



Taxonomic, nomenclatural, and distributional updates in *Casselia* (Verbenaceae): Are the species rare or are their specimens just in the wrong herbarium cabinet?

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ABSTRACT

Casselia, a small South American genus of Verbenaceae found in Brazil, Bolivia, and Paraguay, has often been misidentified within other angiosperm families. Based on a careful review of herbarium specimens plus fieldwork, the present study provides taxonomic, nomenclatural, and geographical distribution alignments in *Casselia*, while also shedding light on the reasons why it is a poorly known and overlooked genus. The novelties encompass the redefinition of the boundaries of *C. confertiflora*, recognition of *C. confertiflora* var. *laciniata* at specific level, reestablishment of *C. zelota* as an accepted species with an epitype designation, as well as geographic distribution readjustment of the *C. integrifolia* and *C. serrata*. Consequently, *Casselia* comprises eight species, occurring along the Atlantic Forest, Cerrado, and Caatinga domains. The only species with a narrow distribution is *C. serrata*. However, the genus is still poorly collected, and the species populations are not abundant. Furthermore, to aid in the recognition of *Casselia* and prevent misidentifications, a detailed description of the genus accompanied by plant photographs and an updated identification key are also provided.

Keywords: Casselieae, Lamiales, misidentification, *Ruellia*, taxonomy

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Introduction

The tribe Casselleae (Verbenaceae, Lamiales) was circumscribed by Troncoso (1974) based on the subtribe Casselleae (Schauer 1847), encompassing the genera *Casselia* Nees & Mart. and *Tamonea* Aubl. This tribe was characterized by the axillary and few-flowered racemes, tubular calyx, infundibuliform corollas, and subcarinose fruits (Schauer 1847; Troncoso 1974). Later, based on morphological traits, *Parodianthus* Tronc. was included in Casselleae (Martínez & Múlgura 2003; Atkins 2004). Molecular phylogenetic studies on Verbenaceae confirmed the monophyly of this tribe (Marx *et al.* 2010), sustained by a compound truncate inflorescence with axillary florescences (homothetic pleiobotrya) and absence of adaxial staminode as synapomorphies (O’Leary *et al.* 2012). Currently, Casselleae comprises 14 species distributed in the Neotropical region (Cardoso *et al.* 2021).

Casselia, *Parodianthus*, and *Tamonea* are distinguished based on fruit differences (Troncoso 1941; Atkins 2004; O’Leary *et al.* 2008; O’Leary & Múlgura 2010). *Casselia* fruit is dry at maturity, splitted into two cluses (uniseminated seeds by abortion of the adaxial carpel), partially covered by the persistent and enlarged calyx; *Parodianthus* species have fleshy fruit with two two-seeded pyrenes, completely surrounded by the persistent and enlarged calyx; while *Tamonea* has indehiscent fruit, four-seeded, usually with four horns, inserted in the persistent calyx that partially surrounds it (Troncoso 1941; O’Leary *et al.* 2008; O’Leary & Múlgura 2010).

Walpers (1845), in a comprehensive treatment of Verbenaceae, recognized four species in *Casselia*: *C. chamaedryfolia* Cham., *C. integrifolia* Nees & Mart. (type species), *C. serrata* Nees & Mart., and *C. veronicaefolia* Cham., which were described by Nees and Martius (1823) and Chamisso (1832). Later, Schauer (1851) increased the number of species to five with the description of *C. mansoi* Schauer. Moldenke (1936) presented a monograph of *Timotocia* Moldenke (homotypic synonym of *Casselia*), recognizing 12 species and two varieties. Later, several names were combined into *Casselia* by Moldenke (1955). This genus was revised by O’Leary and Múlgura (2010), who accepted six species and one variety, while *C. zelota* (Moldenke) Moldenke was considered as doubtful. Also, in that study, five new synonymizations and two lectotypifications were presented.

Casselia is distributed in central and eastern Brazil, eastern Bolivia, and northern Paraguay (O’Leary & Múlgura 2010; Cardoso *et al.* 2021). According to O’Leary and Múlgura (2010), its species are not abundant, with restricted distribution in the Atlantic Forest and Cerrado domains, and have been poorly collected. However, this statement could be attributed to the scarcity of analyzed specimens in this revision (ca. 60 specimens), which may have hindered the taxonomy of the genus and consequently the species distribution.

Within Verbenaceae, *Casselia* can be considered a neglected genus with few studies conducted (O’Leary & Múlgura 2010), probably due to its low number of species. Based on fieldwork and revision of several herbarium specimens, this contribution updates the revision of O’Leary and Múlgura (2010) by providing taxonomic, nomenclatural, and geographical distribution alignments. Additionally, it addresses the reasons why *Casselia* is a poorly known and frequently misidentified genus. Lastly, to prevent the perpetuation of taxonomic inaccuracies and to guide future research efforts, a comprehensive morphological description of *Casselia*, accompanied by photographs and an identification key, are included.

Materials and methods

Casselia taxa were examined both in herbaria and in fieldworks in Brazil, with some specimens collected in the states of Goiás, Tocantins, and Rio de Janeiro. We analyzed specimens from CEN, CESJ, HUEFS, HEPH, MBM, R, RB, SP, SPF, and UB herbaria (acronyms follow Thiers 2023, continuously updated). Additionally, we carried out an analysis of high-quality digital images of *Casselia* specimens available online in databases such as REFLORA (<https://reflora.jbrj.gov.br/>), speciesLink (<https://www.splink.org.br/>), and JSTOR Global Plants (<https://plants.jstor.org/>).

This study follows the morphological species concept (Cronquist 1978; Zachos 2016) and the descriptive terminology is in accordance with Harris and Harris (2003), Gonçalves and Lorenzi (2007), Beentje (2010), and O’Leary and Múlgura (2010). Habitat, elevations, and phenology data were obtained from sheet labels, field observations, and key literature (Moldenke 1936; O’Leary & Múlgura 2010). A more detailed description of the genus and the identification key were developed based on the literature and the analysis of approximately 300 specimens, including types, from all species in South America. A map of the geographic distribution was prepared using QGIS version 3.10 (QGIS Development Team 2019) only for the species treated in this study (i.e., *C. confertiflora* (Moldenke) Moldenke, *C. laciniata* (Moldenke) P.H. Cardoso, *C. integrifolia*, *C. serrata*, *C. zelota*). For those specimens lacking original coordinates, the estimated georeferencing was obtained from the information available on the labels or the centroid for the municipality. The distribution of the other species remains consistent with that presented by O’Leary and Múlgura (2010).

Results and discussion

Taxonomic and nomenclatural amendments

O’Leary and Múlgura (2010) recognized six species and one variety in *Casselia*, with *C. zelota* considered a doubtful taxon. However, the analysis of herbarium specimens



of this taxon supports its recognition as an accepted species. Furthermore, the study of several specimens of *C. confertiflora* var. *laciniata* (Moldenke) Moldenke revealed that this taxon exhibits a distinctive set of traits that allow its recognition at the specific level, while *C. confertiflora* var. *confertiflora* requires a redescription. This last taxon was circumscribed based on a few specimens, but the analysis of numerous specimens revealed several distinct and yet undescribed morphological characteristics (Moldenke 1936; O'Leary & Múlgura 2010).

Consequently, to the six recognized species by O'Leary and Múlgura (2010), the present study adds two new accepted species, turning the total number of *Casselia* taxa to eight, without any taxon under the intra-specific category.

Redefinition of *Casselia confertiflora*

Casselia confertiflora (Moldenke) Moldenke, *Phytologia* 5: 132 1955. Basionym: *Timotocia confertiflora* Moldenke, *Repert. Spec. Nov. Regni Veg.* 39: 148. 1936. Type: Brazil: Goyaz [possible Tocantins], Chapada da Mangabeira, September 1839, *G. Gardner 3369* (holotype, K [barcode] K000487064 image!; isotypes, BR [barcode] BR0000006724825 image!, K000487063 image!, fragment NY [barcode] NY00138146 image!) (Fig. 1).

Subshrubs with xylopodium, erect, 8–25 cm tall, few-branched, branching at the base, without branchlets, branches straight, terete, hirsute or strigose, internodes 0.5–3 cm long. Leaves opposite, usually with 2–5 pairs on each branch, concentrated at the apex of the branches, petiole 0.2–0.3 cm long, strigose, blades 3–7 x 1.5–6 cm, the basal leaf blades entire, diminute and obovate, apical leaf blades entire, ovate, elliptic, lanceolate, or wide-ovate, chartaceous or sub-coriaceous, concolorous or discolorous, sometimes with magenta abaxial surface, base cuneate or obtuse, apex obtuse, acute or attenuate, margin entire near the base or up the middle, becoming regularly serrate or obscurely dentate towards the apex, (5)7–16 teeth per side, each tooth 0.1–0.5 cm long, distant 0.2–0.3 cm, not revolute to slightly revolute, minutely ciliate, adaxial surface smooth or slightly bullate, sparsely strigose or glabrous, abaxial surface pubescent, puberulent, or glabrous, veins slightly prominent abaxially, up to 5 order visible, sessile glands scattered on the blade. Racemes located in the apical part of the branches, congested, with (4)6–10 flowers, peduncles 0.1–0.4(1.4) cm long, strigose or hirsute-strigose; floral bracts 0.2–0.4 cm long, linear, apex acute, abaxial surface sparsely strigose, margin ciliate; flower pedicels 0.1–0.25 cm long, strigose or sparsely hirsute-strigose; calyx tube 0.5–0.8 cm long, green, puberulent between ribs, hispid-strigose along ribs, teeth 0.3–0.5 cm long, purplish, with hispid tips; corolla violet or lilac, tube 1.1–1.4 cm long, lobes 0.4–0.5 cm wide, puberulent, basal lobes with conspicuously dark violet or purple colored nectar guides. Fruit obloid.

Notes: The original description of *Timotocia confertiflora* (= *Casselia confertiflora*) by Moldenke (1936) was based solely

on the type specimen (*G. Gardner 3369*), and O'Leary and Múlgura (2010) analyzed only three additional specimens. The descriptions provided mention elliptic leaves with a cuneate base, regularly serrate margins from the apex to almost the base, and both surfaces puberulent or subglabrate (Moldenke 1936; O'Leary & Múlgura 2010). However, distinct characteristics from these were found in several herbarium specimens.

Casselia confertiflora exhibits wide variation in leaf shape, with some specimens having broadly ovate leaves with obtuse apex and base (e.g.: *B. Schindler & M. Figueira 394*, *G. Viana 160*), while others have lanceolate leaves, cuneate at base and attenuated at apex (e.g.: *G.M. Antar 695*, *E. Melo 7153*, and *R. Farias 164*). However, despite this range of variation, there is a morphological continuum between these two extremes, indicating that the observed differences represent variations within a single species (e.g.: *G.M. Antar 290*, *C.W. Fagg 1907*, *R. Farias 147*). The leaves of *Casselia confertiflora* specimens also vary in indumentum. They can be glabrous, puberulent, sparsely strigose, or sometimes pubescent. Some specimens collected in the same area have glabrous or sparsely strigose leaves (e.g.: *B. Schindler & M. Figueira 394*, *G.M. Antar 290*). The leaf margin can be entire near the base or up the middle, becoming regularly serrate or obscurely dentate towards the apex.

In the identification key, O'Leary and Múlgura (2010) distinguished *Casselia confertiflora* from *C. chamaedryfolia* based solely on the indumentum differences. The former being conspicuously hirsute plants (in contrast with the description) and the latter being glabrous or merely pulverulent plants. However, the indumentum variation of *C. confertiflora* hinders its distinction with *C. chamaedryfolia* (O'Leary & Múlgura 2010). Thus, *C. confertiflora* can be further differentiated from *C. chamaedryfolia* by its congested racemes with more than four flowers and peduncles shorter than the leaves (*vs. lax* racemes with up to four flowers and peduncles usually longer than the leaves), respectively.

Casselia confertiflora can be confused with *C. rosularis* Sandwith, both having slender branches, many-flowered racemes, and congested flowers. However, *C. confertiflora* differs in being plants up to 25 cm tall, having branches usually with elongated internodes (> 0.5 cm), leaves not sprawling on the ground, with smooth or slightly bullate adaxial surface, and calyx tube green with purplish teeth (*vs. plants* up to 10 cm tall, branches with short internodes (< 0.5 cm), leaves appressed to the ground, with strongly bullate adaxial surface and calyx entirely purplish in *C. rosularis*).

Distribution and habitat: *Casselia confertiflora* is endemic to the Cerrado domain in Brazil and can be found in the states of Bahia, Distrito Federal, Goiás, Maranhão, Mato Grosso do Sul, Piauí, and Tocantins (Fig. 2). This species grows in *Cerrado Rupestre* (Rupestrian savanna), typically in sandy-clay soil or among rocks. It was collected with flowers and fruits in January, March, September, October, November, and December.





Figure 1. *Casselia confertiflora* (Moldenke) Moldenke. **A** - Habit, showing xylopodium, leaves and racemes. **B** - Habit, showing leaves obscurely dentate and a congested inflorescence in fruiting. **C** - Flowering branch, showing leaves regularly serrate and congested inflorescence with flowers (the arrow points to the sessile glands on the leaf blade). **D** and **E** - Leaves, showing the discolorous surfaces. **F**. Detail of the calyx in sicco. Photos: **A** and **F** M.F. Simon et al. 3517 (CEN); **B** - G.M. Antar 695 (SPF); **C** - Suzana Martins; **D** and **E** B. Schindler & M. Figueira 394 (CEN).



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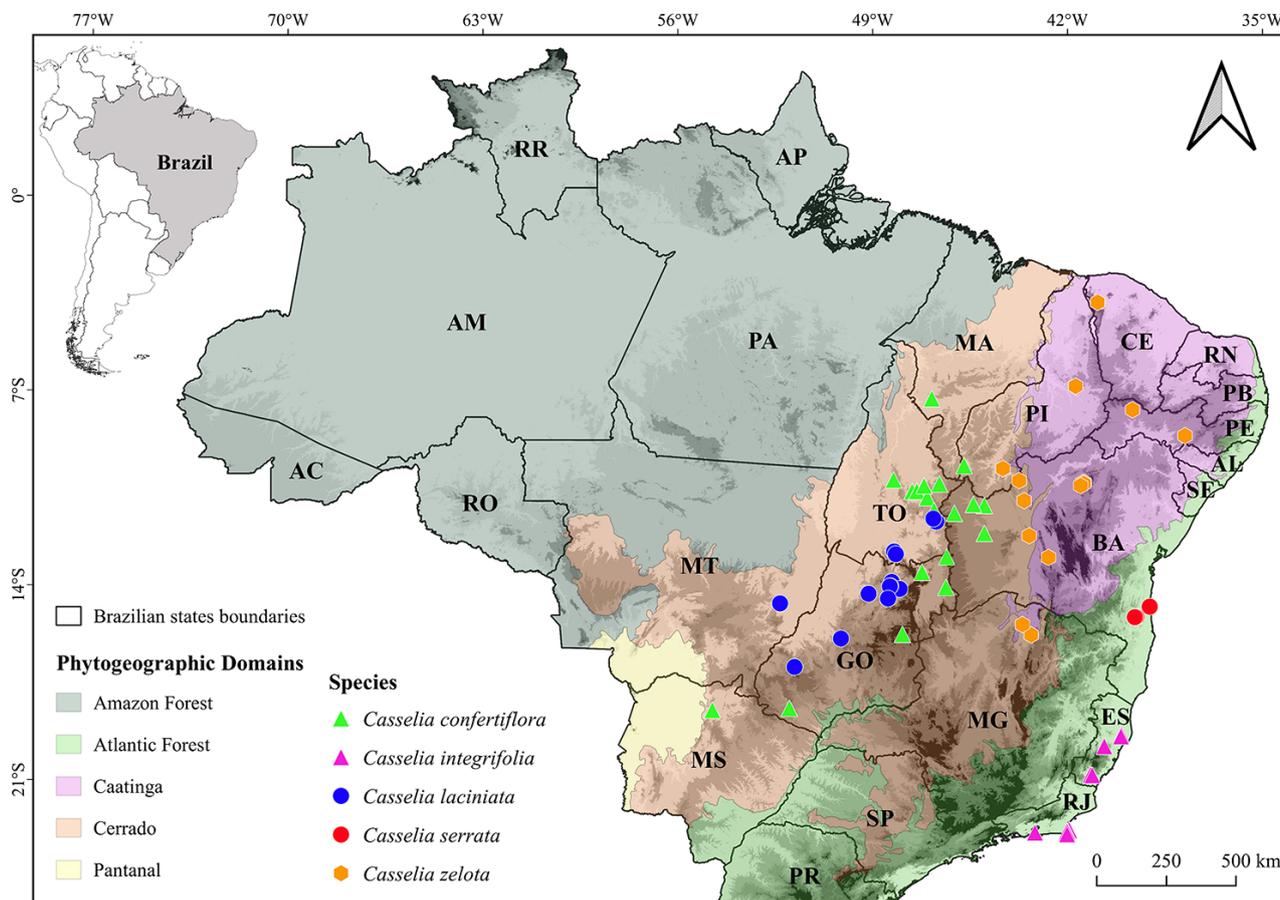


Figure 2. Distribution map of *Casselia* species treated in this study.

Specimens examined: Brazil. Bahia: Barreiras, Roda Velha, 9 October 1976, *G. Hatschbach* 39091 (MBM); Barreiras, Serra ca. 22 km W of Barreiras, 4 March 1972, *W.R. Anderson et al.* 36562 (UB); Formosa do Rio Preto, 13 November 1995, *G. Pereira-Silva* 3148 (CEN); Formosa do Rio Preto, Fazenda Estrondo, próximo a ponte do rio Riachão, 10 November 1997, *M.A. Silva et al.* 3543 (IBGE, US). **Distrito Federal:** Brasília, Granja do Ipê, 23 September 2014, *A.C. Soares et al.* 308 (HEPH); **Goiás:** Alto Paraíso de Goiás, Rio das Almas, 47 km from Alto Paraíso de Goiás on the road to Teresina de Goiás, 12 November 1994, *J.A. Ratter et al.* 7426 (UB); Campos Belos, Povoado de Pouso Alto, 31 October 2000, *M.A. da Silva et al.* 4623 (CESJ); Posse, Nova Vista, 8 October 1976, *G. Hatschbach* 39039 (MBM); Serranópolis, RPPN Pousada das Araras, 28 September 2005, *L.F. Souza* 2596 (HJ, UB). **Maranhão:** Carolina, Parque Nacional Chapada das Mesas, Morro do Arcaçu, Gleba II, 22 October 2015, *A.C. Sevilha* 5551 (CEN). **Mato Grosso do Sul:** Coxim, Rod. MS-217, 500m do trevo com a BR-163, direção de Silviolândia, 18 October 1995, *G. Hatschbach et al.* 63472 (MBM, US). **Piauí:** Gilbués, Conglomerado PI-577. Subunidade 3. Subparcela 9. Indivíduo 1HE, 22 November 2017, *G. Viana* 160 (UB). **Tocantins:** 10°39'S, 47°53'W, 14 November 1998, *R. Farias et al.* 147 (HUEFS); Estrada de

Ponte Alta para Mateiros, 16 November 1998, *R. Farias et al.* 164 (HUEFS); Mateiros, Parque Estadual do Jalapão, Brejo do Bebedouro, 7 December 2005, *J.M. Rezende* 1039 (CEN); Mateiros, ESEC Serra Geral do Tocantins, 30 km W do acampamento da Vila dos Prazeres, 5 October 2018, *M.F. Simon et al.* 3517 (CEN, HUEFS, HUTO); Natividade, Serra de Natividade, subida para a Torre, 20 November 2014, *J.E.Q. Faria et al.* 4281 (UB); Palmas, Bacia do Tocantins, 18 November 2008, *C.W. Fagg* 1907 (CESJ, IBGE, HUEFS); Ponte Alta do Tocantins, Jalapão, estrada entre Ponte Alta do Tocantins e Mateiros, 12 November 2011, *J.E.Q. Faria et al.* 2139 (UB); Ponte Alta do Tocantins, Estação Ecológica Serra Geral do Tocantins, Lagoa do Caldeirão, 29 January 2015, *G.M. Antar et al.* 695 (SPF); Ponte Alta do Tocantins, 40 km E de Sussuapara (linha reta), 8 November 2009, *E. Melo et al.* 7153 (HUEFS); Rio da Conceição, ESEC Serra Geral do Tocantins, local popularmente chamado de “Cascavel”, 19 March 2022, *B. Schindler & M. Figueira* 394 (CEN, CESJ); Rio da Conceição, região da Lagoa da Serra, 14 January 2020, *M. Verdi et al.* 7815 (CEN, RB).

New taxon recognized at specific level

Casselia laciniata (Moldenke) P.H. Cardoso **comb. nov.**
Basionym: *Timotocia confertiflora* var. *laciniata* Moldenke,

Repert. Spec. Nov. Regni Veg. 39: 149. 1936. = *Casselia confertiflora* var. *laciniata* (Moldenke) Moldenke, Phytologia 5: 132. 1955. Type: Brazil: Goyaz [Tocantins], Mission of Duro, October 1839, G. Gardner 3370 (holotype, K [barcode] K000248173 image!; isotypes, E [barcode] E00680961

image!, BM [barcode] BM000895741 image!, BR [barcode] BR0000006724801 image!, K [barcode] K000248174 image!, NY [barcode] NY00138147 image!, P [barcodes] P02885252, P02885255 pro parte, P03915392 images!, SP [barcode] SP003371!, W [barcode] W1889-0294479 image!) (Fig. 3).



Figure 3. *Casselia laciniata* (Moldenke) P.H. Cardoso. **A** - Branch with leaves and inflorescence; **B, C, D, E,** and **F** - Details *in sicco*: **B** - Leaf blade adaxial surface; **C** - Leaf blade abaxial surface; **D** - Flowering calyx; **E** - Fruit partially surrounded by the persistent calyx; **F** - Fruit exocarp. Photos: **A** - Suzana Martins; **B, C** and **D** B.M.T. Walter *et al.* 3480 (CEN); **E** and **F** G. Pereira-Silva 12333 (CEN).



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Subshrubs with xylopodium, 15–40 cm tall, densely branched, branching at the base, without branchlets, branches straight, terete, strigose, internodes 1.2–5.5 cm long. Leaves opposite, 4–10 pairs on each branch, evenly distributed, sub-petiolate, petiole ca. 0.2 cm long, glabrous or puberulent, blades 1.2–5.5 x 0.3–3.1 cm, basal leaf blades entire, diminute and obovate, apical leaf blades pinnatipartite to pinnatisect, elliptic, chartaceous, discolorous, base cuneate, apex acuminate, margin distinctly lacinate-dentate, 3–7(–8) conspicuous teeth per side, each tooth (0.6)0.8–2 cm long, sparsely disposed, 0.4–0.8 cm distant, not revolute to slightly revolute, conspicuously ciliate, adaxial surface smooth, puberulent, abaxial surface puberulent or glabrous, veins slightly prominent abaxially, up to 3 order visible, sessile glands scattered on the blade. Racemes located along and in the apical part of the branches, congested or not, with 2–8 flowers, peduncles 0.2–1.4 cm long, strigose; floral bracts 0.2–0.4 cm long, linear, apex acute, abaxial surface sparsely strigose, margin ciliate; flowers pedicels ca. 0.2 cm long, strigose; calyx tube 0.4–0.5 cm long, green, hispid-strigose along ribs, glabrous between ribs, teeth 0.2–0.3 cm long, purplish, with hispid tips; corolla violet or lilac, tube 1.4–1.6 cm long, lobes ca. 0.5 cm wide, puberulent, basal lobes with conspicuously dark violet or purple colored nectar guides. Fruit obloid.

Notes: Moldenke (1936) described *Timotocia confertiflora* var. *laciniata* (= *Casselia confertiflora* var. *laciniata*) to include plants with leaf blades irregularly lacinate-dentate along the margins, which are taller and leafier than *T. confertiflora* var. *confertiflora* (= *C. confertiflora* var. *confertiflora*). This circumscription was upheld by O’Leary and Múlgura (2010). However, it is worth noting that the distinction between *Casselia* species is primarily based on leaf morphology and habit (Moldenke 1936; O’Leary & Múlgura 2010). In this regard, *C. confertiflora* var. *laciniata* possess a unique set of traits within the genus that justify its recognition as a distinct species.

Thus, *Casselia laciniata* is here considered a distinctive species within the genus based on its densely branched habit, with evenly distributed leaves along the branches, leaf blades that are distinctly lacinate-dentate along margins and conspicuously ciliate. Table 1 highlights the main differences between *C. laciniata* and *C. confertiflora*.

Distribution and habitat: *Casselia laciniata* is endemic to Brazil, occurring exclusively in the Cerrado domain and found in the states of Goiás, Mato Grosso, and Tocantins (Fig. 2). It grows in *Campo Limpo* (open grassland), *Campo Sujo* (shrubby grassland), and *Cerrado Rupestre* (Rupestrian savanna), typically in sandy-clay soils or among rocks. The species was collected with flowers and fruits in October, November, and December.

Specimens examined: **Brazil. Goiás:** 258 km de Anápolis para Belém, 8 November 1963, *N.T. Silva* 57733 (NY, US); Caiapônia, entre Caiapônia e Aragarças, 9 km de Caiapônia, 2 October 1968, *O. Sidney* 1039 (UB); Colinas

do Sul, Estrada pelo dique 2 na direção do Rio Tocantins (paralela a este), 20 October 1996, *B.M.T. Walter et al.* 3480 (CEN, SPF); Colinas do Sul, Estrada Colinas do Sul - Alto Paraíso de Goiás, 24 October 2011, *C. Silva* 672 (HUEFS); Jeroaquara, Serra de Santa Rita, 23 October 1971, *J.A. Rizzo* 7153 (CESJ); Niquelândia, região da Serra Negra, margem esquerda do rio Bagagem, próximo a Faz. Aroeira, após a Codemin (ca. 10 km desta), 7 October 1995, *B.M.T. Walter* 2702 (CEN); Niquelândia, estrada Niquelândia – Rosariana, área de influência da UHE Serra da Mesa, 8 October 1995, *T.B. Cavalcanti* 1861 (CEN); Niquelândia, próximo à área do DNPM (conhecida como Reserva do IBAMA), cerca de 5 km de Niquelândia, 19 October 1996, *R.C. Mendonça et al.* 2859 (IBGE, RB). **Mato Grosso:** Xavantina, ca. 70 km N of Xavantina, 10 October 1964, *H.S. Irwin & T.R. Soderstrom* 6739 (NY, UB, US). **Tocantins:** Km 21 da estrada Dianópolis – Taguatinga, 8 December 1991, *D. Alvarenga et al.* 834 (US); Dianópolis, km 7 da estrada de localidade para Corrente, 5 December 1991, *M.L.F. Resende et al.* 31 (RB); Paranã, Canteiro de obras do UHE São Salvador, 19 October 2006, *G. Pereira-Silva* 10914 (CEN); Paranã, Estrada de acesso à vila Rosário, canteiro de obras da UHE São Salvador, 24 November 2007, *G. Pereira-Silva* 12333 (CEN).

Table 1. Morphological traits to distinguish *Casselia confertiflora* and *C. laciniata*.

Morphological traits	<i>Casselia confertiflora</i>	<i>Casselia laciniata</i>
Plant ramification	few-branched	densely branched
Number of leaves on branches	2–5 pairs, concentrated at the apex of the branches	4–10 pairs, well distributed along the branches
Apical leaf blade	entire	pinnatipartite to pinnatisect
Indumentum of the margin	minutely ciliate	conspicuously ciliate
Number of teeth on the blade margin	(5)7–16 per side	3–7(–8) per side
Teeth length	0.1–0.5 cm long	(0.6)0.8–2 cm long
Distance between teeth	0.2–0.3 cm	0.4–0.8 cm
Venation visible on abaxial surface	up to 5 order	up to 3 order
Number of flowers per raceme	(4)6–10	2–8

Recognition and typification of Casselia zelota

Casselia zelota (Moldenke) Moldenke, *Phytologia* 5: 132. 1955. Basionym: *Timotocia zelota* Moldenke, *Repert. Spec. Nov. Regni Veg.* 39: 133. 1936. Type: Brazil: Bahia, Jacobina, 1840, *J.S. Blanchet* 3133 (holotype, K [barcode] K000013867 image!; isotypes, G [barcode] G00176379 image!, IPA-64041 n.v., K [barcode] K000895067 image!, NY [barcode] NY01871386 image!, P [barcodes] P02141532,



P02141533 images!). Type: Brazil: Piauí, Ipiranga do Piauí, Povoado Tabocas, 22 March 2023, *K.M.L. Borges 251* (epitype, CEN!; isoeptype UFPI-1278 image!) (Fig. 7).

Shrubs with a woody tuberous, 0.5–1.5 m tall, densely branched towards the apex, branches tetragonal, with numerous branchlets, strigose or puberulent, becoming rounded and glabrescent at maturity, exfoliate, internodes 0.5–3.5 cm long, nodes conspicuous. Leaves opposite, sometimes fasciculate, crowded on the branchlets, deciduous, petiole 0.1–0.2 cm long, strigose, blades 0.5–3.5(–5) x 0.3–1.5 cm, entire, elliptic, obovate, ovate, or subrotund, chartaceous, concolours, base cuneate, apex acute, obtuse, or rounded, margin entire, sometimes obscurely dentate at the apex, not revolute, ciliate, adaxial surface smooth, puberulent, abaxial surface puberulent or strigose, veins slightly prominent abaxially, up to 4 order visible, sessile glands scattered on the blade. Racemes located along the branches, 1–2 flowered, peduncles obsolete, strigose; floral bracts 0.2–0.3 cm long, linear, apex acute, abaxial surface sparsely strigose, margin ciliate; flower pedicels 0.2–0.7 cm long, puberulent or strigose; calyx tube 0.3–0.5 cm long, green, regularly strigillose or puberulent, teeth 0.2–0.3 cm long, green, with hispid tips; corolla violet or lilac, tube 0.8–1 cm long, lobes ca. 0.4 cm wide, puberulent, basal lobes with conspicuously dark violet or purple colored nectar guides. Fruit obloid-ellipsoid.

Notes: Moldenke (1936) described *Timotocia zelota* (= *Casselia zelota*) without corollas and fruits. This species was characterized by the leaves crowded on the short twigs, deciduous at maturity, leaf blade up to 2 cm long, chartaceous, with an acute or rounded apex, entire margin, both surfaces puberulent, and 1-flowered racemes (Moldenke 1936). In the genus review, only two images of the type specimens were examined and as they correspond to an immature plant, *C. zelota* was considered a dubious species (O'Leary & Múlgura 2010).

Apart from the original description of *Casselia zelota*, there is no additional information about this species in the literature. However, several specimens labeled with this name are deposited in some Brazilian herbaria. The identity of these specimens as *C. zelota* was confirmed through comparison with the type and the original description (Moldenke 1936). Upon examining these specimens, we have found various ones with corollas, and some specimens with fruits (e.g.: *Gardner 2272*, *Borges 251*). The fruit exhibits the typical characteristics of the genus *Casselia* as mentioned before. As a result, the present study provides confirmation of the identity of *C. zelota*, and a specimen with flowers and fruits exhibiting the important diagnostic characteristics for the recognition of the species is designated as an epitype.

Unfortunately, most of the specimens of *Casselia zelota*, as well as other species of the genus, are collected without fruits. We hypothesize that the fruit, which is relatively large compared to the delicate peduncle of the inflorescence that supports it, may be easily detached as it is not fully

inserted into the persistent calyx. Further studies are needed to confirm it.

Distribution and habitat: *Casselia zelota* is endemic to the Caatinga domain of Brazil and is found in the states of Bahia, Ceará, Minas Gerais, Pernambuco, and Piauí (Fig. 2). It grows in the *Carrasco* vegetation (a dense, deciduous, spineless shrubland vegetation with a higher density of woody individuals, and cacti and bromeliads are almost absent). This species was collected with flowers in January, February, April, October, November, and December, and fruits in February.

Specimens examined: Brazil. Bahia: Barra, Conglomerado BA-360. Subunidade 4. Subparcela 10. Indivíduo 10, 8 January 2008, *A.S. Soares 416* (IFN) (UB); Macaúbas, Boqueirãozinho, 26 November 2004, *G. Hatschbach et al. 78534* (MBM, US); Macaúbas, Vaca Mansa, 27 November 2004, *G. Hatschbach 78648* (MBM, SPF, US); Muquém de São Francisco, Conglomerado BA-694. Subunidade 1. Subparcela 1. Indivíduo 7-RN, 19 January 2018, *T.M. Moraes 1415* (IFN) (UB); Pilão Arcado, Conglomerado BA-193. Subunidade 2. Subparcela 10. Indivíduo 7-RN, 12 December 2017, *E.O. Moura 1705* (IFN) (RB, UB); Sento Sé, na estrada Delfino, via o Rio Murim, para Sento Sé, um pouco depois de Campo Largo, 8 April 2015, *R.M. Harley 57202* (HUEFS); Sento Sé, Povoado do Alegre, leito do riacho após o campo de futebol, próximo a plantação de macaxeira do povoado, 15 December 2017, *E.D.S. Almeida 147* (HVASF); Sento Sé, Área proposta do Parque Nacional Boqueirão da Onça, Povoado Moreno, Nascente Olho da Marcelina, 19 December 2013, *D.S. Fernandes 142* (HVASF); Sento Sé, estrada à 22,8 km de Alegre para o Brejo da Brásida, Alto da Serra, na propriedade do complexo eólico Casa dos Ventos, 16 December 2015, *J.A. Siqueira Filho 3639* (HVASF). **Ceará:** Jati, VPR Ipê, 28 October 2014, *A.P. Fontana & J.R. Silva 8714* (HUEFS, RB); Ubajara, Jaburuna/Sul, Planalto da Ibiapaba, 21 February 1995, *F.S. Araújo 1122* (HUEFS, K). **Minas Gerais:** Janaúba, Rodovia Janaúba – Jaíba, km 10 -12, 22 November 2004, *G. Hatschbach et al. 78421* (MBM); Verdelândia, junto à marca do km 86 da estrada Jaíba/Verdelândia, 20 October 2001, *J.A. Lombardi et al. 4478* (CESJ). **Pernambuco:** Ibimirim, Serra com Torres de Telefonia, margem da PE-110 que liga Ibimirim a Petrolândia, 8 February 2017, *V.M. Cotarelli 2688* (RB). **Piauí:** Prov. Piauiensis, s.l., 1839, *G. Gardner 2272* (K, NY, W); Ipiranga do Piauí, Povoado Tabocas, 22 March 2023, *K.M.L. Borges 251* (CEN, UFPI); Serra da Capivara, 17 November 1981, *A. Fernandes & E. Nunes s.n.* (SPF71172).

Distributional amendments in Casselia integrifolia and C. serrata

According to O'Leary and Múlgura (2010), both *Casselia integrifolia* and *C. serrata* are found in the Atlantic Forest and Cerrado domains, with remarkable disjunctions. The first was recorded in the states of Espírito Santo, Rio de Janeiro (Atlantic Forest), Mato Grosso, Mato Grosso do Sul



(Cerrado), and Piauí (s. loc., Caatinga), and the second in the states of Bahia and Rio de Janeiro (O’Leary & Múlgura 2010, map on p. 11). However, analysis of the vouchers revealed that neither of the two species is found in the Cerrado domain, with some specimens misidentified.

Casselia integrifolia is an irregularly branched subshrub, sometimes decumbent, with tortuous branches, ovate or elliptical leaves, chartaceous, glabrous or puberulent on both surfaces, with inconspicuous veins, racemes with 2–4 flowers, and calyx minutely puberulent (Moldenke 1936; O’Leary & Múlgura 2010). The leaf margin of *C. integrifolia* is typically entire, but sometimes it may exhibit slight dentation, as seen in the type specimen of *Casselia integrifolia* var. *fischeri*, which is a heterotypic synonym (O’Leary & Múlgura 2010). The authors identified all specimens of *Casselia* with leaves displaying entire or obscurely dentate margins as *C. integrifolia*. Nevertheless, this trait is not exclusive to *C. integrifolia*. Three other species, *C. confertiflora*, *C. rosularis*, and *C. zelota* can also exhibit entire or obscurely dentate leaf margins. Consequently, the following specimens from Mato Grosso, Mato Grosso do Sul, and Piauí states were reidentified: *Hatschbach* 63472 is *C. confertiflora*, *Hatschbach* 33147 is *C. rosularis*, *Gardner* 2272 is *C. zelota*, and *Hatschbach* 37421 is probably *C. rosularis*. In contrast to the findings presented by O’Leary and Múlgura (2010), the re-identification of these specimens limits the distribution of *C. integrifolia* to the Atlantic Forest domain in the states of Rio de Janeiro and Espírito Santo (Fig. 2).

Casselia serrata is distinguished by its elliptical and membranaceous leaves, with regularly toothed margins, and racemes with long peduncles, with 2–4 flowers. The occurrence for the state of Rio de Janeiro (*Glaziou* 13060) is based on a mistranslation of the label of the fragment specimen housed at NY herbarium: “*Env. de Rio de Janeiro*” - meaning it was sent from Rio de Janeiro but does not necessarily indicate the origin of the specimen itself. On the other hand, the duplicate of *Glaziou* 13060 deposited at R herbarium indicates that the specimen was collected in the state of Minas Gerais. Moreover, this specimen was misidentified as *C. serrata* (O’Leary & Múlgura 2010), but it actually belongs to *C. glaziovii* (Briq. & Moldenke) Moldenke.

O’Leary and Múlgura (2010) indicated the presence of *Casselia serrata* in the Cerrado, possibly due to a misinterpretation, believing that the specimen found in Bahia might have been collected within this domain. However, the specimens from Bahia were collected in the southern part of the state, which is within the Atlantic Forest domain. Therefore, *C. serrata* is restricted to the state of Bahia and found only in the Atlantic Forest domain, with few known occurrence records (Fig. 2).

Casselia’s most common doppelgangers, who and why?

The consultation of herbarium collections revealed that several specimens of *Casselia* are commonly misidentified

as taxa from distinct angiosperm families, Acanthaceae (*Ruellia* L. and *Stenandrium* Nees), Gesneriaceae, Lamiaceae (*Marsypianthes* Mart. ex Benth.), Loganiaceae (*Spigelia* L.), Lythraceae (*Cuphea* P.Browne), Plantaginaceae (*Angelonia* Bonpl.), Rubiaceae, and Violaceae. Figure 5 illustrates some herbarium specimen labels that demonstrate such misidentifications. Most of these taxa belong to Lamiales, an order with herbaceous to shrubby members with large zygomorphic flowers, where Verbenaceae is included (Endress 2010; Schäferhoff *et al.* 2010; APG IV 2016; Fonseca 2021). Outside Lamiales, *Casselia* specimens are also misidentified as species from Gentianales (Loganiaceae and Rubiaceae), Malpighiales (Violaceae), and Myrtales (Lythraceae) (APG IV 2016).

Among the taxa mentioned above, *Casselia* is most frequently confused with *Ruellia*. Some *Ruellia* species are small subshrubs very similar to *Casselia*, with opposite leaves, conspicuous calyx, zygomorphic corollas, with five rounded lobes, lilac with colored streaks or veins that probably function as nectar guide, and four stamens (Ezcurra 1993; O’Leary & Múlgura 2010; Fernandes *et al.* 2023). Moldenke (1975) drew attention to this similarity several times and wrote: “Material of *C. glaziovii* has been misidentified in some herbaria as belonging in the Acanthaceae, a very understandable mistake” (p. 193) and “Material of *C. integrifolia* has been misidentified and distributed in some herbaria as Acanthaceae” (p. 195). However, *Casselia* species can be easily differentiated from *Ruellia* in having a tubulous and 5-toothed calyx, corolla with a funnellform tube, stamens included, with not fused filaments, the posterior pair with a glandular thickening of the connective tissue, oblique stigma, and a subcarinose fruit splitting into two cluses (*vs.* five-parted calyx, corolla with a narrow basal tube, more or less cylindrical, that opens abruptly into a widened portion, exerted or included stamens, with fused filaments at the base by a staminal membrane, two-lobed stigma, and fruit a biloculate, two-valved, loculicidal capsule) respectively (Ezcurra 1993; Fernandes *et al.* 2023).

The distinctive floral morphology of *Casselia* could explain why it is not being easily recognized within Verbenaceae. Its flowers have a large and funnel-shaped corolla with purplish nectar guides. This trait is also present in *Ruellia* (Ezcurra 1993), but in Verbenaceae, it is less frequent and is only found in the three small Casselieae genera and *Duranta* L. (O’Leary *et al.* 2012; Cardoso *et al.* 2021). The most well-known and species-rich genera of Verbenaceae are *Glandularia* J.F.Gmel., *Lantana* L., *Lippia* L., *Stachytarpheta* Vahl, and *Verbena* L. (Cardoso *et al.* 2021), which present cylindrical tubular, hypocrateriform or infundibuliform corollas, very different from the *Casselia* (Atkins 2004). Therefore, many botanists probably do not associate *Casselia* as a member of Verbenaceae, resulting in misidentifications.



Casselia morphology and distribution

Habit: Species of *Casselia* are subshrubs or shrubs with erect or decumbent stems, unbranched or densely branched, with a woody tuberous root or xylopodium (Figs. 1, 3, 4, 6, 7). Most species are 10–50 cm tall, but *C. rosularis* is smaller than 10 cm, with its leaves usually appressed to the ground, exhibiting a rosette-like habit when viewed from above (Fig. 7C), while *C. zelota* can reach 1.5 m (Fig. 4, 7E).

Most species are basally-branched, with two to numerous branches emerging from the woody tuberous root or xylopodium, usually without ramifications in the upper part (Figs. 1A, 6A, F). In contrast, *C. serrata* and *C. zelota* are densely branched apically, with numerous branchlets (Fig. 4A, Fig. 7E). In *C. zelota* the branches are exfoliated at maturity and the nodes are conspicuous (Fig. 4A, Fig. 7E). *Casselia integrifolia* is irregularly branched, sometimes decumbent, with tortuous branches (Fig. 7A).

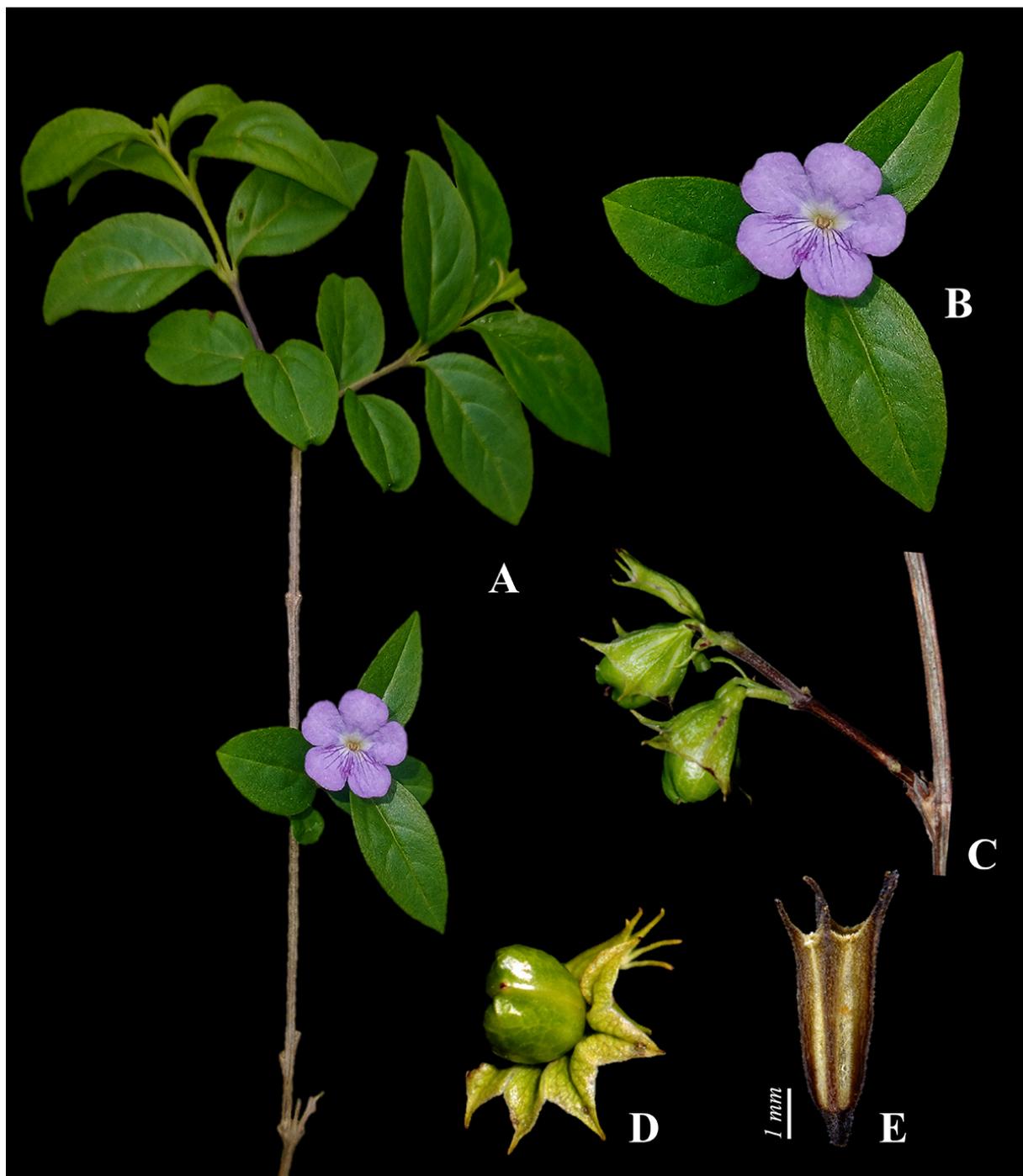


Figure 4. *Casselia zelota* (Moldenke) Moldenke. **A** - Branch with leaves and raceme; **B** - Detail of the leaves and flower; **C** - Branch with calyx and fruits; **D** - Detail of the fruit; **E** - Detail of the calyx *in sicco*. Photos: K.M.L. Borges 251 (CEN, UFPI).

**Taxonomic, nomenclatural, and distributional updates in *Casselia* (Verbenaceae):
Are the species rare or are their specimens just in the wrong herbarium cabinet?**



Figure 5. Labels of *Casselia* specimens showing previous identifications as other taxa. **A** - Acanthaceae, Scrophulariaceae, and Verbenaceae (*Verbena*); **B** - Plantaginaceae; **C** - Gesneriaceae; **D** - Lythraceae (*Cuphea*); **E** - Rubiaceae; **F** - *Ruellia* (Acanthaceae); **G** - Acanthaceae, Loganiaceae (*Spigelia*).

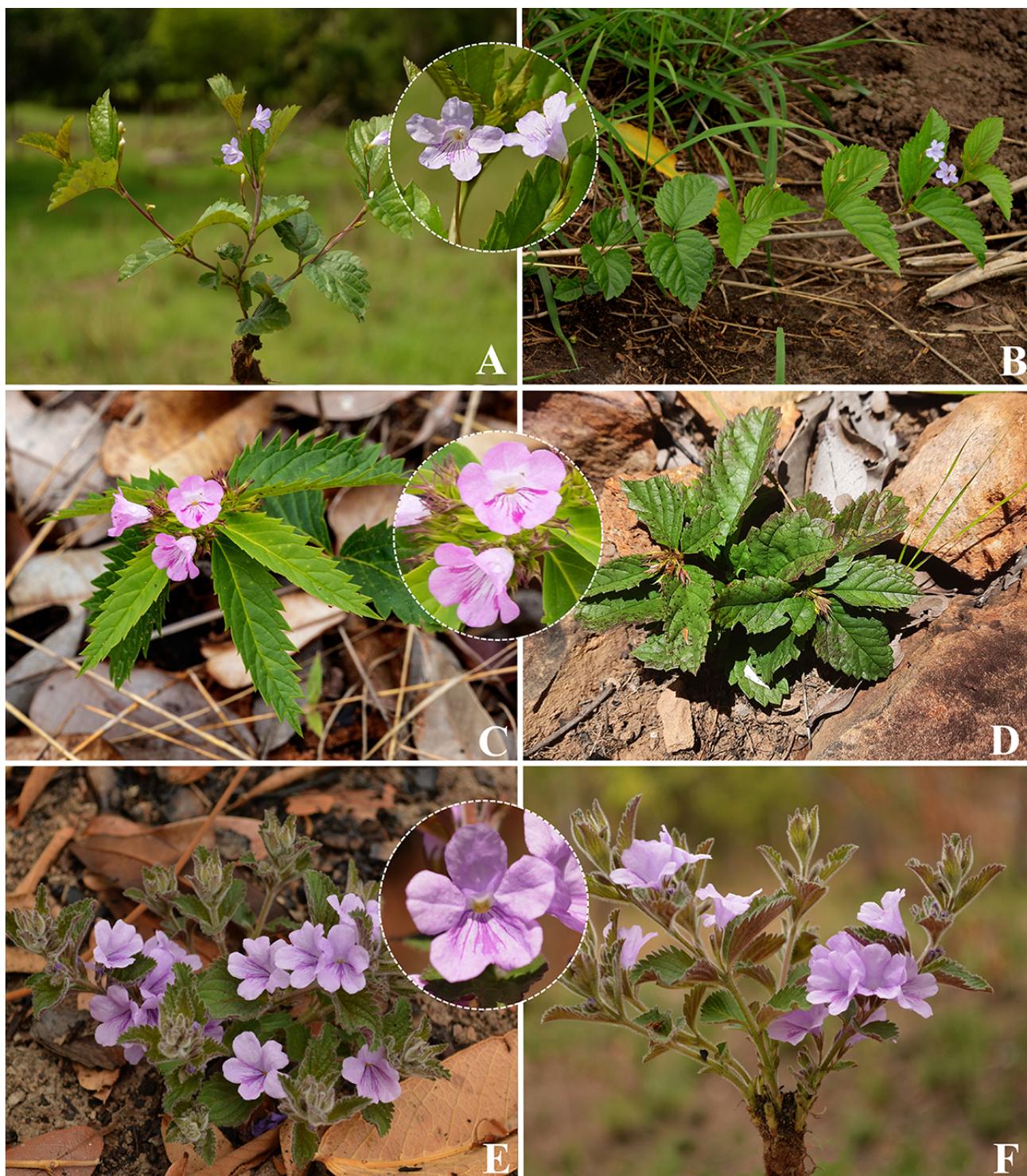


Figure 6. Habit of *Casselia* species, showing details of branches, leaves, racemes, and flowers. **A** and **B** - *C. chamaedryfolia* Cham., subshrub; **C** and **D** - *C. confertiflora* Moldenke (Moldenke), subshrub; **E** and **F** - *C. glaziovii* (Briq. & Moldenke) Moldenke, subshrub. Corolla details are highlighted in the circles. Photos: **A** and **B** - J.E.Q. Faria 10834; **C** - Suzana Martins; **D** - B. Schindler & M. Figueira 394 (CEN, CESJ); **E** and **F** - J.E.Q. Faria 9850 (HEPH).

Taxonomic, nomenclatural, and distributional updates in *Casselia* (Verbenaceae):
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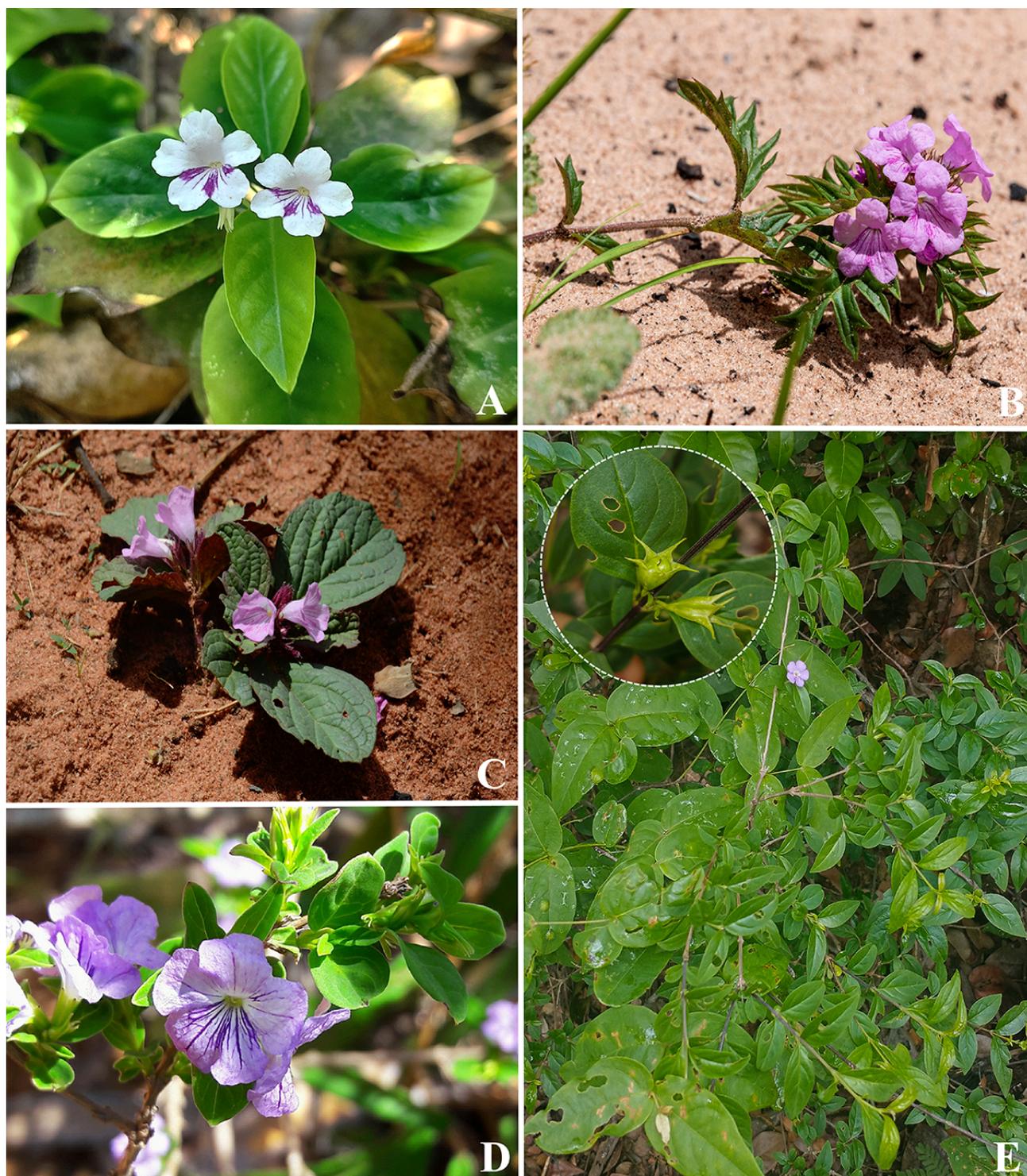


Figure 7. Habit of *Casselia* species, showing details of branches, leaves, racemes, flowers, and fruits. **A** - *C. integrifolia* Nees & Mart., subshrub; **B** - *C. laciniata* Moldenke (P.H.Cardoso), subshrub; **C** - *C. rosularis* Sandwith, subshrub; **D** and **E** - *C. zelota* Moldenke (Moldenke), shrub. The circle highlights the fruit of *C. zelota*. Photos: **A** - M. Figueira & B. Schindler 1892 (CEN); **B**. Suzana Martins; **C** - M. Figueira & B. Schindler 1507 (CEN). **D** - Gildasio Oliveira; **E** - K.M.L. Borges 251 (CEN, UFPI).

Indumentum: Species of *Casselia* can be glabrous or hairy, and in some species the presence or absence of trichomes is related to the environment. The trichomes are simple and their density and length may vary on the different organs. The branches are usually strigose; the leaves are usually puberulent, with trichomes concentrated along veins and margins (Fig. 3C); the calyx is often hispid along the ribs (Figs. 1F, 3D); and the corolla lobes are often puberulent.

Leaves: Phyllotaxis is opposite (Fig. 6B) and the leaf blade can be entire (Fig. 7A) or pinnatipartite to pinnatisect (Fig. 3A-C). Some species have the basal pair of leaves usually reduced (Fig. 1C, Fig. 6A and F, Fig. 7B). Leaf disposition varies according to the species and can be crowned-shaped at the apex of the branches (Fig. 4A, Fig. 7D) or evenly distributed (Fig. 6B, F). Leaf internodes can be short (less than 0.5 cm) (Fig. 1B, Fig. 7C) or not (Fig. 4A, Fig. 6A). Leaves can be petiolate or sessile, membranaceous, chartaceous, or rarely subcoriaceous. The surfaces are often discolorous, sometimes purplish on the abaxial side (Fig. 1A and E), but usually brownish or blackish *in sicco*. Leaf blades can be elliptic, obovate, ovate, or subrotund. The leaf margins are variable, and can be entire (Figs. 4A, B, 7A) to distinctly lacinate-toothed (Fig. 7B), slightly revolute or not. The apex can be acute, attenuate, obtuse, to rounded, and the base can be cuneate or obtuse. The venation can be semicraspedodromous or brochidodromous, and the veins may be conspicuously or slightly prominent on the abaxial surface. The adaxial surface is often smooth, or bullate. Sessile glands are often found on the abaxial surface.

Inflorescences: The inflorescences are axillary racemes (homothetic pleiobotrya), pedunculate and bracteate (Figs. 4C, 6A). The racemes can be few-flowered (1 to 4 flowers) (Fig. 6A) or many-flowered (4 to 12 flowers) (Fig. 6C). The peduncles are shorter than the leaves (Figs. 1C, 6F), except in *C. chamaedryfolia*, which can have the same length or sometimes longer than the leaves (Fig. 6A). The bracts are minute, linear, appressed to the peduncle, and often deciduous, therefore, with little taxonomical value.

Flowers: The flowers have a filiform and short pedicel, and are 5-merous (Figs. 6, 7). They are congested in many-flowered racemes (Fig. 1C, Fig. 6C, Fig. 7C) or lax in few-flowered racemes (Fig. 6A, Fig. 7D and E). The calyx is tubulous, conspicuous, 5-ribbed, and 5-toothed, green, green-purplish or entirely purplish (Fig. 1F, Fig. 3D, Fig. 4E). The teeth are equal, sub-linear and long-acuminate at apex. The calyx is persistent, becoming campanulate

in fructification, partially surrounding the fruit (Fig. 3E, Fig. 4C, D, Fig. 7E). The corolla can be light-blue, pinkish, lilac, or white, with a funnellform tube, 5-parted limb, and rounded lobes (Figs. 6, 7). The two basal lobes are fused, having purplish nectar guides (Figs. 6, 7). The androecium is composed of four fertile stamens, didynamous, included, the posterior pair with a glandular thickening of the connective tissue. The filaments are filiform, and the anthers are dorsifixed, oblong, or ovate. The gynoecium is included, with oblique stigma, minutely papilose, and terminal style; the ovary is glabrous, with 1 carpel, 2 locules, and 2 ovules.

Fruit: The fruit is subcarnose, fleshy, becoming dry at maturity, and splitting into two cluses, with a venose exocarp, partially covered by the persistent and enlarged calyx (Fig. 3E and F, Fig. 4C and D).

Distribution: *Casselia* currently comprises eight species, all of which are found in Brazil, six of them endemic to the country. The two non-endemic species are *C. chamaedryfolia* which also grows in Bolivia and Paraguay, and *C. rosularis* which is also found in Bolivia (O’Leary & Múlgura 2010). The genus is distributed in three phytogeographic domains: Atlantic Forest (*C. integrifolia* and *C. serrata*), Cerrado (*C. chamaedryfolia*, *C. confertiflora*, *C. glaziovii*, *C. laciniata*, and *C. rosularis*), and Caatinga (*C. zelota*). Thus, the species richness is concentrated mainly in the Cerrado domain.

Among the species of *Casselia*, the only one that has a rather restricted distribution is *C. serrata*. However, *Casselia* is still a poorly collected genus, and the species populations are not abundant (O’Leary & Múlgura 2010; B. Schindler and M. Figueira, *personal observation*). This could be linked to the fact that the majority of the species flower during the rainy season, which may limit collection opportunities. Additionally, according to the information on the labels of some specimens, certain species flowering shortly after the passage of fire in the Cerrado domain, and we believe that their corollas are quickly shed from the plant after pollination.

An updated identification key

Casselia species are distinguished from each other mainly by characteristics related to habit, leaf morphology, number of flowers per raceme, peduncle length, and calyx. The distribution of the species is also useful for identification, since the same species does not occur in different phytogeographic domains.

Identification key for *Casselia* species

- | | |
|---|----------------------------|
| 1. Leaf blade pinnatipartite to pinnatisect | <i>C. laciniata</i> |
| 1'. Leaf blade entire | 2 |
| 2. Racemes with 4 or more flowers, congested, located at the apex of the branches | 3 |
| 2'. Racemes with 4 or less flowers, lax, well-distributed along the branches | 4 |



**Taxonomic, nomenclatural, and distributional updates in *Casselia* (Verbenaceae):
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3. Plants with leaves not sprawling on the ground; adaxial surface smooth or slightly bullate; calyx tube green with purplish teeth ***C. confertiflora***
- 3'. Plants rosette-like with some leaves appressed or close to the ground; adaxial surface strongly bullate; calyx tube and teeth purplish ***C. rosularis***
4. Leaf margin often entire or sometimes obscurely dentate at the apex 5
- 4'. Leaf margin conspicuously dentate, serrate or crenate-serrate 6
5. Tortuous branches, cortex not exfoliated at maturity; petiole 0.5–3 cm long (Plants from the Atlantic Forest domain) ***C. integrifolia***
5. Straight branches, cortex exfoliated at maturity; petiole 0.1–0.2 cm long (Plants from the Caatinga domain)
..... ***C. zelota***
6. Plants densely branched towards the apex, with branchlets; calyx teeth 0.05–0.1 cm long (Plants from the Atlantic Forest domain, endemic from Bahia state) ***C. serrata***
- 6'. Plants branched at the base, without branchlets; calyx teeth 0.15–0.25 cm long (Plants from the Cerrado domain, not found in Bahia state) 7
7. Branches glabrous or puberulent; racemes with peduncle 1.5–4.5 cm long, usually surpassing the leaves
..... ***C. chamaedryfolia***
- 7'. Branches strigose-pubescent; racemes with peduncle 0.8–1.2, not surpassing the leaves ***C. glaziovii***

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