa* (*M. Oliveira 3451*), (e) *S.*

angulata (*F.S. Souto et al. 166*), (f) *S. pluribracteata* (*F.S. Souto et al. 188*), (g) *S. quinquangulata* (*L.C. Gomes 199*), (h) *S. splendida* (*I. Loiola 696*).

Figure 5 Indument on the abaxial surface of the leaflets of species of *Senna* ser. *Bacillares*, by SM: (a) *S. angulata* (*F.S. Souto et al. 166*), (b) *S. pinheiroi* (*L.A. Pereira & E.C.O. Chagas 263*), (c) *S. rizzinii* (*R.T. Queiroz 93*), (d) *S. rugosa* (*M. Oliveira 3451*), (e) *S. quinquangulata* (*L.C. Gomes 199*), (f) *S. georgica* (*F.S. Souto et al. 182*), (g) *S. pluribracteata* (*F.S. Souto et al. 188*), (h) *S. splendida* (*I. Loiola 696*).

Figure 6 Indument of the midrib on the both surfaces and on the edges of the leaflets of species of *Senna* ser. *Bacillares*, by SM: (a-b) *S. chrysocarpa* (*V.G.R. Cardoso 03*), (c-d) *S. georgica* (*F.S. Souto et al. 182*), (e-f**)** *S. splendida* (*I. Loiola 696*), (g**)** *S. chrysocarpa* (*V.G.R. Cardoso 03*), (h) *S. pluribracteata* (*F.S. Souto et al. 188*), (i) *S. georgica* (*F.S. Souto et al. 182*), (j) *S. splendida* (*I. Loiola 696*).

Figure 7 Morphology of simple trichomes on both surfaces of the leaflets of species of *Senna* ser. *Bacillares*, by LM: (a) Multicellular trichome in *S. angulata* (*A. Gomes 373*), (b-d) Unicellular trichome: (b) *S. chrysocarpa* (*C. Schlindwein 945*), (c) *S. macranthera* (*F.S. Souto et al. 158*), (d) *S. georgica* (*F.S. Souto et al. 174*).

Figure 8 Trichomatic indexes on both surfaces of the leaflets of species of *Senna* ser. *Bacillares*: (a) Adaxial surface, (b) Abaxial surface.

Figure 9 Anticlinal cell walls on the adaxial surface of leaflets epidermis of species of *Senna* ser. *Bacillares*, in peradermic sections, by LM: (a) *S. chrysocarpa* (*J.A. Siqueira-Filho et al. 176*), (b) *S. pluribracteata* (*F.S. Souto et al. 188*), (c) *S. quinquangulata* (*R.P. Lyra-Lemos et al. 5737*), (d) *S. rizzinii* (*R.P. Lyra-Lemos et al. 10567*), (e) *S. rugosa* (*M.R.C Sales de Melo 43*), (f) *S. angulata* (*F.S. Souto et al. 166*), (g) *S. georgica* (*F.S. Souto et al. 182*), (h) *S. macranthera* (*P.C. Gadelha-Neto et al. 2331*), (i) *S. splendida* (*D.C. Moura 1291*), (j) *S. pinheiroi* (*J.B.S. Oliveira et al. 75*). Legend: tr, trichome.

Figure 10 Anticlinal cell walls on the abaxial surface of leaflets epidermis of species of *Senna* ser. *Bacillares*, in peradermic sections, by LM: (a) *S. georgica* (*L.H.L. Moreira 84*), (b) *S. macranthera* (*M. Correia 433*), (c) *S. rizzinii* (*M.F. Agra et al. 5905*), (d) *S. splendida* (*Moura & Silva 1291*), (e) *S. angulata* (*F.S. Souto et al. 166*), (f) *S. pinheiroi* (*J.B.S. Oliveira et al. 75*), (g) *S. quinquangulata* (*R.P. Lyra-Lemos et al. 5737*), (h) *S. rugosa* (*M.R.C Sales de Melo 43*), (i) *S. chrysocarpa* (*J.A. Siqueira-Filho et al. 176*), (j) *S. pluribracteata* (*F.S. Souto et al. 188*). Legends: ani, anisocytic stomata; ano, anomocytic stomata; at, anomotetracytic stomata; pr, paracytic stomata; tr, trichome.

Figure 11 Mesophyll of leaflets of species of *Senna* ser. *Bacillares*, in cross sections, by LM: (a) *S. chrysocarpa* (*V.G.R. Cardoso 03*), (b) *S. pluribracteata* (*F.S. Souto et al. 188*), (c) *S. quinquangulata* (*L.C. Gomes 199*), (d) *S. rugosa* (*M.R.C. Sales de Melo 43*), (e) *S. angulata* (*A. Gomes 373*), (f) *S. georgica* (*F.S. Souto et al. 174*), (g) *S. rizzinii* (*R.T. Queiroz 93*), (h) *S. macranthera* (*P.C. Gadelha-Neto et al. 2331*), (i) *S. pinheiroi* (*J.B.S. Oliveira 75*), (j) *S. splendida* (*F.S. Souto et al. 183*). Legends: dr, druse; ep, epidermis; pap, papillae; pc, prismatic crystals; pp, palisade parenchyma; sc, spherical crystals, sp, spongy parenchyma; tr, trichome; vb, vascular bundle.

Figure 12 (a) Stomatal index and (b) stomatal density of species of *Senna* ser. *Bacillares*.

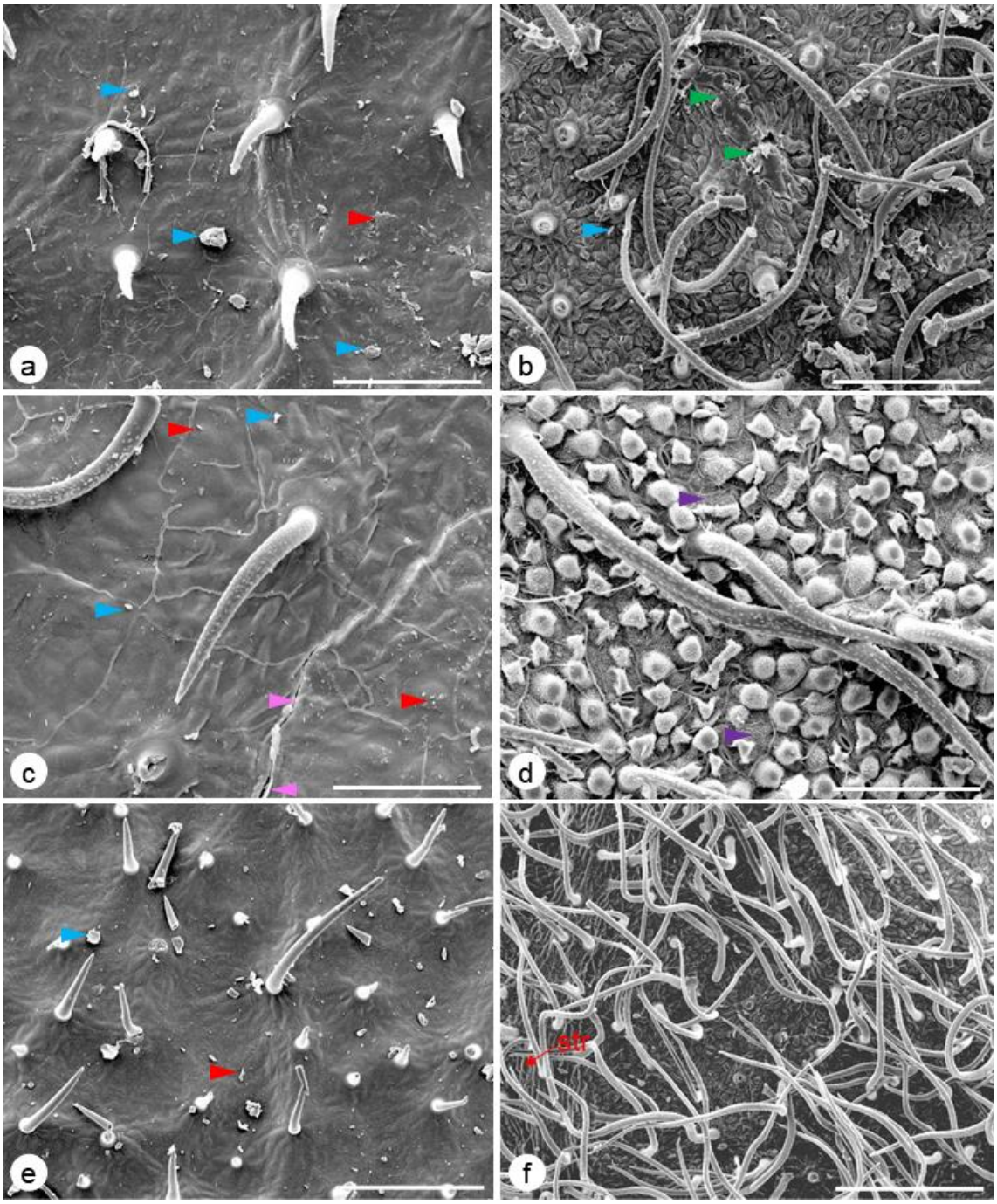
Figure 13 The leaflets edges of species of *Senna* ser. *Bacillares*, in cross sections, by LM: (a) *S. chrysocarpa* (*J.A. Siqueira-Filho et al. 176*), (b) *S. pluribracteata* (*F.S. Souto et al. 188*), (c) *S. quinquangulata* (*P.B. Alves et al. 89*), (d) *S. rizzinii* (*J.E. Gomes de Lima 124*), (e) *S. georgica* (*F.S. Souto et al. 182*), (f) *S. macranthera* (*F.S. Souto et al. 158*), (g) *S. rugosa* (*M. Oliveira 3451*), (h) *S. pinheiroi* (*N.T. Amazonas 194*), (i) *S. splendida* (*I. Loiola et al. 696*), (j) *S. angulata* (*A. Gomes 373*). Legends: cu, cuticle; scl, sclerenchyma; tr, trichome; vb, vascular bundle.

Figure 14 The midrib of leaflets of species of *Senna* ser. *Bacillares*, in cross sections, by LM: (a) *S. chrysocarpa* (*V.G.R. Cardoso 03*), (b) *S. pinheiroi* (E. Barbosa 45), (c) *S. pluribracteata* (*F.S. Souto et al. 188*), (d) *S. rizzinii* (*R.P. Lyra-Lemos et al. 10567*), (e) *S. georgica* (*M.F.A. Lucena & J. Lucena 324*), (f) *S. quinquangulata* (*J.D. Garcia 1338*), (g) *S. rugosa* (*M.R.C. Sales de Melo 43*), (h) *S. angulata* (*F.S. Souto et al. 166*), (i) *S. macranthera* (*E. Córdula et al. 263*), (j) *S. splendida* (*F.S. Souto et al. 165*). Legends: co, collenchyma; dr, druse; ep, epidermis; est, stomata; fp, fundamental parenchyma; pc, prismatic crystals; ph, phloem; pp, palisade parenchyma; sc, spherical crystals; scl, sclerenchyma; tr, trichome; xy, xylem.

Figure 15 The petiole of leaf of species of *Senna* ser. *Bacillares*, in cross sections, by LM: (a) *S. pluribracteata* (*F.S. Souto et al. 188*), (b) *S. georgica* (*F.S. Souto et al. 182*), (c) *S. macranthera* (*P.C. Gadelha-Neto et al. 2331*), (d) *S. quinquangulata* (*J.D. Garcia 1338*), (e) *S. rizzinii* (*M.F. Agra et al. 5905*), (f) *S. chrysocarpa* (*R.P. Lyra-Lemos et al. 7080*), (g) *S. pinheiroi* (*A.M. Miranda & L.P. Félix 1511*), (h) *S. angulata* (*A. Gomes 373*), (i) *S. rugosa* (*M. Oliveira 3451*), (j) *S. splendida* (*F.S. Souto et al. 183*). Legends: dr, druse; fp, fundamental parenchyma; mp, medullary parenchyma; ph, phloem; scl, sclerenchyma; xy, xylem.

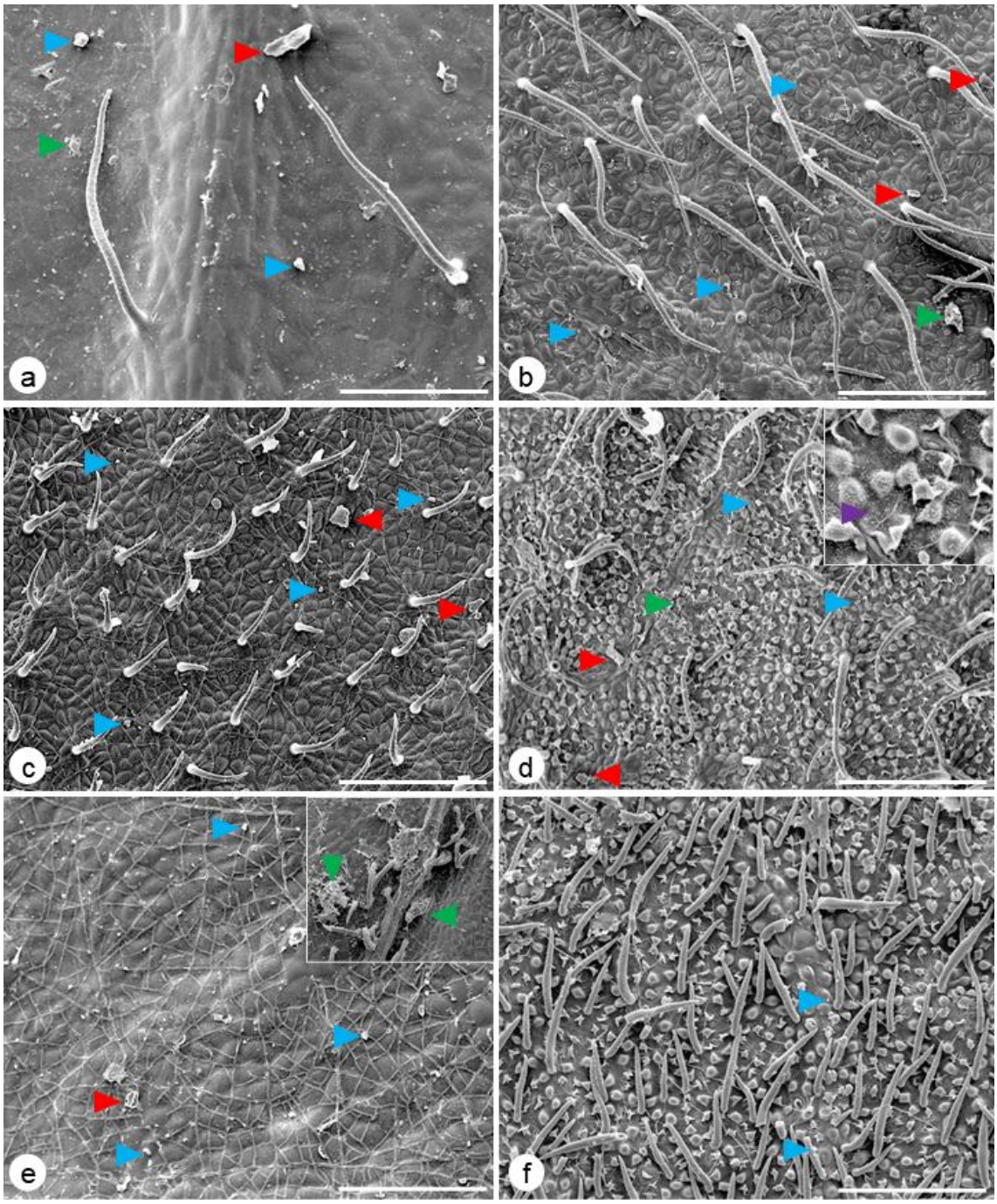
Figure 16 The leaf rachis of species of *Senna* ser. *Bacillares*, in cross sections, by LM: (a) *S. splendida* (*N.M. Rodrigues et al. 1729*), (b) *S. macranthera* (*F.S. Souto et al. 158*), (c) *S. rizzinii* (*R.P. Lyra-Lemos et al. 10567*), (d) *S. pluribracteata* (*F.S. Souto et al. 188*), (e) *S. rugosa* (*M. Oliveira 3451*), (f) *S. pinheiroi* (*L.A. Pereira & E.C.O. Chagas 263*), (g) *S. quinquangulata* (*L.C. Gomes 199*), (h) *S. angulata* (*F.S. Souto et al. 166*), (i) *S. georgica* (*M. Oliveira 1436*), (j) *S. chrysocarpa* (*C. Schlindwein 945*). Legends: fp, fundamental parenchyma; mp, medullary parenchyma; ph, phloem; scl, sclerenchyma; xy, xylem.

120 **Figure 1**



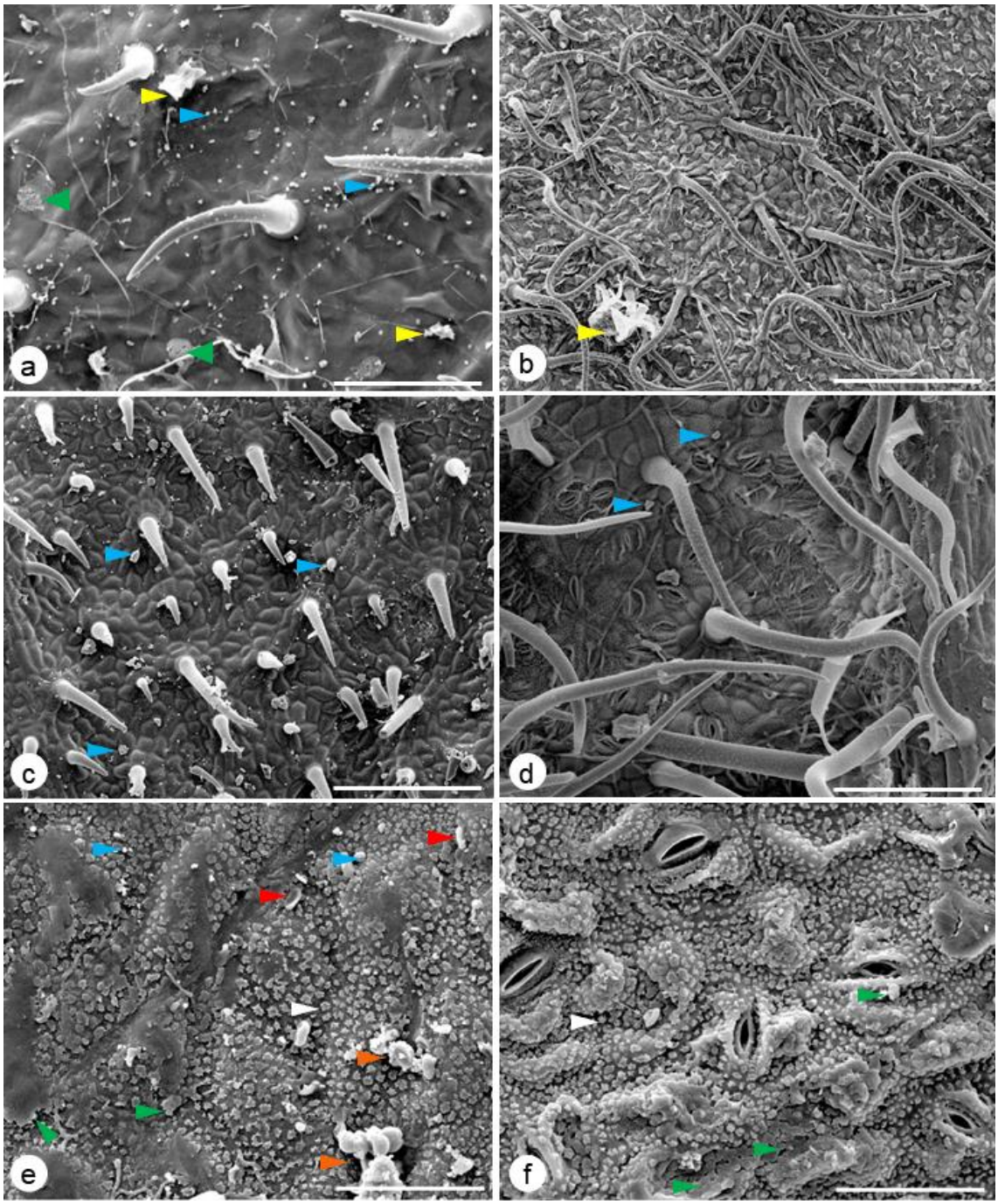
121

122 **Figure 2**



123

Figure 3



126 **Figure 4**

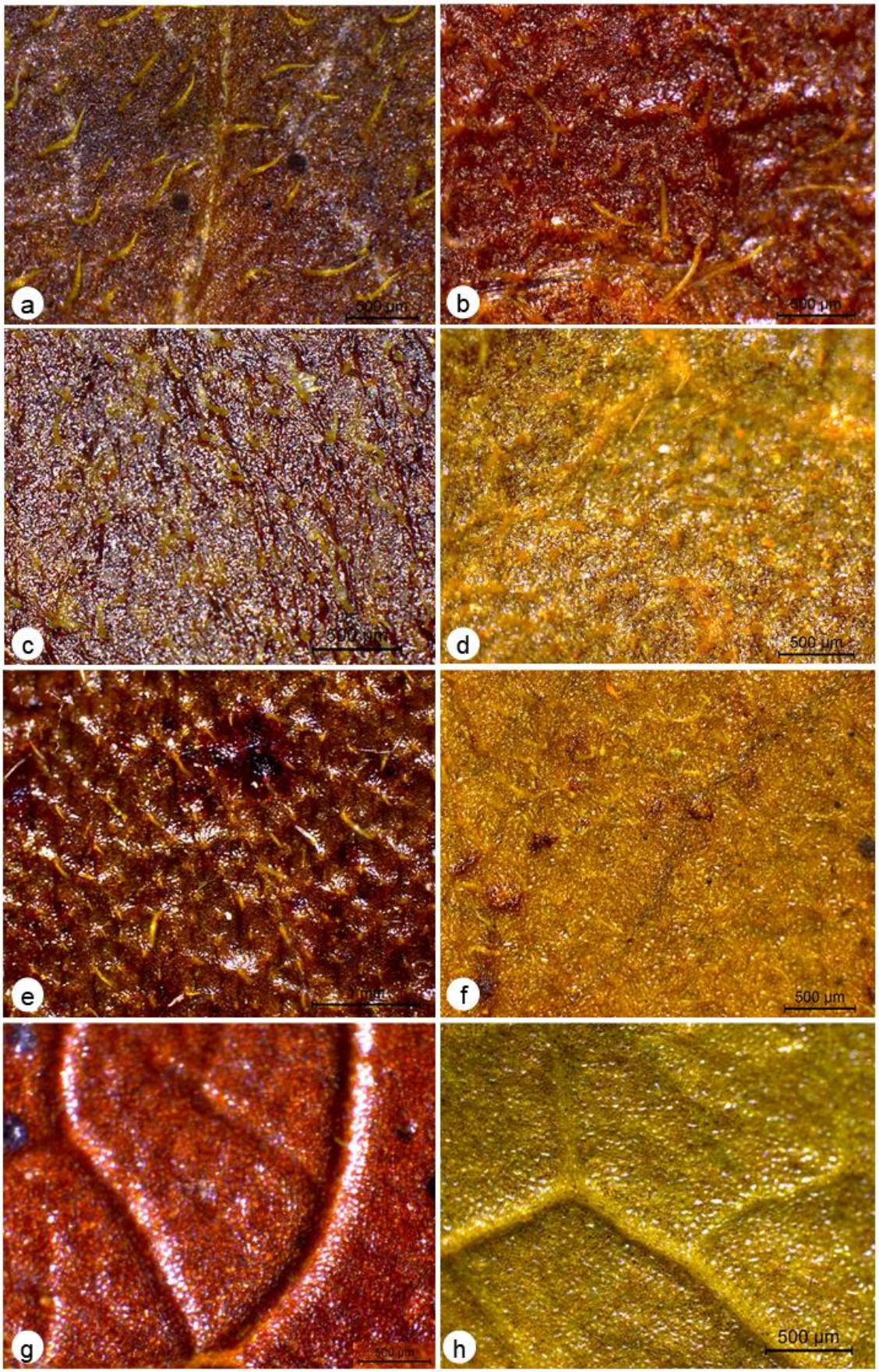


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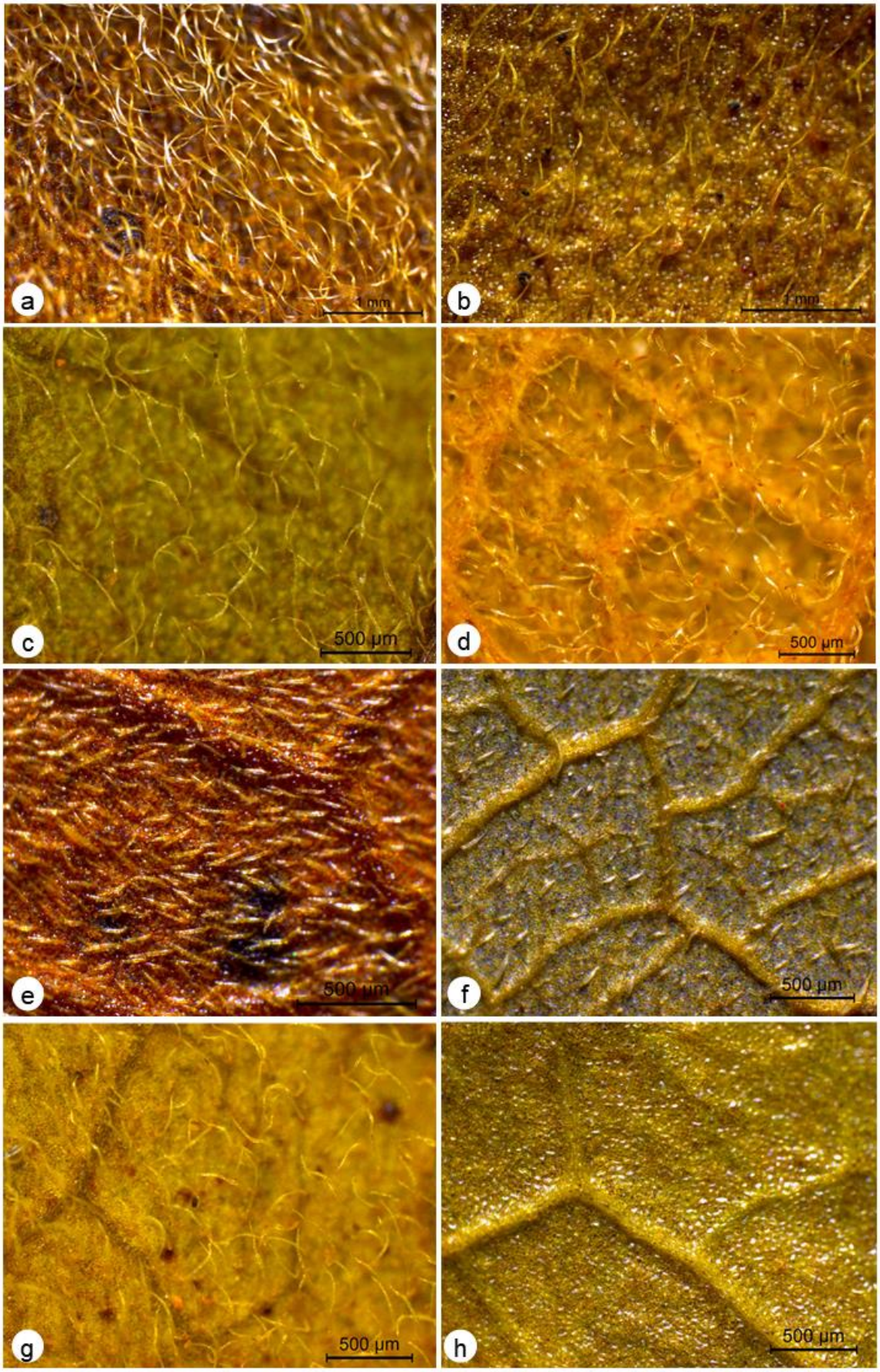
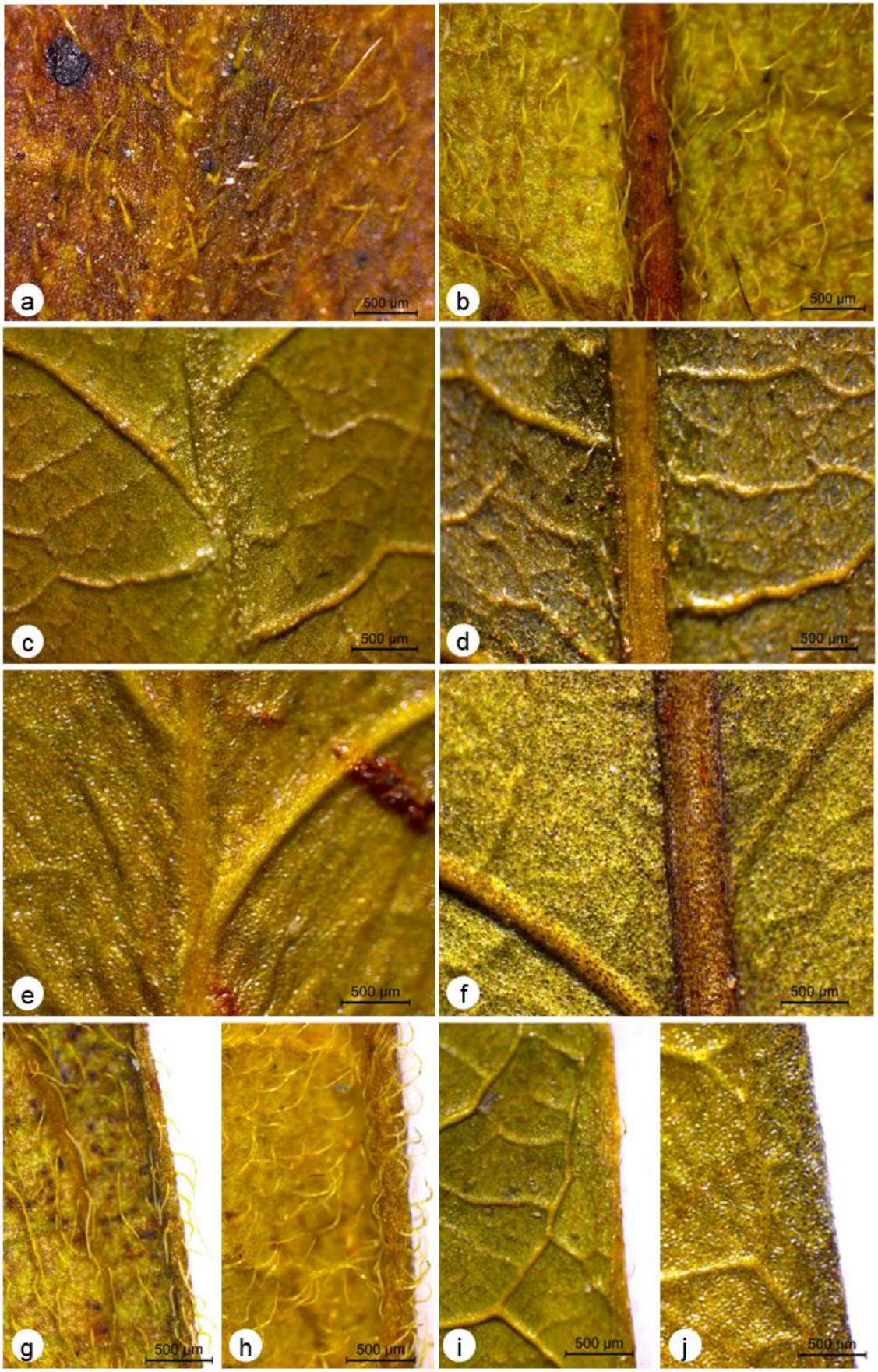
Figure 5



130 **Figure 6**



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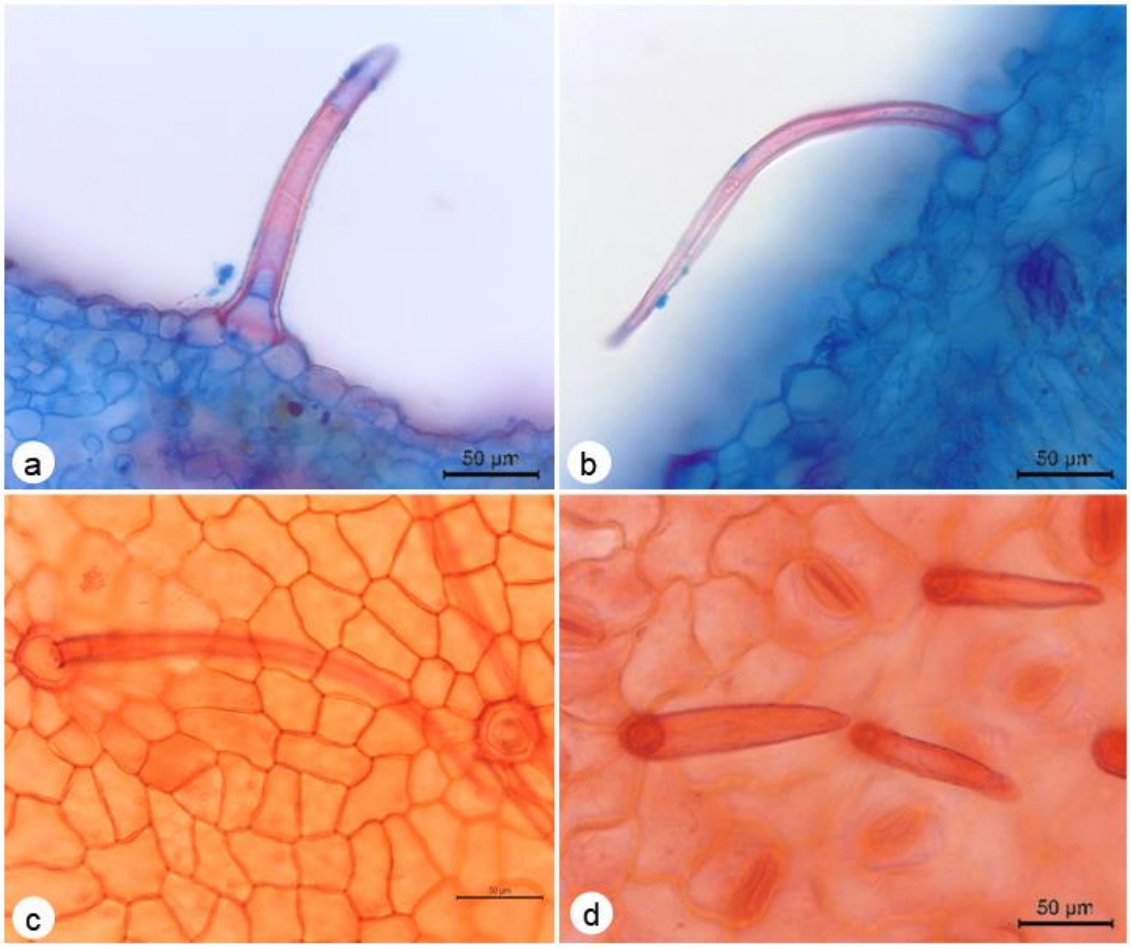
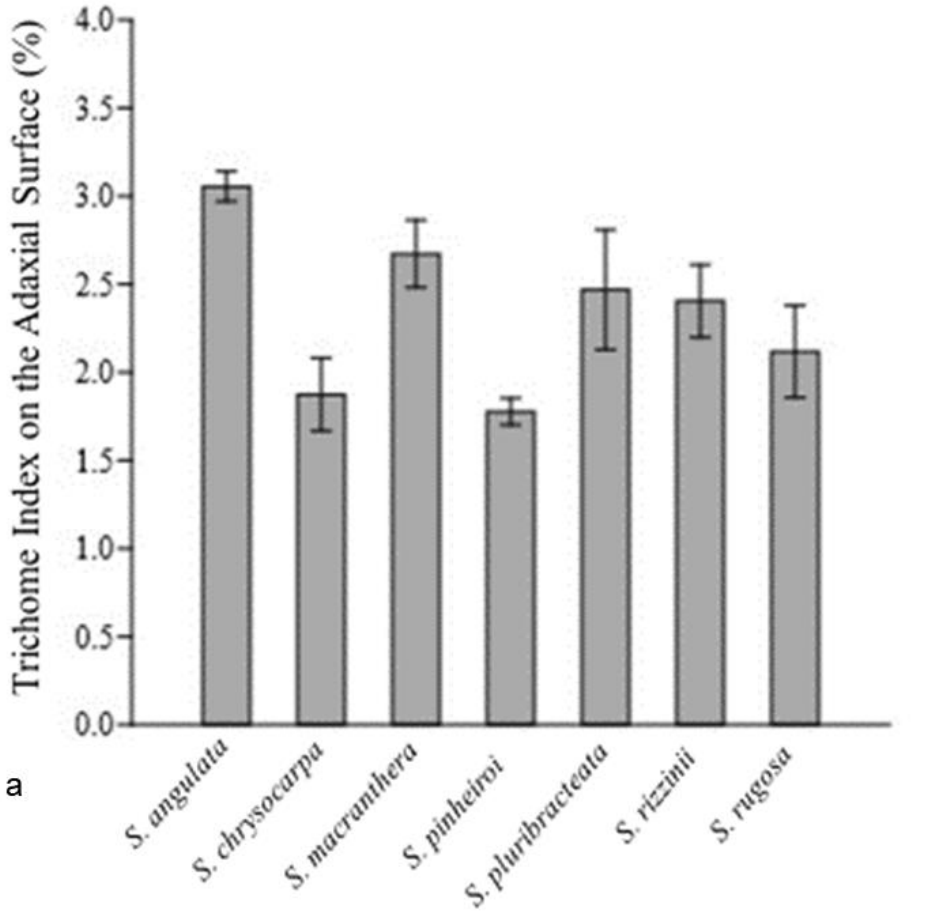
132 **Figure 7**

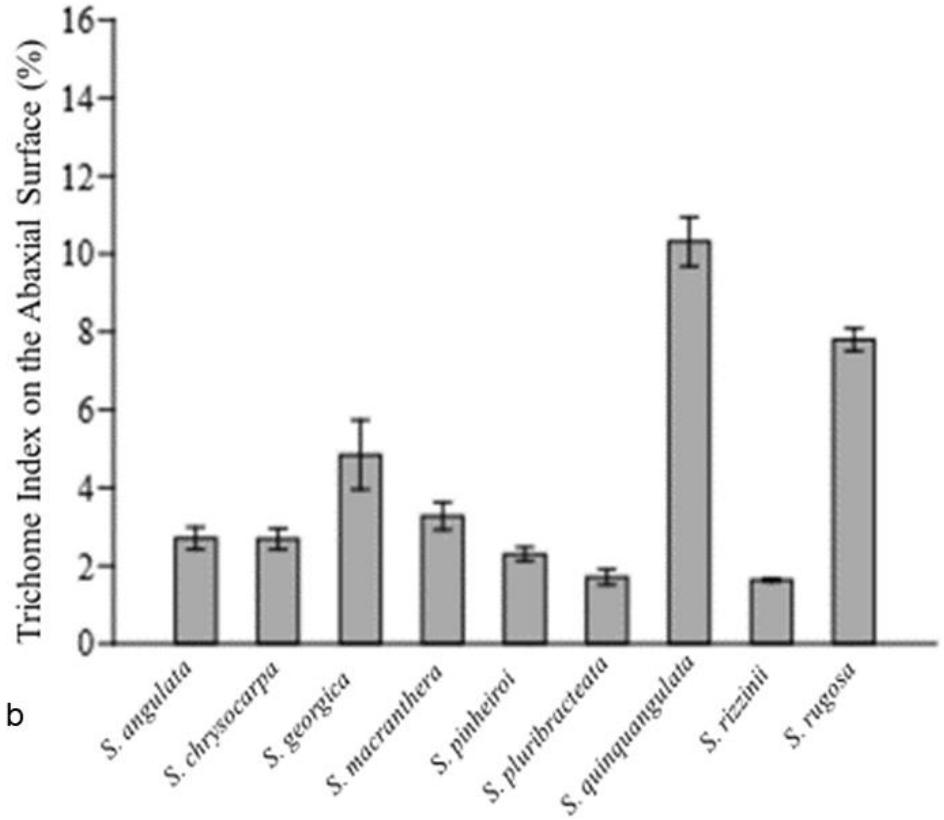


133

Figure 8

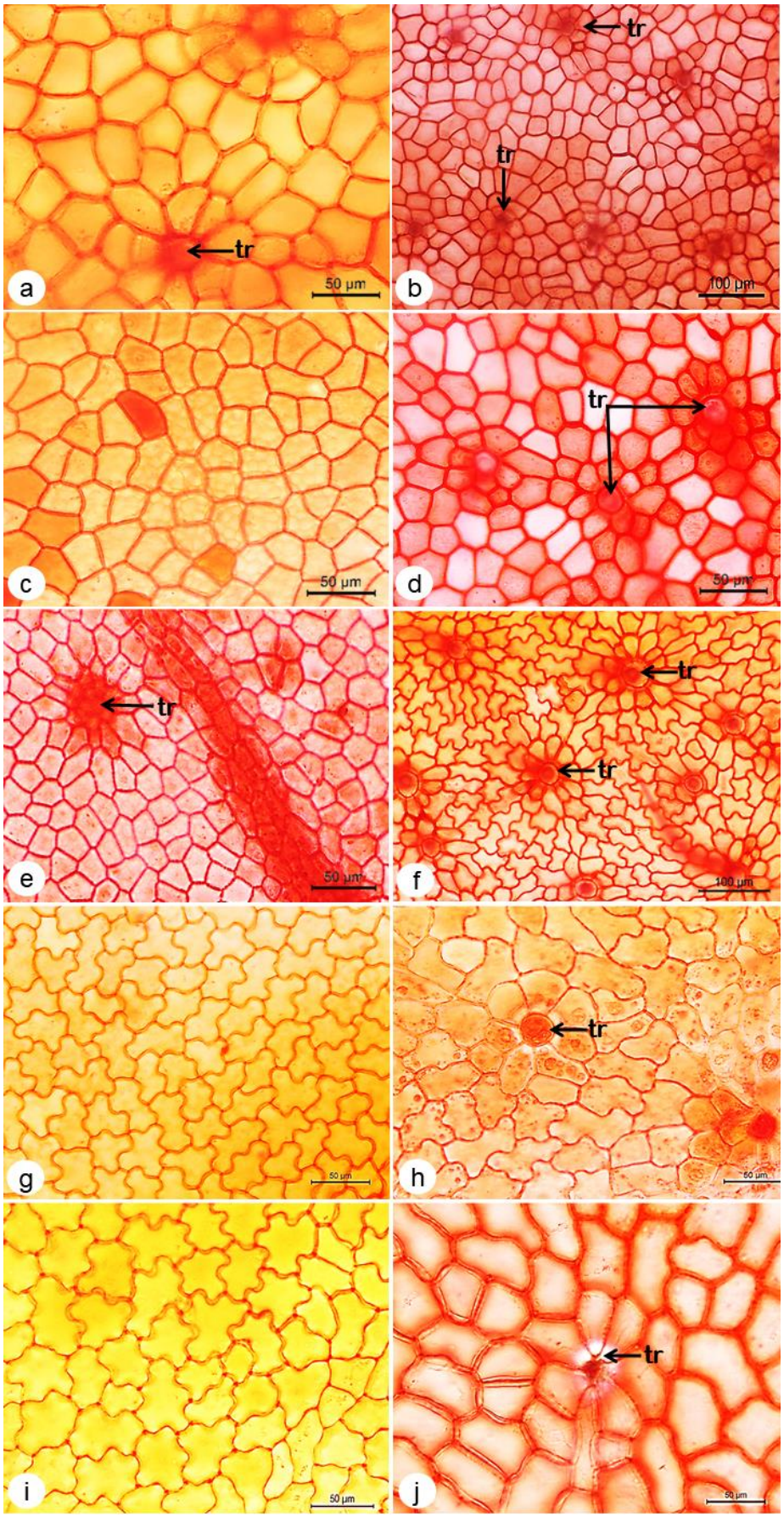

Trichome Index on the Adaxial Surface (%)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
S. angulata
S. chrysocarpa
S. macranthera
S. pinheiroi
S. pluribracteata
S. rizzinii
S. rugosa

a


Trichome Index on the Abaxial Surface (%)
16
14
12
10
8
6
4
2
0
S. angulata
S. chrysocarpa
S. georgica
S. macranthera
S. pinheiroi
S. pluribracteata
S. quinquangulata
S. rizzinii
S. rugosa

b

Figure 9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50 µm

Figure 10

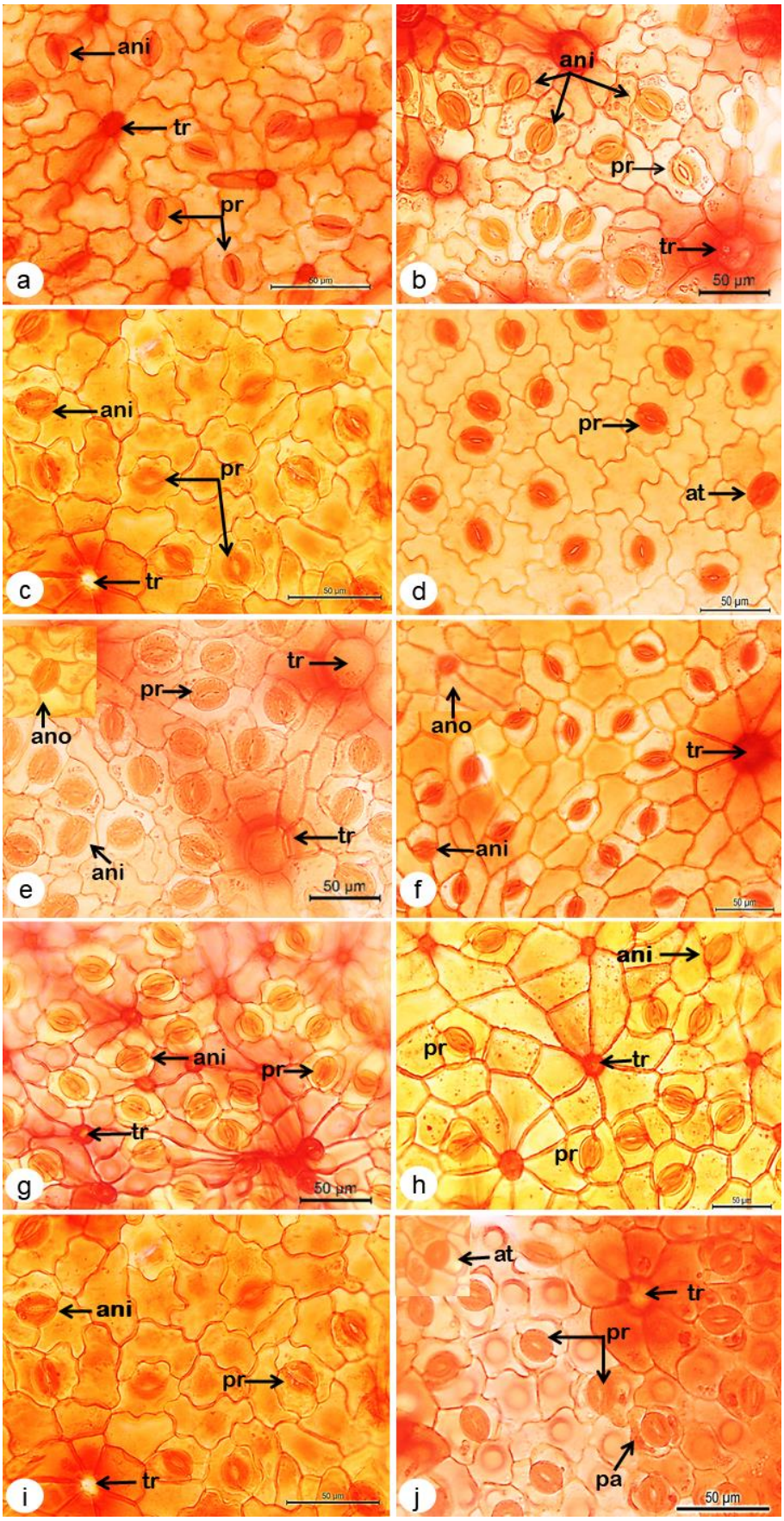
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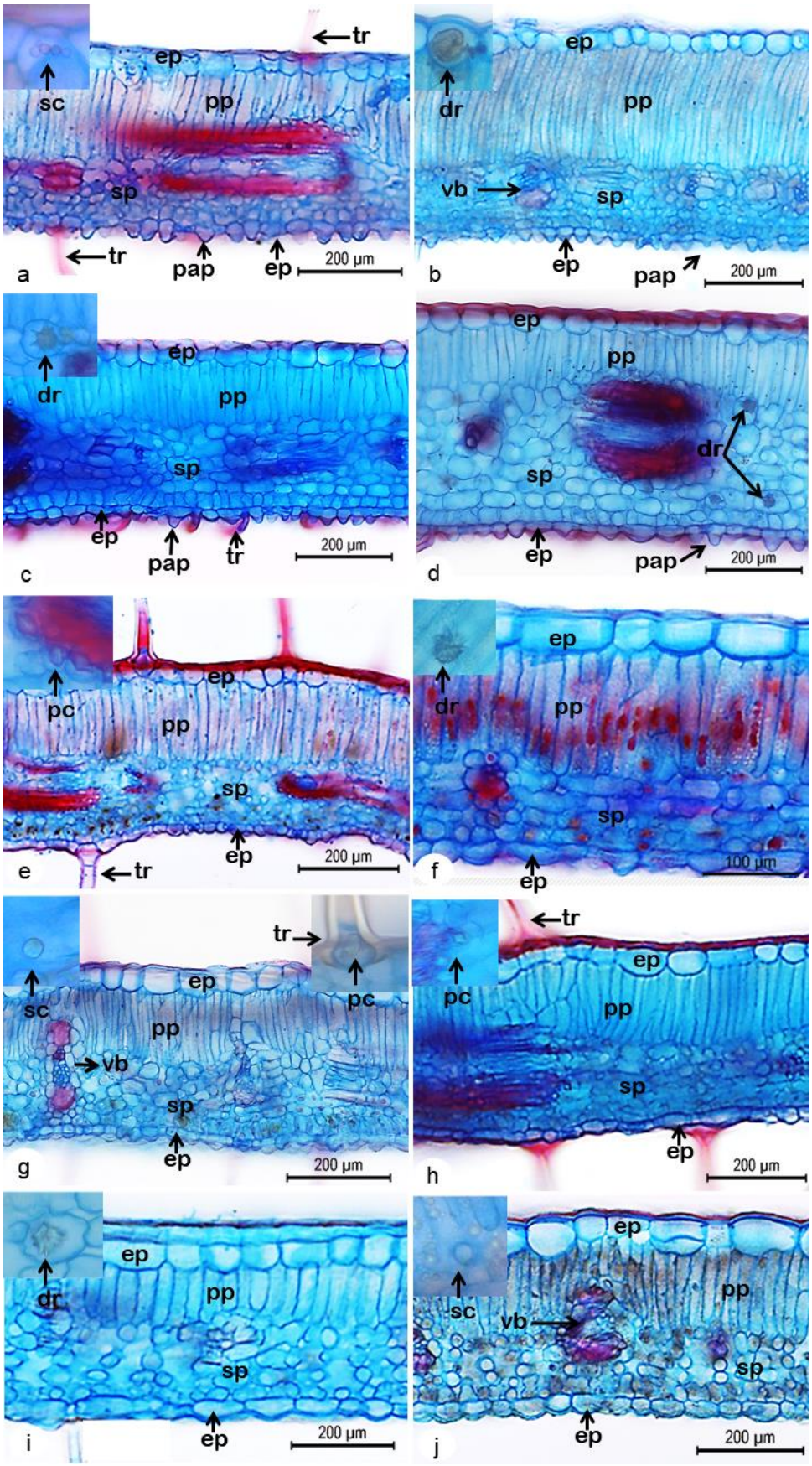
Figure 11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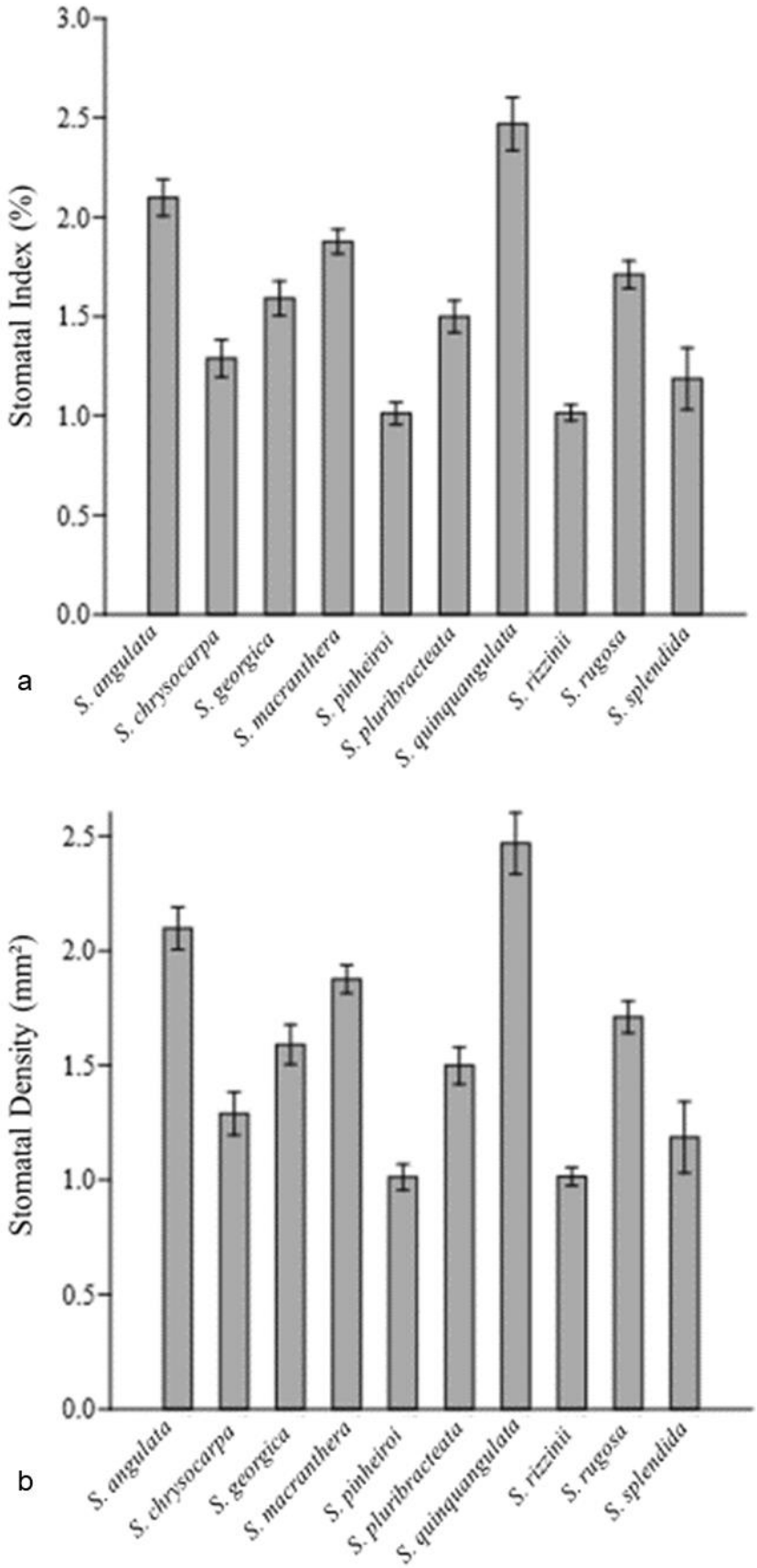
sp
ep
200 µm

142 **Figure 12**



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144 **Figure 13**

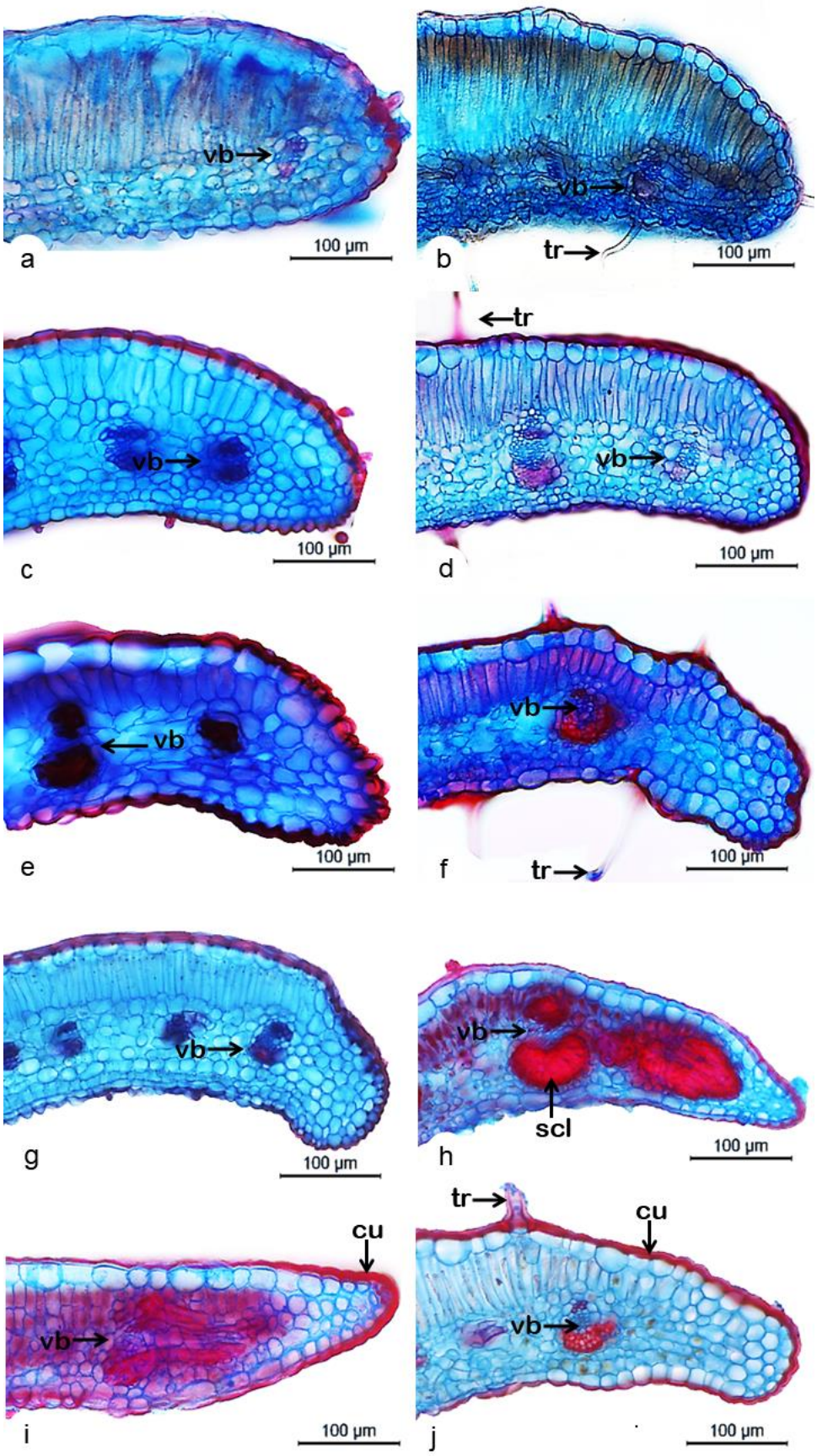

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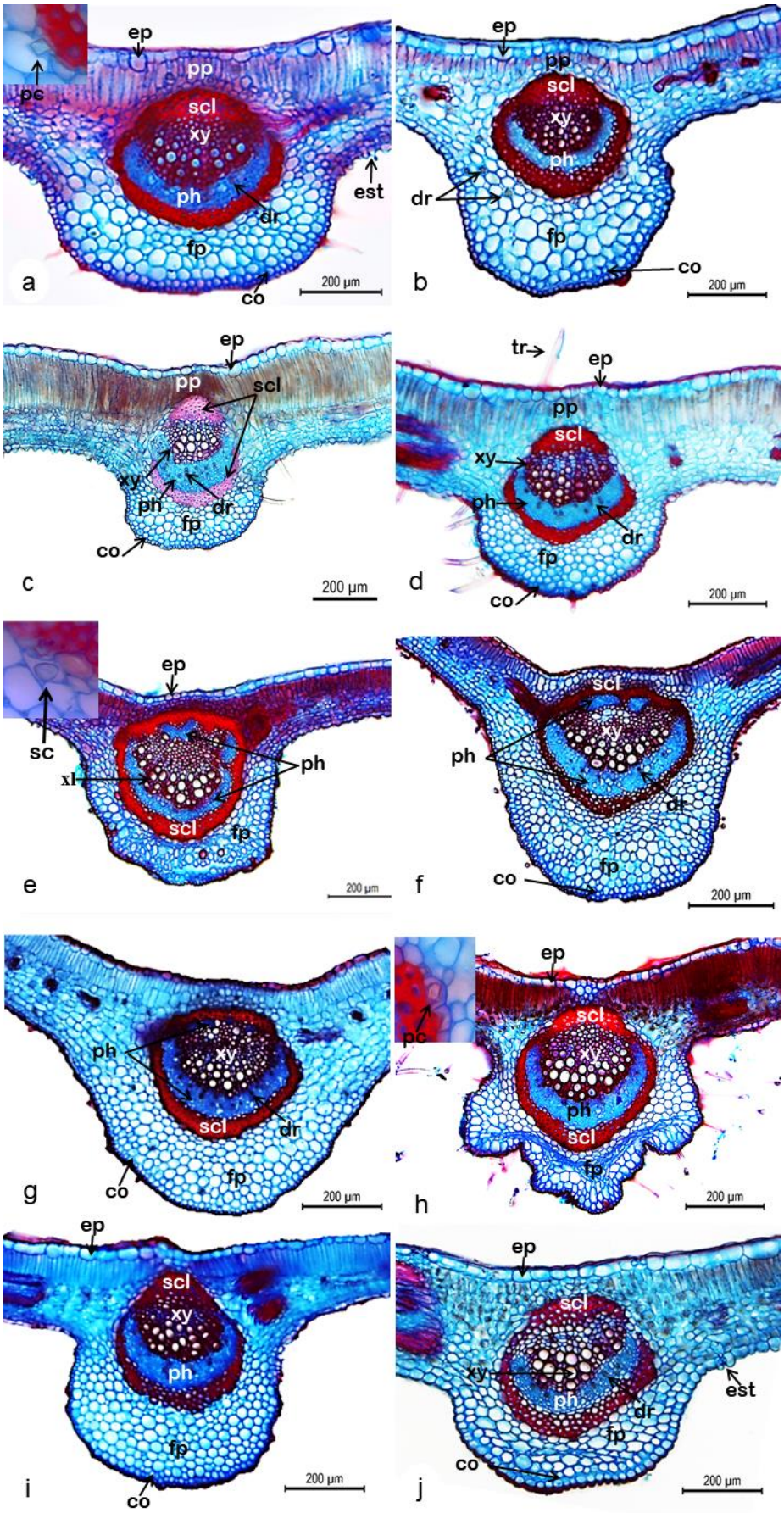
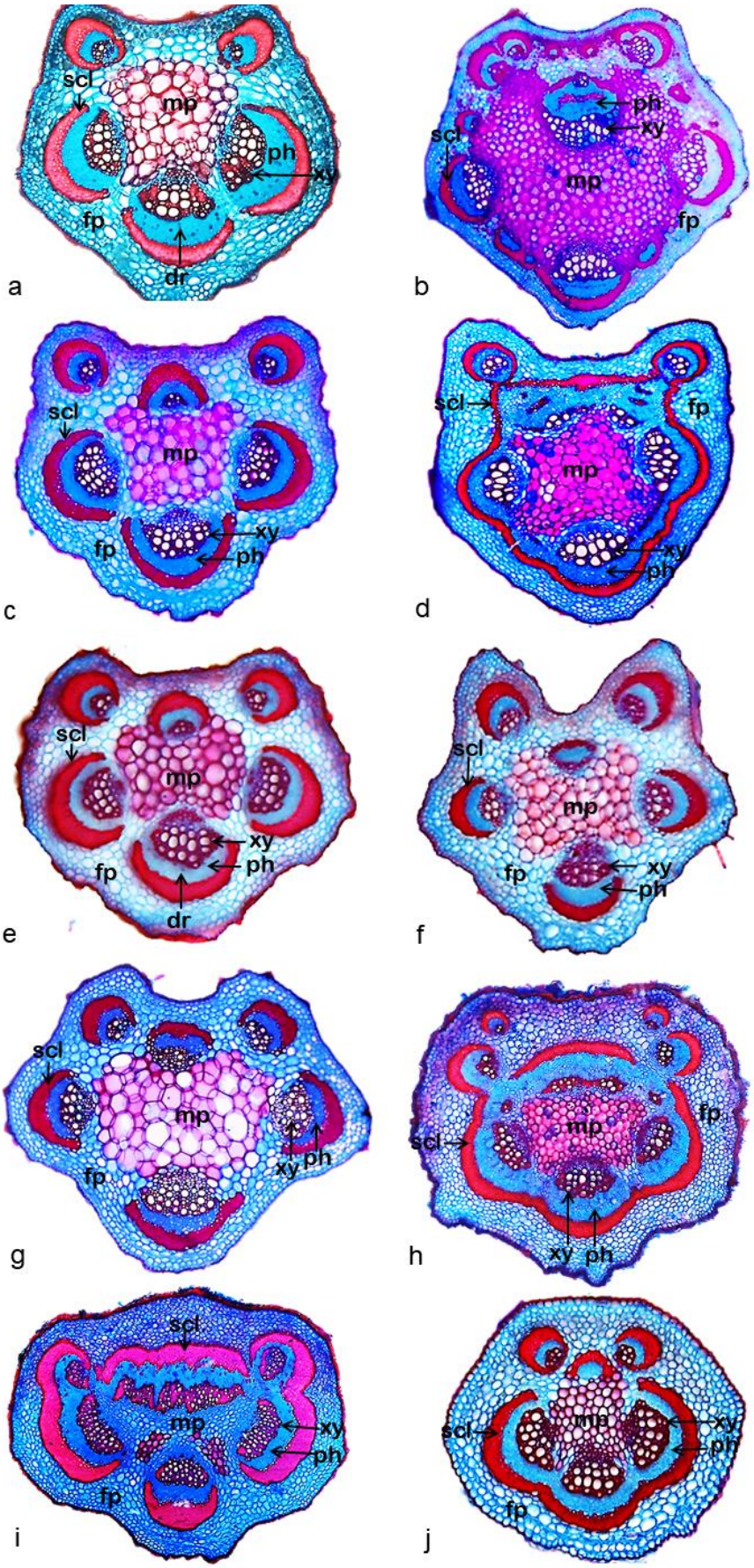
Figure 14

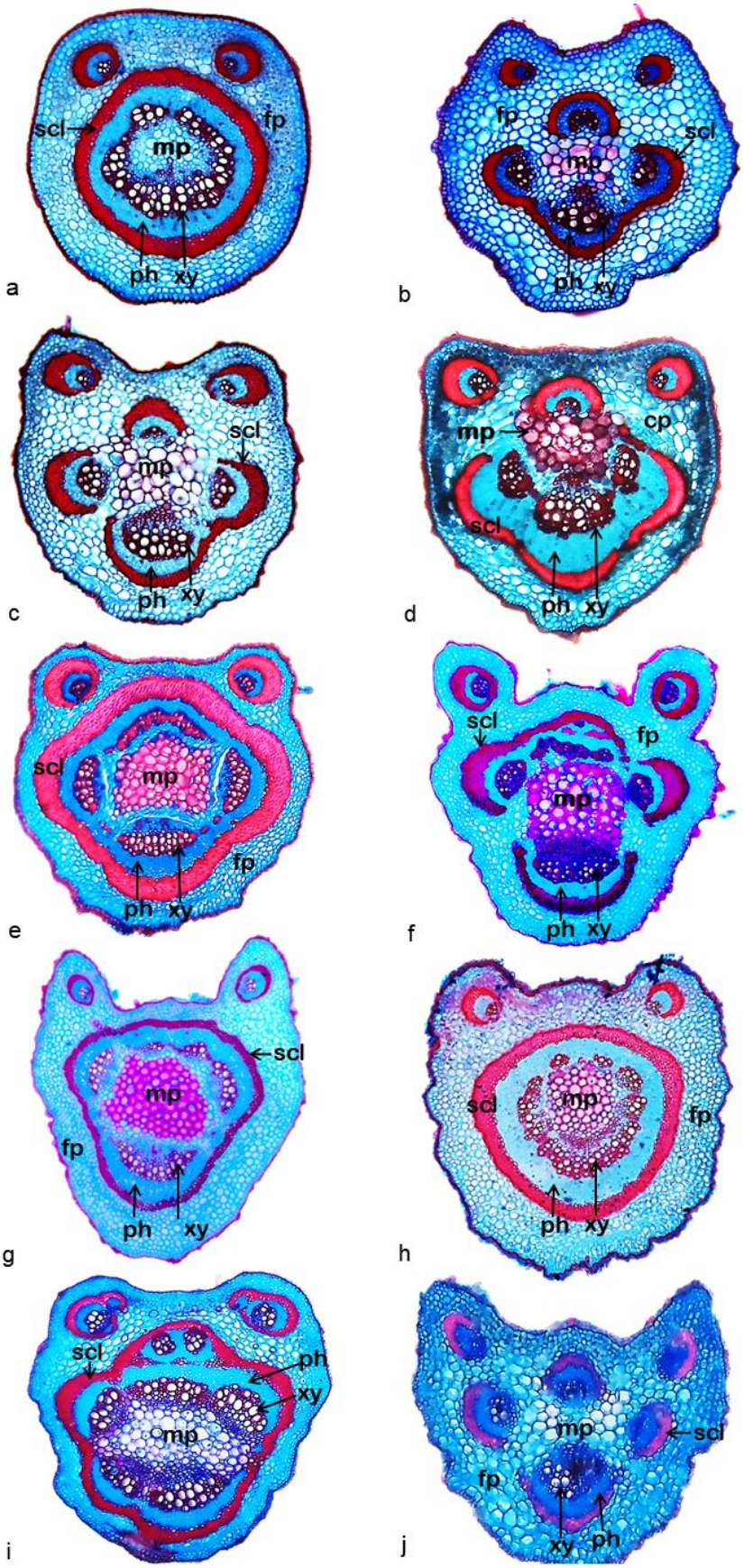


148 **Figure 15**



149

Figure 16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fp
ph
xy
h
scl
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Table 1 Species and voucher specimens of *Senna* ser. *Bacillares* analyzed in the anatomical study.

Species	Voucher Collector name and number (herbarium acronym)
Senna angulata (Vogel) H.S. Irwin & Barneby	*A. Gomes 373* *F.S. Souto et al. 166*
Senna chrysocarpa (Desv.) H.S. Irwin & Barneby	*A.C. Martins-Monteiro 106* (MAC) *C. Schlindwein 945* (UFP) *J.A. Siqueira-Filho et al. 176* (UFP) *R.P. Lyra-Lemos et al. 7080* (UFP) *V.G.R. Cardoso 03* (MAC)
Senna georgica H.S. Irwin & Barneby	*F.S. Souto et al. 174* *F.S. Souto et al. 182* *L.H.L. Moreira & R.T. Queiroz 84* (JPB) *M.F.A. Lucena & J. Lucena 324* (PEUFR) *M. Oliveira 1436* (UFP)
Senna macranthera (Collad.) H.S. Irwin & Barneby	*F.S. Souto et al. 158* *M. Correia 433* (UFP) *M.M. Medeiros & A.L. Rangel 17* (JPB) *M.S. Pereira 139* (JPB) *R.T. Queiroz 111* (UFP)
Senna pinheiroi H.S. Irwin & Barneby	*A.M. Miranda & L.P. Félix 1511* (PEUFR) *E. Barbosa 45* (MAC) *J.B.S. Oliveira 75* (UFP) *L.A. Pereira & E.C.O. Chagas 263* (JPB) *N.T. Amazonas 194* (JPB)
S. pluribracteata F.S. Souto & R.T. Queiroz	*F.S. Souto et al. 188*
Senna quinquangulata (Rich.) H.S. Irwin & Barneby	*J.B.S. Oliveira et al. 9* (UFP) *L.C. Gomes 199* (PEUFR) *J.D. Garcia 1338* (UFP)

	P.B. Alves et al. 89 (MAC)
	R.P. Lyra-Lemos et al. 5737 (MAC)
Senna rizzinii H.S. Irwin & Barneby	*J.E. Gomes de Lima 124* (PEUFR)
	M.F. Agra et al. 5905 (UFP)
	R.P. Lyra-Lemos et al. 10567 (MAC)
	R.P. Lyra-Lemos et al. 10514 (MAC)
	R.T. Queiroz 93 (UFP)
Senna rugosa (G. Don) H.S. Irwin & Barneby	*M. Oliveira 3451* (UFP)
	M.R.C. Sales de Melo 43 (PEUFR)
Senna splendida (Vogel) H.S. Irwin & Barneby	*D.C. Moura & R.A. Silva 1291* (UFP)
	F.S. Souto et al. 165
	F.S. Souto et al. 183
	I. Loiola et al. 696 (UFP)
	N.M. Rodrigues et al. 1729 (UFP)

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Table 2 Micromorphology of epicuticular waxes and cuticle on the leaflet epidermis of *Senna* ser. *Bacillares* species.

Species	Epicuticular waxes													Cuticle				
	Adaxial surface							Abaxial surface						Adaxial surface		Abaxial surface		
	Cr	Fl	Gra	Mp	Pla	Rod	Ros	Cr	Gra	Mp	Mcp	Pla	Ros	Rug	Smt	Pap	Rug	Str
S. angulata	-	-	+	-	+	-	-	+	+	-	-	-	-	-	+	-	+	-
S. chrysocarpa	-	+	+	-	+	-	-	-	-	-	+	-	+	-	+	+	-	-
S. georgica	-	-	-	-	-	-	+	-	-	-	-	-	+	-	+	-	+	-
S. macranthera	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	-	+	+
S. pinheiroi	-	-	+	-	+	-	-	-	+	-	-	+	-	-	+	-	+	-
S. pluribracteata	-	-	+	-	+	-	-	+	+	-	+	+	+	+	-	+	-	-
S. quinquangulata	+	-	+	-	+	-	-	-	+	-	+	-	-	-	+	+	-	-
S. rizzinii	+	-	+	+	-	-	-	-	-	+	+	-	+	-	+	+	-	-
S. rugosa	-	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-	+	-
S. splendida	+	-	+	-	+	+	+	+	-	-	-	-	+	-	+	-	+	-

Legends: -, Absence; +, Presence; Cr, Crusts; Fl, Fissured layers; Gra, Granules; Mcp, Microplatelets; Mp, Membranous platlets; Pap, Papillose; Pla, Plateles; Rod, Rodlets; Ros, Rosettes, Rug, Rugose; Smt, Smooth; Str, Striate.

Table 3 Indument, type of trichomes and trichomatic indexes on both surfaces of the leaflets of species of *Senna* ser. *Bacillares*.

Species	Indument									Simple trichomes				Trichomatic indexes (%)	
	Adaxial surface				Abaxial surface					Adaxial surface		Abaxial surface			
	Gla	Pbl	Pub	Str	Gla	Pbl	Pub	Str	Tom	Uni	Mul	Uni	Mul	Ad	Ab
S. angulata	-	+	-	-	-	-	-	-	+	+	+	+	+	3.05	2,73
S. chrysocarpa	-	-	+	-	-	-	+	-	-	+	+	+	+	1.87	2,69
S. georgica	+	-	-	-	-	+	-	-	-	-	-	+	+	0	4,85
S. macranthera	-	-	+	-	-	-	-	-	+	+	+	+	+	2.67	3,28
S. pinheiroi	-	-	+	-	-	-	-	-	+	+	+	+	+	1.78	2,32
S. pluribracteata	-	-	-	+	-	-	-	+	-	+	+	+	+	2.47	1,68
S. quinquangulata	+	-	-	-	-	-	+	-	-	-	-	+	+	0	10,31
S. rizzinii	-	-	+	-	-	-	-	-	+	+	+	+	+	2.40	1,63
S. rugosa	-	-	+	-	-	-	-	-	+	+	+	+	+	2.20	7,80
S. splendida	+	-	-	-	+	-	-	-	-	-	-	-	-	0	0

Legends: -, Absence; +, Presence; Ab, Abaxial surface; Ad, Adaxial surface; Gla, Glabrous; Mul, Multicellular; Pbl, Puberulent; Pub, Pubescent; Str, Strigose; Tom, Tomentose; Uni, Unicellular.

Table 4 Anticlinal cell walls and stomata types on the leaflet epidermises of species of *Senna* ser. *Bacillares*.

Species	Contour of the anticline walls						Abaxial epidermis	Types of stomata				Stomatal index (%)	Stomatal density (mm²)
	Adaxial surface			Abaxial surface									
	Cv	SCv	Sn	Csi	Scv	Sn		Ani	Ano	At	Pr		
S. angulata	-	-	+	-	+	-	Sp	+	+	+	+	20.97	2.10
S. chrysocarpa	-	+	-	+	-	-	Cp	-	+	+	+	13.19	1.29
S. georgica	-	-	+	-	-	+	Sp	+	+	+	+	15.86	1.59
S. macranthera	-	-	+	-	-	+	Sm	+	+	+	+	18.79	1.88
S. pinheiroi	+	-	-	-	+	-	Sm	+	+	+	+	18.32	1.01
S. pluribracteata	-	+	-	+	-		Cp	-	+	+	+	17.55	1.50
S. quinquangulata	-	+	-	-	+	-	Cp	+	+	-	+	20.36	2.47
S. rizzinii	-	+	-	-	-	+	Sp	-	+	+	+	14.98	1.02
S. rugosa	-	+	-	-	+	-	Cp	-	+	+	+	17.11	1.71
S. splendida	-	-	+	-	-	+	Sm	-	+	-	+	17.79	1.19

Legends: -, Absence; +, Presence; Ani, Anisocytic; Ano, Anomocytic; At, Anomotetracytic; Cp, Conspicuously papillose; Cur, Curved; Csi, Curved to sinuous; Pr, Paracytic; SCv, Straight to curved; Si, Sinuous; Sm, Smooth; Sp, Sparsely papillose.

166 **Table 5** Mesophylls and edges on the leaflet of species of *Senna* ser. *Bacillares*.

Species	Mesophyll						Edge
	Spongy Parenchyma (nº. Strata)	Mesophyll size (mean values)			Inorganic Idioblasts			
		Overall size (mm)	Palisade parenchyma (%)	Spongy parenchyma (%)	Dr	Pc	Sc	
S. angulata	5-6	1159.44	54.6	45.4	-	+	+	Truncado
S. chrysocarpa	5-6	861.31	63.5	36.5	+	-	+	Arredondado
S. georgica	6-7	551.72	54.4	45.6	+	+	-	Recurvo
S. macranthera	5-6	820.86	52.1	47.9	-	+	-	Recurvo
S. pinheiroi	5-6	803.73	53.8	46.2	+	+	+	Agudo
S. pluribracteata	6-7	1623.67	60.5	39.5	+	+	+	Arredondado
S. quinquangulata	5-6	879.2	38.1	61.9	+	+	+	Arredondado
S. rizzinii	5-6	850.62	47.2	52.8	+	+	+	Arredondado
S. rugosa	6-7	1025.29	38.2	61.8	+	+	-	Recurvo
S. splendida	4-5	765.27	51.4	48.6	+	-	+	Agudo

167 Legends: -, Absence; +, Presence; Dr, Druse; Pc, Prismatic crystals; Sc, Spherical crystals.

Table 6 Anatomical characters of the midrib of the species of *Senna* ser. *Bacillares*.

Species	Characters						
	Palisade parenchyma (adaxial surface)	Angular collenchyma	Adaxial phloem bundles	Sclerenchyma	Inorganic Idioblasts		
					Dr	Pc	Sc
S. angulata	Descontínuo	-	-	Continuous	+	+	-
S. chrysocarpa	Contínuo	+	-	Continuous	+	+	-
S. georgica	Descontínuo	-	+	Continuous	+	+	+
S. macranthera	Descontínuo	+	-	Discontinuous	+	+	+
S. pinheiroi	Contínuo	+	-	Continuous	+	+	-
S. pluribracteata	Contínuo	+	-	Discontinuous	+	+	-
S quinquangulata	Descontínuo	+	+	Continuous	+	+	-
S. rizzinii	Contínuo	+	-	Discontinuous	+	+	-
S. rugosa	Descontínuo	+	+	Continuous	+	+	-
S. splendida	Descontínuo	+	-	Discontinuous	+	+	-

Legends: -, Absence; +, Presence; Dr, Druse; Pc, Prismatic crystals; Sc, Spherical crystals.

Table 7 Anatomical petiolar characters of the species of *Senna* ser. *Bacillares*.

Species	Characters								
	Shape	Angular collenchyma	Number of vascular bundles		Sclerenchyma	Inorganic Idioblasts			
			Central	Accessorie		Cs	Dr	Cp	Sc
S. angulata	Rab	-	4	4	Discontinuous	+	+	+	-
S. chrysocarpa	Psc	+	4	2	Discontinuous	-	+	+	-
S. georgica	Pca	+	6	3	Discontinuous	-	+	+	-
S. macranthera	Pca	-	4	2	Discontinuous	-	+	+	-
S. pinheiroi	Psc	+	4	2	Discontinuous	-	+	+	-
S. pluribracteata	Pent	+	3	2	Discontinuous	+	+	+	-
S. quinquangulata	Pca	+	5	2	Continuous	-	+	+	-
S. rizzinii	Pwc	+	4	2	Discontinuous	-	+	+	+
S. rugosa	Rab	-	4	2	Discontinuous	-	+	+	-
S. splendida	Semc	+	4	2	Discontinuous	-	+	+	+

Legends: -, Absence; +, Presence; Cs, Crystalline sand; Dr, Druse; Pc, Prismatic crystals; Pca, Pentagonal, slightly concave adaxially; Pent, Pentagonal; Psc, Pentagonal-sinuous concave adaxial; Pwc, Pentagonal, slightly wavy and concave adaxial; Rab, Rectangular, abaxial convex; Sc, Spherical crystals; Semc, Semicircular.

Table 8 Anatomical characters of leaf rachis of the species of *Senna* ser. *Bacillares*.

Species	Characters						
	Shape	Number of vascular bundles		Sclerenchyma	Inorganic Idioblasts		
		Central	Accessories		Cs	Dr	Pc
S. angulata	Sap	1	2	Continuous	+	+	+
S. chrysocarpa	Trap	4	2	Discontinuous	-	+	+
S. georgica	Sap	4	4	Continuous	-	+	+
S. macranthera	Eac	4	2	Discontinuous	-	+	+
S. pinheiroi	Obap	4	2	Discontinuous	-	+	+
S. pluribracteata	Pent	4	2	Discontinuous	+	+	+
S. quinquangulata	Obap	4	2	Continuous	-	+	+
S. rizzinii	Eac	4	2	Discontinuous	-	+	+
S. rugosa	Pent	4	2	Continuous	-	+	+
S. splendida	Circ	1	2	Continuous	-	-	+

Legends: -, Absence; +, Presence; Circ, Circular; Cs, Crystalline sand; Dr, Druse; Eac, Elliptical, adaxial concave; Obap, Obdeltoid with two adaxial projections; Pc, Prismatic crystals; Pent, Pentagonal; Sap, Semicircular with adaxial projections; Trap, Triangular with adaxial projections.

4 CONSIDERAÇÕES FINAIS

Neste estudo foram reconhecidas dez espécies para o gênero *Senna* ser. *Bacillares* na Mata Atlântica ao norte do Rio São Francisco. Dentre as espécies estudadas, foi descrita uma nova espécie para a ciência (*Senna pluribracteata*), além de quatro novos registos, dos quais dois são para a Mata Atlântica (*S. rugosa* para Pernambuco e *S. rizzinii* para Alagoas, Paraíba, Pernambuco e Rio Grande do Norte) e duas novas citações, sendo uma para a flora da Paraíba (*S. angulata* var. *miscadena*) e uma para flora do Rio Grande do Norte (*S. georgica* var. *georgica*). Desta forma, este trabalho representa uma importante contribuição ao conhecimento da flora da porção da Mata Atlântica ao norte do Rio São Francisco, ampliando o número de espécies de *Senna* circunscritas para a área, além da descrição de uma nova espécie, até o momento, endêmica da Mata Atlântica da Paraíba.

Em relação aos estudos de anatomia foliar das espécies de *Senna* ser. *Bacillares*, observou-se um conjunto de caracteres uteis para distinguir taxonomicamente as espécies estudadas, com destaque para a epiderme foliolar e seus anexos, juntamente com a anatomia do bordo foliolar, pecíolo e raque foliar (formato e o número de feixes vasculares principais e acessórios). Desta forma, enfatizamos a importância da anatomia foliar como um subsídio adicional a taxonomia de *Senna* ser. *Bacillares*, sendo, desta forma, uma ferramenta adicional à sistemática de *Senna*.

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ANEXO A – Normas de submissão na Systematic Botany

https://bioone.org/journals/systematic-botany/author-guidelines

AUTHOR LAST NAMES (> 2 = ET AL.): SHORT TITLE ALL CAPS < 70 CHARACTERS

Paper Title: All Major Words in Capitals, Bold Font

First Author,[1, 2] Second Author,[3] and Last Author[4, 5]

[1]Address for first author, no abbreviations, USA; e-mail address

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[3]Address for second author, no abbreviations, all other countries spelled out; e-mail address second author.

[4]Address for last author; e-mail address for last author.

[5]Author for correspondence

Abstract—The abstract should be a summary of the information content of the paper, around 300 words or less. Do not cite references, taxonomic authorities, or use abbreviations in the abstract. It can be on a separate page, but does not need to be. All text must be in English, but a second abstract may be published in another language. We strongly urge authors who are not native speakers of English to have either a native speaker who is familiar with botany critically evaluate the manuscript or hire an English editing service before submitting. Authors will only be allowed two revisions to ensure that the English grammar and style are correct before the manuscript is rejected. It is not the duty or responsibility of the Editorial staff to edit English. Authors are encouraged to use this format as a template and to use recently published issues for more details on formatting.

Keywords—Alphabetical order, separated by commas.

The introduction starts without a heading.

Members of the American Society of Plant Taxonomists (ASPT) are encouraged to submit manuscripts pertinent to plant systematics and closely related disciplines for publication in *Systematic Botany*. Manuscripts that are likely to result in a paper longer than 50 pages should be submitted to our sister publication *Systematic Botany Monographs*. (One can estimate the print length by dividing the manuscript pages by three and then adding one page for each full page illustration, figure, or map; the Editors will assist you if the manuscript is close to the threshold.) Membership in ASPT is required for at least one author from calendar year of submission continuously through to calendar year of publication (Not a member? Join ASPT here). Many factors, including ability to find reviewers, length of time to complete revisions, and publication schedule determine when a manuscript may be published, and authors cannot assume a

manuscript will be published in the same calendar year that it is submitted. Manuscripts considered to be significantly lacking in depth, originality, or quality of English grammar or syntax may be returned without review. Acceptance of papers for publication depends on merit as judged by each of two or more referees. Manuscripts must not have previously been published in whole or in part (including other languages) and must not be in consideration for publication in another journal at the time of submission.

Cite each figure and table in the text. Number figures and tables such that they are cited in numerical order. Use "Figure" only to start a sentence; otherwise, "Fig." or "Figs."

Abbreviations: Use these without spelling out first; DNA, ITS, CTAB, MYA, PCR, cpDNA, nrDNA, USA, bp, dbh, fl, fr, hr, min, s, yr, mo, wk, d, diam, m, cm, mm, **µ**m; designate temperature as 30°C. DNA region abbreviations should be in all italics (*rpl32-trnL*) except ITS and ETS.

Use Index Herbariorum acronyms for all cited herbaria.

Write out other abbreviations the first time used in the text; abbreviate thereafter, but do not use capitals for all words unless they are proper nouns. "Transmission electron microscopy (TEM) was used...."

Numbers: Write out one to nine unless it is part of a measurement or in taxonomic descriptions (e.g., four samples, 3 mm, 35 sites, 6 yr). Use 1000 instead of 1,000; 0.13 instead of .13; % instead of percent. Number ranges should be separated by an en-dash (3–4). Use a space on either side of all mathematical operators, but not with % (30% not 30 %) or degrees (10°C not 10 °C; 7.15°S, 69.45°W not 7.15° S, 69.45° W). Italicize statistical indicators such as *p* and *r*. Italicize *n* and *x* when expressing chromosome numbers, but do not italicize the numerical value, 2*n* not *2n*.

Serial commas: In a series of three or more words joined by a conjunction, use a

comma before the conjunction (the “Oxford comma”). Example: red, black, and white.

Author citations: Each taxon name at generic rank and below must include an author citation at least once in the paper. This may be the first time a name is mentioned in the text or in a table or appendix. Use IPNI author citations without spaces (e.g., A.Gray, Hook.f., S.F.Blake).

Each reference cited in the text must be listed in the Literature Cited section, and vice versa. Jones (1990) or (Jones 1990). Jones and Jackson (1990) or (Jones and Jackson 1990). Jones et al. (1990) or (Jones et al. 1990). Jones (1990, 1994) or (Jones 1990, 1994). Jones and Smith (in press) or (Jones and Smith in press) J. Jones (unpubl. data); J. Jones (in mss.); (J. Jones pers. obs.); or J. Jones (pers. comm.). See notes below on assigning a, b, etc. to multi-authored papers with the same first author in the same year.

All data, program code, and other methods must be appropriately cited. Such materials must be recognized as original intellectual contributions and afforded recognition through citation. Articles will not be published until the citations conform to these standards. All data sets and program code used in a publication must be cited in the text and listed in the reference section. References for data sets and program code must include a persistent identifier, such as a (DOI). Persistent identifiers ensure future access to unique published digital objects, such as a text or data set. Data generated in the present study, along with novel code, or supplemental files can be submitted to Dryad and cited appropriately. All other citations of data and code should conform to appropriate data repository they were sampled from.

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Cited section.

MATERIALS AND METHODS (A PRIMARY HEADING, USING SMALL CAPS)

Second Level Headings—These divide content under the primary headings. The primary headings are centered, whereas all other headings are left justified. For *Systematic Botany*, only the primary headings used here are to be used in manuscripts, do not make your own. Additional primary headings may be used in *Systematic Botany Monographs*.

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When citing a manufacturer (Qiagen, Valencia, California) spell out city and name; if not a city in the USA or UK, spell out city and country (New England Biolabs, Frankfurt am Main, Germany).

Vouchers must be cited for all molecular analyses in Appendix 1. Vouchers cited in the Taxonomic Treatment for revisions or monographs, are listed as Additional Specimens Examined or as Representative Specimens.

Transparency—Be explicit about sampling and analyses and provide justification for analyses that are not commonly used.

The policy of *Systematic Botany* is to publish papers where authors follow standards for disclosing key aspects of the research design and data analysis. Authors are required to review the Tools for Transparency in Ecology and Evolution (https://osf.io/y8aqx/) or the standards available for many research applications from http://www.equator-network.org/ and use those that are relevant for the reported research applications. The journal will verify that the appropriate standards were adopted and followed. Failure to follow the relevant standards may result in the paper

not being published.

RESULTS

Data—Data should be submitted to Dryad (http://datadryad.org/) after the manuscript is submitted, and ASPT will pay for the costs. The Dryad submission must be cited in the revised text (These authors 2017) and included in the Literature Cited following Dryad's format. DNA sequences must be submitted to GenBank.

Data, Analytic Methods (Code), and Research Materials Transparency—The policy of Systematic Botany is to publish papers only if the data, methods used in the analysis, and materials used to conduct the research are clearly and precisely documented and are maximally available to any researcher for purposes of reproducing the results or replicating the procedure. Authors reusing data available from public repositories must provide program code, scripts for statistical packages, and other documentation sufficient to allow an informed researcher to precisely reproduce all published results. Authors must conform to the standards for TOP Guidelines, Level 2 for guidelines 2, 3, and 4 (https://osf.io/y8aqx/, p. 14 of document). Failure to conform will prevent final acceptance of manuscript.

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model that will be reported. Authors must, in acknowledgments or the first footnote, indicate if they did or did not preregister the research with or without an analysis plan in an independent, institutional registry.

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research published in this journal.

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New Names and Combinations—*Systematic Botany* and *Systematic Botany Monographs* publish new taxa or revised nomenclature, but only when such taxa are placed in a broader context, such as (this list is not meant to be complete) a key to all species, or species in the area, demonstration of how the new taxa alter the generic concept, or demonstration that the new taxon is distinct from published ones (via phylogenetic or morphometric analyses). These papers need to include an illustration clearly showing the diagnostic characters, but a line drawing is not required. Authors are encouraged to include information on conservation status, if available.

Format nomenclatural citations with a hanging left indent rather than tabbing to achieve the same appearance.

ACCEPTED BINOMAL Auth. [use abbreviations in IPNI], Abbreviated citation of original publication [use abbreviations in IPNI]. Citation of basionym and its original publication if different from accepted binomial. Follow with all other synonym citations for this basionym [nomenclatural synonyms] here in chronological order. TYPE: COUNTRY. Description of collection locality for the type, date [ex. 12 May 1992], *Voucher (all collectors with initials + collection number* or *s.n.)*

(holotype: XYZ!, isotypes: ABC!, DE, FG [presumed destroyed], PQR! [fragment], STU [photo!]). If you supply information that is not on specimen label, place it in square brackets .

Synonymous name [taxonomic synonym] Auth., Abbreviated citation of original publication. Include all synonym citations for this basionym here. TYPE: COUNTRY. Collection locality for this type, date. *Voucher* (holotype: XYZ!, isotypes: ABC!, FG!, JKL, PQR!, STU).

New species Auth., sp. nov.TYPE: COUNTRY. Collection data for the type, date, *Voucher* (holotype: XYZ!, isotypes: ABC!, DE!, PQR!, STU).

New combination (previous author) Auth., comb. nov. Citation of basionym. TYPE: COUNTRY. Collection locality for the type, date, *Voucher* (holotype: XYZ!, isotypes: PQR, STU [photo!], ABC!, DE).

A diagnosis in English or Latin may be included at this point.

The next paragraph is the description, and bold font can be used to set apart different structures. The following, modified from the *Flora of North America North of Mexico Guide for Contributors* (Flora of North America 2008), provides an overview of the sequence of descriptors. Describe plants in the conventional order: from habit to seeds, base to apex, proximal to distal, abaxial before adaxial, and staminate before pistillate. Place each major structure in a separate sentence and separate subparts by semicolons. The general order for describing characters is given below. Note that it is not required that all of these be included, and descriptions in certain plant groups may involve additional features or other modifications.

Growth form, persistence, habit, nutrition. **Roots** and/or other belowground parts. **Stems** general; trunks; bark; wood; branches, shoots; twigs; scapes; buds general. **Leaves** general arrangement, complexity; stipules; petiole; leaf blade; lobes; higher-

order axes and petiolules; leaflets; modified leaflets. **Inflorescences** general position, type; peduncle; branches (i.e., description of higher-order axes); bracts; different flower (or head or spikelet) types; pedicels if described. **Flowers** general (including sexuality); receptacle and hypanthia; perianth (tepals) or calyx (sepals) and/or corolla (petals); corona; glands and/or discs; androecia (at flowering); gynoecia (at flowering). **Fruits** general type; aggregation of or division within fruit; fruit or mericarp structure; accessory structures; multiple fruit structure; seeds external structures, internal anatomy; germination, abortion; endosperm; embryos. The last sentence of many descriptions is citation of figures, published or in this manuscript, that illustrate the taxon. Figure 1.

Distribution and Habitat—Other subheadings may be used. Use complete sentences here and in all sections.

Etymology—Required for all newly described taxa and nomina nova.

Notes—This section is for explaining the taxonomy, providing additional clarification for distinguishing among closely allied taxa, or providing other items not covered above.

Additional Specimens Examined **[or** ***Representative Specimens*****]—Country. —** SECOND POLITICAL DIVISION [USUALLY STATE OR PROVINCE, SOMETIMES DEPARTMENT]: (if third level present [e.g., county, district, sometimes department, municipality, etc.], sort by that division). Description of site, (for geocoordinates use decimal degrees instead of degrees, minutes, seconds; if converted from coordinates on label, put in brackets [46.486°, −114.789°]), *Voucher 1* (herbaria); *Voucher 2* (herbarium).

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1. Keys should be formatted as indented keys, not as bracket keys, but place all key leads flush left. Don't worry about indenting, that will be done at the

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1. Format key leads with a hanging left indent rather than tabbing to achieve the same appearance. Couplets are numbered, but no primes are used. Each key lead should end either in a species name, or refer the user to the next couplet. 2
2. Make couplets as concise and unambiguous as possible. *Species name*
2. Contrasting leads of a couplet should be worded in parallel and should be fully comparable; information in keys should be consistent with taxonomic descriptions, please check this before submitting the manuscript; geographical information that would be helpful to a keyer may be included as the last item in a key statement. *Species name*

DISCUSSION

Publication Charges—Members of ASPT are not assessed page charges; however, members are strongly encouraged to contribute to the cost of publishing. Authors are assessed charges for alterations made after type has been set. The following are charges that are not waived:

$5.00 each for author corrections above the five free allowed

$20.00 each for figure replacements

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$500.00 for open access—*Systematic Botany*. A payment of $500 above any special charges makes the article eligible for open access. This fee is prorated for articles fewer than 10 pages.

Publication Online Ahead of Print—Papers for *Systematic Botany* will be made available online ahead of print unless authors specify otherwise. The online version will

be the publication date of record and each article will receive a date stamp stating the official publication date and assigned a doi that will be retained when the article is printed.

Papers Longer than 50 Printed Pages—should be sent to the Editor-in-Chief of *Systematic Botany Monographs*.

Acknowledgments

Include gratitude to those that helped out, and cite funding sources.

Author Contributions

AA provided the data and analysis of the amber fossils (measurements and morphological data), all photographs except the extant Strychnos species and was the primary author for the palaeontological parts of the manuscript. BB provided data, photo and text regarding extant taxa in the Gentianales and other asterids, evaluation of asterid dating times and was the primary author of the new species description.

Literature Cited

Papers by the same author are cited in chronological order (Smith 1999, Smith 2001, Smith 2005a, Smith 2005b, Smith 2012); followed by two-authored papers ordered by second author and publication date (Smith and Jones 2004, Smith and Jones 2007, Smith and Williams 1997); and then by multi-authored papers. All works with the same first author and more than one additional author should be ordered chronologically. Multiple citations of Green et al. in the same year will be cited 1990a, 1990b and will be assigned a or b based on order cited in literature cited, not by order of citation in text. In citations of second and additional authors, the author initials precede

the authors' surnames.

Journal: Author(s). Year. Title of article with only first word and proper nouns capitalized. *Journal Name* (spelled out, not abbreviated) 00: 00–00. Do not include issue number unless issues are separately paginated.

Book [Thesis, Dissertation]: Author(s). Year. *Title with all Major Words Capitalized*. City: Publisher.

Article/chapter in edited book: Author(s). Year. Title with only first word and proper nouns capitalized. Pp. 00–00 in *Book Title*, vol. number, ed. number, ed. Names of editors with initials preceding surnames(s). City: Publisher.

The following are examples of various citations:

Bauml, J. A. 1979. *A Study of the Genus* Hymenocallis *(Amaryllidaceae) in Mexico*. M.S. thesis. Ithaca, New York: Cornell University.

Flora of North America. 2008. Flora of North America North of Mexico Guide for Contributors—March 2008. http://floranorthamerica.org/files/FNA%20ContribGuide%202008.pdf (accessed 2 Mar 2017).

IUCN. 2012. IUCN red list categories and criteria version 3.1. Ed. 2. Gland, Switzerland and Cambridge, UK: IUCN.

Kim, S.-C., D. J. Crawford, J. Francisco-Ortega, and A. Santos-Guerra. 1996. A common origin for woody *Sonchus* and five related genera in the Macaronesian islands: molecular evidence for extensive radiation. *Proceedings of the National Academy of Sciences USA* 93: 7743–7748.

McNeill, J., F. R. Barrie, W. R. Buck, V. Demoulin, W. Greuter, D. L. Hawksworth, P. S. Herendeen, S. Knapp, K. Marhold, J. Prado, W. F. Prud'home van Reine, G. F. Smith, J. H. Wiersema, and N. J. Turland. 2012. *International Code of Nomenclature for*

algae, fungi, and plants (Melbourne Code). *Regnum Vegetabile* 154. Koenigstein: Koeltz Scientific Books.

Miller, M. A., W. Pfeiffer, and T. Schwartz. 2010. Creating the CIPRES Science Gateway for inference of large phylogenetic trees. Pp. 1–8 in *Proceedings of the Gateway Computing Environments Workshop (GCE)*. New Orleans: Gateway Computing.

Nooteboom, H. P. 2003. Symplocaceae. Pp. 443–449 in *The Families and Genera of Vascular Plants,* vol. 6, ed. K. Kubitzki. Berlin: Springer Verlag.

Smith, C. F. 1998. *A Flora of the Santa Barbara Region, California*, ed. 2. Santa Barbara: Santa Barbara Botanic Garden.

Specht, C. D. and D. W. Stevenson. In press. A new generic taxonomy for the monocot family Costaceae (Zingiberales). *Taxon*.

Swofford, D. L. 1998. PAUP* Phylogenetic analysis using parsimony (*and other methods), v. 4.0 beta 10. Sunderland: Sinauer Associates.

Thiers, B. 2017. [continuously updated] *Index Herbariorum: A global directory of public herbaria and associated staff.* New York Botanical Garden's Virtual Herbarium. Available from: http://sweetgum.nybg.org/science/ih/ (last accessed January 2017).

Wang, X. 2014. Data from: ITS1: A DNA barcode better than ITS2 in eukaryotes? Dryad Digital Repository. http://dx.doi.org/10.5061/dryad.n56t9

TABLE 1. Table caption. Do not use footnotes. Use the table option. Do not center text, and capitalize first word in each cell. A table should include information systematically displayed in simple columns and rows, with the vertical and horizontal spatial arrangement necessary for understanding the context even if it requires the presence of blank pieces of page. Suitable for presenting information such as differences

between taxa. Tables are should be no longer than 1 printed page each. Longer tables should be considered appendices.

	Trait 1	Trait 2
Taxon 1	Yellow	Leaves 3–5 cm wide
Taxon 2	Red	Leaves 9–11 cm wide

APPENDIX 1. Appendix caption. List all vouchers and GenBank numbers for molecular analyses here. Submit as comma-delimited text. Subheadings can be used and can be in a bold font. Order of data in the appendix should be specified, species, voucher, herbarium, GenBank numbers for ITS, *ndhF-rpl32*, *rps16* intron. Authors are also encouraged to cite digital records of collections if they have been assigned and should include a global unique identifier that is generally a combination of the following: OccurrenceID, Institution Code and/or institutionID, Collection Code and/or collectionID, Catalog number. An em dash is used where data was not obtained. Appendices include information arranged linearly and continuously, with different items separated by commas, semicolons, or periods. A more efficient way of packaging text given that there are no blank pieces of page. Required for GenBank numbers and associated information such as vouchers, etc. Appendix 1 will be published with the paper, other appendices should be considered supplemental material unless the data are essential for properly interpreting the results.

Ingroup: *Species 1*, *Voucher 1*, HER, JL888999, JK999777, KR000999. *Species 2*, *Voucher 2*, HER, JH888666, —, KI888555.

Outgroup: *Species 3*, *Voucher 3*, HER, KI777555, KJ665489, UY663595.

FIG. 1. Figure caption. Use capital letters for subheadings and in the figure itself. A.

Subheadings should begin with a capitalized word and end in a period. B. Spell out abbreviations you may have used in the text. C. Make captions and figures stand alone as much as possible (e.g., include species names on maps or figures). D. Acknowledge photographers, illustrators, and any other sources for figure materials that are not generated by the authors. Be certain permission is granted if material is borrowed from other sources.

FIG. 2. Number figures in the order they are cited in the text. First citation is Fig. 1, next is Fig. 2, etc.

FIG. 3. Illustrations may be line drawings, maps, diagrams, graphs, or black and white (half-tone) or color photographs. Figures should be submitted in color using CMYK and appear in full color for $30 per figure in *Systematic Botany*. (Contact the editor for pricing of color plates in *Systematic Botany Monographs*.) Authors who wish to avoid all color charges should only submit black and white or grayscale figures.

FIG. 4. Final figures should be submitted as tiff files. All resolution requirements are for figures when sized at either full page or single column width (see below). Do not adjust resolution by shrinking the size of the figure. Line art (e.g., cladograms, botanical illustrations) **must** be at least 1200 pixels per inch (473 pixels per cm). Photographs (grayscale or color) **must** be a minimum of 350 dpi (138 pixels per cm). Images with mixed line art and grayscale **must** be at least 900 pixels per inch (354 pixels per cm). Be sure to check resolution when the figure is printed **at the appropriate size** for the journal.

FIG. 5. Two widths are possible for *Systematic Botany*: a full-page width figure is 7 inches **177** mm wide, and a one-column width figure is 3.375 inches, **85** mm wide. Full page height is **240** mm (9.5 inches), but allow space for the caption if possible. Figures for *Systematic Botany Monographs* should be scaled at 5 inches wide (127 mm) and a

maximum of 8 inches (203 mm) high.

FIG. 6. Line drawings and many photographs require scale bars; a numerical magnification may also be included in the caption. All measurements derived from scale bars should be checked against measurements in keys/descriptions and vice versa. Be sure to calculate magnification accordingly if reproduction is not at 100%. Include a scale and references to latitude and longitude on each map.

FIG. 7. Be sure to save black and white photographic images as grayscale orbitmap, not color. **Do not** save layers! (in Photoshop, choose "Flatten Image" from the Layer menu). Crop the image so that the image extends from edge to edge, there should be **no** blank white margins. Save as a tiff file using LZW compression (an option in Photoshop). (Do not use jpeg, which degrades images; line art is especially badly degraded in jpegs). Consult with editor if uncertain whether an image file will be acceptable. Images submitted for review may be of lower resolution than final copies for publication.

FIG. S1. Supplemental figures and captions may be included in the initial submission, but in all revisions they must be removed and published in Dryad.

Submit manuscripts for *Systematic Botany* to http://www.editorialmanager.com/sysbot/. If this will be your first submission of a manuscript to the *Systematic Botany* Editorial Manager website, you must first register by clicking "register now" and following the instructions.

Submit manuscripts for *Systematic Botany Monographs* directly to the Editor-in-Chief of *Systematic Botany Monographs*.

Note: All manuscript submissions are promptly acknowledged via email. If you do not receive an acknowledgement you should inquire to be sure it was received!

Questions? Contact the Editorial Office: systbot@gmail.com or the Editor-in-Chief of *Systematic Botany Monographs*.

ANEXO B – Normas de submissão na Acta Botanica Brasilica

https://acta.botanica.org.br/instructions/

Instructions

Language editing

If English is not your first language, it is strongly recommended to have your manuscript edited for language before submission. This is not a mandatory step, but may help to ensure that the academic content of your paper is fully understood by journal editors and reviewers. Language editing does not guarantee that your manuscript will be accepted for publication. Authors are liable for all costs associated with such services.

Types of articles

Original Articles

Reviews

Viewpoints

Methods

Short Communications

Summary of submission processes

Submission management and evaluation of submitted manuscripts will involve the Journal's online manuscript submission system. The manuscript text should be prepared in English (see Preparing the article file below for details) and submitted online (http://mc04.manuscriptcentral.com/abb-scielo). Figures, tables and other types of content should be organized into separate files for submission (see Preparing Tables, Figures and Supplementary material below for details). If you are using the online submission system for the first time please go to the login page and generate a login name and password after clicking on the "New user – register here" link. If you are already registered but need to be reminded of your login name or password please go to the login page and inform your email in "password help". Please never create a new account if you are already registered. If you are unable to access our web-based submission system, please contact the Editorial Office (acta@botanica.org.br)

Cover letter

All manuscripts must be submitted with a cover letter, which should summarize the scientific strengths of the paper that the authors believe qualify it for consideration by Acta Botanica Brasilica. The cover letter should also include a statement declaring that the manuscript reports unpublished work that it is not under active consideration for publication elsewhere, nor been accepted for publication, nor been published in full or in part (except in abstract form). Please also provide a statement that the authors have the rights to publish all images included in the manuscript.

Preparing the article file

(Please consult a last issue of Acta Botanica Brasilica for layout and style)

All manuscripts must follow these guidelines: the text should be in Times New Roman font, size 12, double-spaced throughout and with 25 mm margins; the paper size should be set to A4 (210 x 297 mm). All pages should be numbered sequentially. Each line of the text should also be numbered, with the top line of each page being line 1. For text files .doc, .docx and .rtf are the only acceptable formats. Files in Adobe® PDF format (.pdf files) will not be accepted. When appropriate, the article file should include a list of figure legends and table heads at the end. This article file should not include any illustrations or tables, all of which should be submitted in separate files. Do not include field code either.

The first page should state the type of article (Original Article, Review, Viewpoint, Method or Short communication) and provide a concise and informative full title followed by the names of all authors. Each name should be followed by the Orcid number and an identifying superscript number (1, 2, 3 etc.) associated with the appropriate institutional address to be entered further down the page. Only one corresponding author should be indicated with an asterisk and should always be the submitting author. The institutional address(es) of each author should be listed next, each address being preceded by the superscript number where appropriate. The address must be synthetic and in English with institution, postal code, city, state and country. Do not translate laboratory, department and university. Titles and positions should not be mentioned. This information is followed by the e-mail address of the corresponding author.

The second page should contain a structured Abstract not exceeding 200 words in a single paragraph without references. The Abstract should outline the essential content of the manuscript, especially the results and discussion, highlighting the relevance of main findings.

The Abstract should be followed by between five and ten Keywords. Note that essential words in the title should be repeated in the key words.

Original articles should be divided into sections presented in the following order:

Title page

Abstract

Introduction

Materials and methods

Results

Discussion

Acknowledgements

References

Tables and Figures legends

Supplementary Data (if applicable)

Materials and methods and Results should be clear and concise. The Discussion section should avoid extensive repetition of the results and must finish with some conclusions. This section can be combined with results (Results and Discussion), however, we recommend authors consult the Editoral Board for a previous evaluation.

Plant names must be written out in full in the abstract and again in the main text for every organism at first mention but the genus is only needed for the first species in a list within the same genus (e.g. Hymenaea stigonocarpa e H. stilbocarpa). The authority (e.g., L., Mill., Benth.) is required only in Materials and methods section. Use The International Plant Names Index (www.ipni.org) for correct plants names. Cultivars or varieties should be added to the scientific name (e.g. Solanum lycopersicum ‘Jumbo’). Authors must include in Materials and methods a reference to voucher specimen(s) and voucher number(s) of the plants or other material examined.

Abbreviations must be avoid except for usual cases (see recent issues) and all terms must be written out in full when used to start a sentence. Non-conventional abbreviations should be spelled out at first mention.

Units of Measurement. Acta bot. bras. adopts the Systéme International d'Unités (SI). For volume, use the cubic metre (e.g. 1 × 10–5 m3) or the litre (e.g. 5 μL, 5 mL, 5 L). For concentrations, use μM, μmol L–1 or mg L–1. For size and distance use meters (cm, mm, um, etc) and be consistent in the manuscript.

Numbers up to nine should be written out unless they are measurements. All numbers above ten should be in numerals unless they are starting sentences.

Citations in the text should take the form of Silva (2012) or Ribeiro & Furr (1975) or (Mayer & Wu 1987a; b; Gonzalez 2014; Sirano 2014) and be ordered chronologically. Papers by three or more authors, even on first mention, should be abbreviated to the name of the first author followed by et al. (e.g. Simmons et al. 2014). If two different authors have the same last name, and the article have the same year of publication, give their initials (e.g. JS Santos 2003). Only refer to papers as 'in press' if they have been accepted for publication in a named journal, otherwise use the terms 'unpubl. res.', giving the initials and last name of the person concerned (e.g., RA Santos unpubl. res.).

References should be arranged alphabetically based on the surname of the author(s). Where the same author(s) has two or more papers listed, these papers should be grouped in year order. Letters 'a', 'b', 'c', etc., should be added to the date of papers with the same citation in the text. Please provide DOI of 'in press' papers whenever possible.

For papers with six authors or fewer, please give the names of all the authors. For papers with seven authors or more, please give the names of the first three authors only, followed by et al.

Please follow the styles:

Books

Smith GM. 1938. Cryptogamic botany. Vol. II Bryophytes and Pteridophytes. 2nd. edn. New York, McGraw-Hill Book Company.

Chapters in books

Schupp EW, Feener DH. 1991. Phylogeny, lifeform, and habitat dependence of ant-defended plants in a Panamanian forest. In: Huxley CR, Cutler DC. (eds.) Ant-plant interactions. Oxford, Oxford University Press. p. 175-197.

Research papers

Alves MF, Duarte MO, Oliveira PEAM, Sampaio DS. 2013. Self-sterility in the hexaploid Handroanthus serratifolius (Bignoniaceae), the national flower of Brazil. Acta Botanica Brasilica 27: 714-722.

Papers in press (ahead of print)

Alves JJ, Sampaio MTY. 2015. Structure and evolution of flowers. Acta Botanica Brasilica (in press). doi: 10.1590/0102-33062015abb3339.

Online-only journals

Wolkovich EM, Cleland EE. 2014. Phenological niches and the future of invaded ecosystems with climate change. AoB Plants 6: plu013 doi:10.1093/aobpla/plu013

Thesis (citation should be avoided)

Souza D. 2014. Plant growth regulators. PhD or MSc Thesis, University, City.

Websites and other sources (citation should be avoided)

Anonymous. 2011. Title of booklet, leaflet, report, etc. City, Publisher or other source, Country.

References to websites should be structured as: author(s) name author(s) initial(s). year. Full title of article. Full URL. 21 Oct. 2014 (Date of last successful access).

Acknowledgements should be in fewer than 80 words. Be concise: “we thank…” is preferable to “The present authors would like to express their thanks to…”. Funding information should be included in this section.

The following example should be followed:

We acknowledge the Center of Microscopy (UFMG) for providing the equipment and technical support for experiments involving electron microscopy. We also thank J.S. Santos for assistance with the statistical analyses. This work was supported through a research grant from the Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq (ID number).

For SHORT COMMUNICATIONS note that the editorial guidelines applying to original papers must also applying here. In general, the difference between original papers and short communications is the lack of subsections in the text and limited space for illustrations in the latter. Figures and tables can be present, assuming that the overall size of the manuscript does not exceed the five printed page limit (supplementary material can be added). The abstract (as

described for original articles) must be followed by a “running text” (a single section, without subheadings), followed by the acknowledgments and references.

Preparing Figures, Tables and Supplementary material

All figures (photographs, maps, drawings, graphs, diagrams, etc.) and tables must be cited in the text, in ascending order. Citations of figures in the text should appear in an abbreviated, capitalized form (e.g., Fig. 1, Fig. 2A-D, Fig. 3A, Figs. 3A, 4C, Tab.1).

The maximum dimensions of individual figures should be 170 × 240 mm. The width of an individual component can be 170 mm or 85 mm, without exception, whereas the height can be ≤ 240 mm. For continuous tone images (e.g., photographs), please supply TIFF files at 300 dpi. More complex drawings, such as detailed botanical illustrations will not be redrawn and should be supplied as 600 dpi TIFF files.

Grouping of related graphics or images into a single figure (a plate) is strongly encouraged. When a block of illustrative material consists of several parts, each part should be labelled with sequential capital letters, in the order of their citation in the text (A, B, C, etc.). The letters that identify individual images should be inserted within white circles in the lower right-hand corner. For separate the grouped images, authors should insert white bars (1mm thickness).

Individual images (not grouped as a plate) should be identified with sequential Arabic numerals, in the order of their citation in the text (Fig. 1, Fig. 2, Fig. 3, etc.), presented in the same manner as the letters identifying individual images (described above).

The number that identifies a grouped figure (e.g., Fig. 2) should not be inserted into the plate but should rather be referenced only in the figure caption and the text (e.g., Fig. 2A-C).

Scale bars, when required, should be positioned in the lower right-hand corner of the figure. The scale bar units should be given either at the end of the figure caption or, when a figure contains multiple scale bars with different units, above each bar.

Details within a figure can be indicated with arrows, letters or symbols, as appropriate.

Tables should be preceded by titles, indicated with sequential Arabic numerals (Table 1, 2, 3, etc.; do not abbreviate). Tables should be created using the Table function of Microsoft Word™. Columns and rows should be visible, although no dark lines should be used to separate them. Horizontal rules should be used only at the top (below the title) and bottom (below the final row) of the table. Do not use fills, shading or colors in the tables.

When appropriate, excess (but important) data can be submitted as Supplementary Files, which will be published online and will be made available as links. This might include additional figures, tables, or other materials that are necessary to fully document the research contained in the paper or to facilitate the readers' ability to understand the work.

Supplementary Materials are linked from the main article webpage. They can be cited using the same DOI as the paper.

Supplementary Materials should be presented in appropriate .doc file for text and tables and .tiff file at 300dpi for figures and graphics. The full title of the paper and author names should be included in the header. All supplementary figures and tables should be referred in the manuscript body as "Table S1" and/or "Figure S1".

Acta bot. bras. intends to maintain archives of Supplementary Materials but does not guarantee their permanent availability. Acta bot. bras. reserves the right to remove Supplementary Materials from a published article in the future.

The Review Process

All authors will receive an email acknowledging the submission of the manuscript, with its correspondent reference number. The Editor-in-Chief will evaluate manuscript adherence to instructions, quality and novelty and will decide on the suitability for peer reviewing. Manuscripts failing to adhere to the format will be returned to the authors. Manuscripts are sent to at least two anonymous referees that are given 21 days to return their reports.

Submitting a revised paper

After peer review, go to "click here to submit a revision" and upload the new manuscript version. Remember to delete the documents in duplicate.

Publication and printing process

After acceptance, a PDF proof will be sent to corresponding authors as an e-mail attachment. Corrected proofs should be returned within 72 h. It is the sole responsibility of the corresponding author to check for errors in the proof.

Each article is identified by a unique DOI (Digital Object Identifier), a code used in bibliographic referencing and searching.

The dates of submission and acceptance will be printed on each paper.

The corresponding author will receive a free PDF or URL that gives access to the article online and to a downloadable PDF.

The corresponding author is responsible for distributing this PDF or URL to any co-authors.

Misconduct

Misconduct on submitted manuscripts will lead to immediate rejection. Duplicate publication, plagiarism, figure manipulation, dual-submission, and any other fraudulent method will not be tolerated.

If misconduct is detected after the manuscript publication, the article will be retracted and a retraction note will be published.

Submitted manuscripts can be scanned to detect plagiarism and verify the papers' originality.

ANEXO C – Normas de submissão na Microscopy Research & Technique

https://onlinelibrary.wiley.com/page/journal/10970029/homepage/forauthors.html

AUTHOR GUIDELINES

1. SUBMISSION

Authors should kindly note that submission implies that the content has not been published or submitted for publication elsewhere except as a brief abstract in the proceedings of a scientific meeting or symposium.

Once the submission materials have been prepared in accordance with the Author Guidelines, manuscripts should be submitted online via the journal online editorial system.

By submitting a manuscript to or reviewing for this publication, your name, email address, and affiliation, and other contact details the publication might require, will be used for the regular operations of the publication, including, when necessary, sharing with the publisher (Wiley) and partners for production and publication. The publication and the publisher recognize the importance of protecting the personal information collected from users in the operation of these services, and have practices in place to ensure that steps are taken to maintain the security, integrity, and privacy of the personal data collected and processed. You can learn more at https://authorservices.wiley.com/statements/data-protection-policy.html.

2. AIMS AND SCOPE

Microscopy Research and Technique (MRT) publishes articles on all aspects of advanced microscopy original architecture and methodologies with applications in the biological, clinical, chemical, and materials sciences. Original basic and applied research as well as technical papers dealing with the various subsets of microscopy are encouraged. MRT is the right form for those developing new microscopy methods or using the microscope to answer key questions in basic and applied research. MRT encourages the proposal of special issues and open access. MRT fosters the submission of educational papers. MRT is also the right journal for publishing selected papers from scientific conferences. It is expected that manuscripts submitted for consideration will have as main points of focus the microscopy approach and the scientific and technical value. Methods are expected to be discussed in a quantitative way considering the original aspects in microscopy. Authors are expected to employ proper statistics, present previously unpublished data, discuss whether the experiment has answered the proposed question, compare the results with those in salient published literature. The submission should

be conform to MRT's prescribed journal format and high quality images are expected to be proposed for the cover. Submissions that only support conclusions of discovery from other research fields should be submitted to journals specializing in those fields.

3. MANUSCRIPT CATEGORIES AND REQUIREMENTS

In addition to Original Research Articles and Review Articles, Microscopy Research and Technique is now accepting submissions for its new rapid publication format, "MRT Letters" and "Primers".

Original Research Articles, requires Abstract, Introduction, Materials and Methods, Results, and Discussion sections. The literature review should be succinct. There are no restrictions on the number of pages or figures.

Review Articles in which a specific field is reviewed through an exhaustive literature survey. An abstract is required. A Materials and Methods section and a Results section are not required. There are no restrictions on the number of pages or figures. Review articles are usually invited, but submitted review articles will be considered.

MRT Letters will be placed at the front of each issue and will be reserved for important results and breakthroughs in any area of microscopy that need to be published rapidly. These short papers, no longer than 3 typeset pages, will use the same structure as the longer original research articles. MRT Letters should be sent directly to an associate editor in your field to facilitate its review within a week. Authors submitting letters deemed unsuited for the MRT Letters section may be invited to submit a longer original research article.

Primers are short papers containing basics related to a specific topic, for example key components for microscopy architectures, sample preparation for localization methods, entry level concepts about super resolution. Primers are thought for master thesis and PhD students and for orienting new post docs in research groups.

All manuscripts, whether invited or regular submissions, are peer reviewed. Articles intended for Special Issues should be designated as such during the submission process.

4. PREPARING THE SUBMISSION

Parts of the Manuscript

The manuscript should be submitted in separate files: main text file; figures.

Main Text File

The text file should be presented in the following order:

i. A short informative title that contains the major key words. The title should not contain abbreviations (see Wiley's best practice SEO tips);

ii. A short running title of less than 40 characters;

iii. The full names of the authors;

iv. The author's institutional affiliations where the work was conducted, with a footnote for the author’s present address if different from where the work was conducted;

v. Abstract and keywords;

vi. Research Highlights and Graphical Abstract;

vii. Main Text;

viii. Acknowledgements;

ix. References;

x. Tables (each table complete with title and footnotes);

xi. Figure Legends;

xii. Appendices (if relevant).

Figures and supporting information should be supplied as separate files.

Authorship

Please refer to the journal’s authorship policy the Editorial Policies and Ethical Considerations section for details on eligibility for author listing.

Acknowledgments

Contributions from anyone who does not meet the criteria for authorship should be listed, with permission from the contributor, in an Acknowledgments section. Financial and material support should also be mentioned. Thanks to anonymous reviewers are not appropriate.

Conflict of Interest Statement

Authors will be asked to provide a conflict of interest statement during the submission process. For details on what to include in this section, see the section 'Conflict of Interest' in the Editorial Policies and Ethical Considerations section below. Submitting authors should ensure they liaise with all co-authors to confirm agreement with the final statement.

Abstract

Please provide an abstract of 250 words or fewer containing the major keywords summarizing the article.

Keywords

Please provide three to five keywords.

Research Highlights

Research Highlights are the most important findings and/or conclusions of the article (or review), stated concisely. Research Highlights will be displayed online immediately below the article's title (they will not appear in the printed version of the paper). Main Points should consist of 2 to 3 short sentences and should not exceed 250 characters (including spaces). These are required for all papers published in the journal, and must be submitted at the time of the manuscript submission in ScholarOne.

Graphical Abstract

The graphical abstract provides readers with a visual representation of the conclusions and an efficient way to appreciate the key finding and main message of the work. This feature is part of the online article format and will appear in the online Table of Contents of each issue of the journal but will not appear in the printed version of the paper. Please upload an illustration describing the context and significance of the findings for the broader journal readership to attract the attention of non-specialists. The image should be a single image not containing multiple panels. It is meant to represent one key aspect of the results. The selected image must be a figure or part of a figure that is included in the paper. To prepare the image, select an image or graphic that is easy to read and as much as possible devoid of cluttering items, conveying clear, non-speculative, visual information about the biological context of the findings. Labels, while useful, must be kept to a minimum. The image should be provided in one of the following height and width configurations: 400 x 300 pixel, 300 x 400 pixel, or 400 x 400 pixel, and at a maximal resolution of 72 dpi. Please use Arial or Helvetica font with a size of 10–12 points; preferred file types are EPS and TIFF. The Graphical Abstract is mandatory for all papers

published in the journal. When uploading, please designate the image as Graphical Abstract Image in ScholarOne Manuscripts.

Main Text

The journal uses US spelling; however, authors may submit using either option, as spelling of accepted papers is converted during the production process.

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Alexie, S. (1992). The business of fancy dancing: Stories and poems. Brooklyn, NY: Hang Loose Press. Edited Book

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Morris (Eds.), Crime and justice: An annual review of research (Vol. 4, pp. 225–256). Chicago, IL: University of Chicago Press.

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Patent

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Magazine

Mathews, J., Berrett, D., & Brillman, D. (2005, May 16). Other winning equations. Newsweek, 145(20), 58–59.

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Schwartz, J. (1993, September 30). Obesity affects economic, social status. The Washington Post, pp. A 1, A4.

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