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Verbenaceae in Emas National Park (Goiás state, Central Brazil), with a focus on chromatic variation in the corollas of *Lippia filifolia*

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Abstract. Emas National Park is a critical region for the conservation of biodiversity in the Cerrado domain, yet its flora remains insufficiently studied from a taxonomic perspective. To enhance taxonomic and biogeographic knowledge of Verbenaceae in the Brazilian Central Plateau and to support ongoing conservation efforts, we provide a synopsis, photographs, and an identification key for the taxa occurring in this protected area. In total, 12 taxa belonging to three genera were recorded, with *Lippia stachyoides* var. *guajajarana* being endemic to the Park. This study focused on documenting the chromatic variation in the corollas of *Lippia filifolia*. While specimens from the Espinhaço Range and Serra da Canastra (Minas Gerais state) exhibit yellow corollas, those from Emas National Park (Goiás state) display red coloration, an uncommon trait within the genus.

Keywords: Cerrado, Lantaneae, protected areas, taxonomy.

INTRODUCTION

Our current knowledge about biodiversity stems from the extensive efforts by naturalists and, more specifically, taxonomists, who have historically undertaken and continue to carry out field expeditions to explore nature and describe new taxa, offering crucial information on the ecology, evolution and distribution of species (Godfray and Knapp 2004; Löbl et al. 2023). In the 21st century, human activities have become the main threat to biodiversity's accelerated decline, and many species are at risk of extinction (Brooks et al. 2002; Pimm et al. 2014; Lughadha et al. 2020). Notably, the success of conservation strategies is closely linked to the expansion of taxonomic knowledge (McNeely 2002).

Data on species richness, endemism, rarity, and extinction risk are crucial for identifying priority areas for conservation and result from comprehensive taxonomic research and exploratory collection efforts (Mace 2008; Morrison et al. 2009; Mittermeier et al. 2004). In this context, megadiverse countries like Brazil, where Linnaean and Wallacean deficits are particularly pronounced, rely heavily on basic taxonomic research to develop effective conservation strategies (Martinelli 2007; Fonseca and Venticinque 2018).

Verbenaceae are an important component of the Brazilian flora, represented by 15 genera and 301 species, 194 of which are exclusive (Salimena et al. 2024). Several species within this family have fascinated naturalists over the centuries due to the striking beauty of their inflorescences and flowers, such as *Duranta erecta* L., *Lantana camara* L., and *Petrea volubilis* L., which are widely cultivated for ornamental purposes (Lorenzi and Souza 2001). *Lippia alba* (Mill.) N.E.Br. ex Britton & P.Wilson stands out as one of the most popular species of the family, and it is widely utilized in the pharmaceutical industry and popular medicine (Aguiar 2005; Costa et al. 2017). However, most species in the family are unknown or poorly known in terms of their potential uses, and this is partly due to their restricted distributions, primarily in remote and hard-to-access areas, such as the *campos rupestres* (rupestrian grasslands) of the Espinhaço Range (Cardoso et al. 2024a; Salimena et al. 2024).

Floristic studies on Verbenaceae have been conducted mainly in protected areas of Brazil's Southeast region, particularly those characterized by the presence of *campos rupestres* and *campos de altitude* (high-altitude grasslands), which are key habitats with the highest concentration of species (e.g., Salimena-Pires and Giulietti 1998; Cruz and Salimena 2017; Cardoso et al. 2020a; Santiago et al. 2020; Ribeiro et al. 2022; Silva et al. 2023). Furthermore, taxonomic treatments have been carried out at a regional level, including for the Distrito Federal (Salimena et al. 2015), the states of Goiás and Tocantins (Salimena et al. 2016), and the state of Espírito Santo (Cardoso et al. 2021). Such studies have provided essential data for the systematics and biogeography of Verbenaceae, besides contributing to advancing conservation efforts in the areas studied. The taxonomic treatment of Verbenaceae in the Serra da Canastra National Park in Minas Gerais state, for example, led to the discovery and description of a new species, *Stachytarpheta grandiflora* P.H.Cardoso & Salimena (Cardoso et al. 2019a, 2020b). Similarly, the taxonomic treatment for the Caparaó National Park, situated on the border between the states of Minas Gerais and Espírito Santo, resulted in the discovery of *Lantana caudata* P.H.Cardoso & Salimena

and *Lippia mantiqueirae* P.H.Cardoso & Salimena (Cardoso et al. 2019b, c, d). Additionally, the study of Verbenaceae in Serra Negra, in the state of Minas Gerais, extended the distribution of *Stachytarpheta mexiae* Moldenke, with its first record in the Atlantic Forest domain (Cardoso et al. 2018).

Continuing the floristic studies on Verbenaceae in Brazil, we present here a synopsis of the taxa found in Emas National Park (hereafter ENP), emphasizing the record of *Lippia filifolia* Mart. & Schauer with red corollas. Previously, this species was documented only with yellow corollas (Salimena et al. 2016; Salimena & Cardoso 2024). This study includes description of the diagnostic characteristics of each taxon, an identification key, photographs, and a map displaying the updated distribution of *Lippia filifolia*. ENP stands out as a critical area for botanical research, underscored by the discovery of several taxa within its boundaries (Filgueiras et al. 1999; Arbo 2002; Devecchi et al. 2018; Moreira et al. 2018; Cardoso et al. 2020c). Despite its recognized biological importance, the flora of the Park remains taxonomically underexplored. In this context, Batalha and Martins (2002), who conducted the first vascular flora survey in ENP, stated: "We emphasize the need for more floristic survey in which the frequently overlooked herbaceous component should also be sampled."

MATERIALS AND METHODS

The ENP, created in 1961, is a fully protected area within the Cerrado domain (Batalha and Martins 2002; MMA 2004). It is situated on the Brazilian Central Plateau, spanning 131.864 hectares between the latitudes 17°49' and 18°28'S, and longitudes 52°39' and 53°10'W (Figure 1A, B), with altitudes that do not exceed 900 meters. The Park covers parts of the municipalities of Mineiros and Chapadão do Céu in the southeastern portion of Goiás state, as well as the municipality of Costa Rica in the state of Mato Grosso do Sul (MMA 2004). Open cerrado physiognomies – *campo limpo*, *campo sujo* (a shrub savanna), and *campo cerrado* (a savanna woodland) are the most common types of vegetation in the ENP, covering about 80% of the total area, but it also includes Seasonal Semideciduous Forest and wetland ecosystems, such as *veredas* and floodplain grasslands (*campos úmidos*) (Batalha and Martins 2002; MMA 2004; Batalha and Martins 2007; França et al. 2007). The geological features of the ENP consist of uniform sediment deposits interspersed with volcanic rocks, all part of the Paraná sedimentary basin (MMA 2004). The soils comprise sandstone or basalt, predominantly dark-

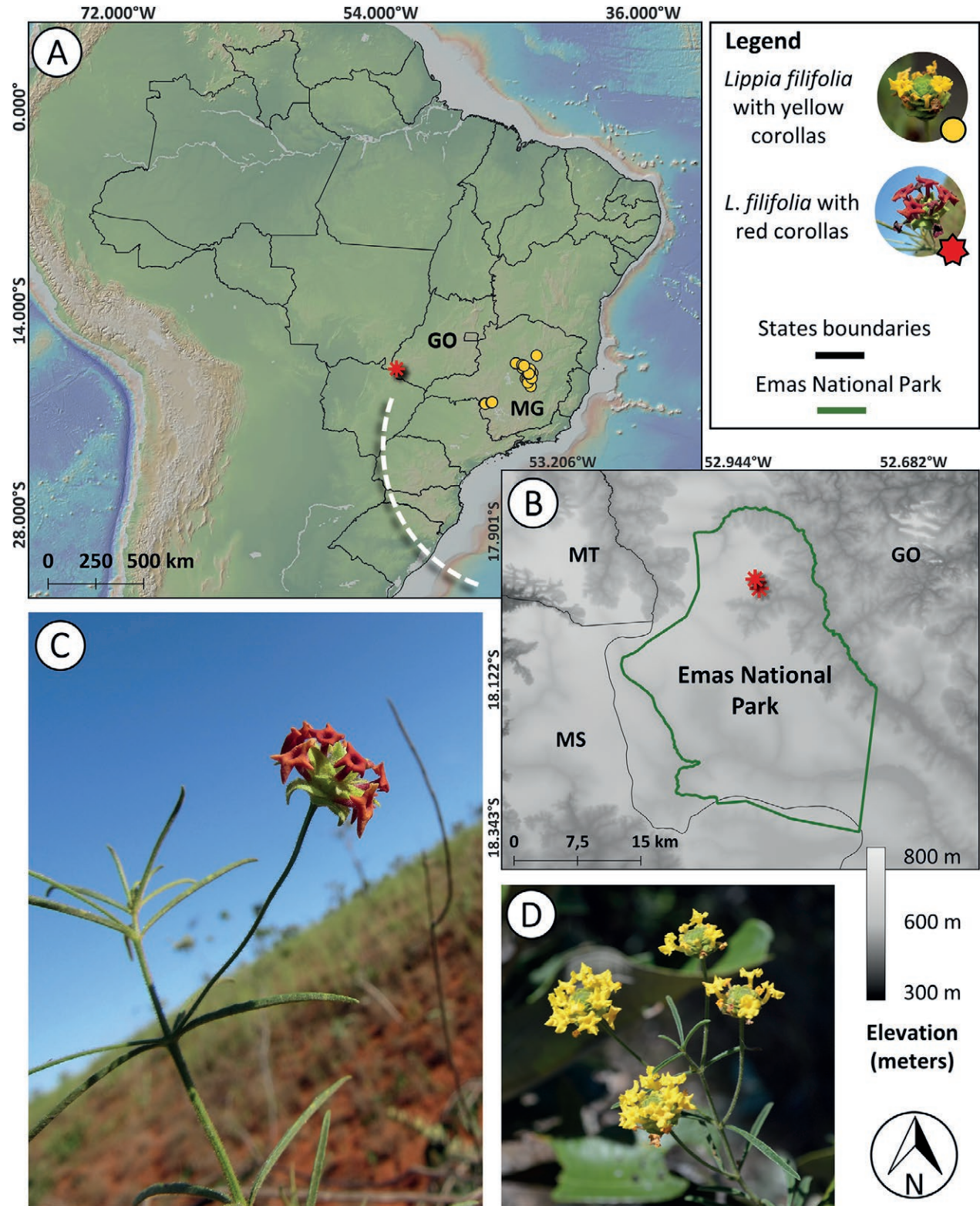


Figure 1. Geographic distribution of *Lippia filifolia* and boundaries of Emas National Park. (A) displays the overall distribution of *Lippia filifolia* in Brazil (GO = Goiás state and MG = Minas Gerais state). (B) shows the occurrence of *Lippia filifolia* in Goiás state within Emas National Park (GO = Goiás state, MT = Mato Grosso state, and MS = Mato Grosso do Sul state). (C and D) photographs of *Lippia filifolia* individuals showcasing the variation in corolla color. Photo C by Isa Lucia de Moraes and D by Vinicius Dittrich.

red latosols, red-yellow latosols, quartz sands, lithologic and cambisols (MMA 2004). According to Köppen classification, the climate of the ENP is characterized as wet tropical savanna (Aw), marked by distinct wet and dry seasons, with a rainy summer and a dry winter lasting approximately six months (Ramos-Neto and Pivello 2000). The annual precipitation ranges from 1,200 to 2,000 mm, concentrated between September and March, with an average annual temperature of 24.6°C (Ramos-Neto and Pivello 2000; MMA 2004).

The last author conducted field expeditions in the ENP from June 2023 until September 2024, with intervals of one to two months between them. Each expedition spanned three consecutive days of collections. Various areas of the Park were explored using a non-systematic walking method (Filgueiras et al. 1994), with open cerrado physiognomies being the main vegetation types surveyed. The collected specimens were deposited at JAR herbarium (acronyms following Thiers 2024). For the synopsis of Verbenaceae, we examined high-resolution images of herbarium specimens available through the REFLORA (<http://reflora.jbrj.gov.br>) and the *speciesLink* (<http://splink.cria.org.br>), along with physical collections from the CESJ, JAR, RB, SP, and SPF herbaria (acronyms following Thiers 2024). The first author carried out taxonomic identifications by analyzing protologues, type specimens, and key literature of Verbenaceae. Descriptive terminology was based on Harris and Harris (2003), Gonçalves and Lorenzi (2007), Beentje (2010) and in the Verbenaceae key literature. Information on the species' distribution was based on field observations, specimen labels and literature (e.g. Salimena et al. 2016; Cardoso et al. 2020c; Salimena et al. 2024). The identification key was developed by analyzing specimens collected within the Park and field observations, supplemented by key literature and examining additional specimens.

RESULTS AND DISCUSSION

In Emas National Park, Verbenaceae are currently represented by 12 taxa included in three genera: *Casselia* Nees & Mart. (1 sp.), *Lippia* L. (9 taxa), and *Stachytarpheta* Vahl (2 spp.). Batalha and Martins (2002) surveyed the vascular flora of the ENP based on gatherings made between November 1998 and October 1999, documenting 601 species belonging to 303 genera and 80 families. The authors recorded 13 species of Verbenaceae: *Aegiphila lanata* Moldenke, *Aegiphila lhotzkiana* Cham., *Amasonia hirta* Benth, *Casselia chamaedryfolia* Cham., *Lippia hirta* (Cham.) Meisn. ex D. Dietr., *Lippia hoehnei* Moldenke, *Lippia lupulina* Cham., *Lippia martiana* Schauer,

Lippia primulina S.Moore, *Lippia stachyoides* Cham., *Lippia turnerifolia* Cham., *Stachytarpheta maximilianii* Schauer, and *Stachytarpheta simplex* Hayek. However, the first three species are now classified under Lamiaceae, with *Aegiphila lanata* and *Aegiphila lhotzkiana* currently regarded as synonyms of *Aegiphila verticillata* Vell. (França 2024). Furthermore, based on the analysis of the vouchers, some species represent misidentifications: *Casselia chamaedryfolia* was reidentified as *Casselia glaziovii* (Briq. & Moldenke) Moldenke; the specimen identified as *Lippia hirta* is the holotype of *Lippia stachyoides* var. *guajajarana* P.H.Cardoso & Salimena; *Lippia lupulina* was reidentified as *Lippia primulina* S.Moore; and *Lippia turneraefolia* as *Lippia nana* Schauer. Additionally, *Stachytarpheta maximilianii* and *Stachytarpheta simplex* are heterotypic synonyms of *Stachytarpheta cayennensis* (Rich.) Vahl and *Stachytarpheta gesnerioides* Cham., respectively.

Most of the Verbenaceae taxa recorded in the present study are endemic to the Cerrado domain in Brazil (Salimena et al. 2024), with *Lippia stachyoides* var. *guajajarana* being endemic to the Park, known from only two gatherings, and likely threatened with extinction (Cardoso et al. 2020c). However, some species, such as *Lippia organoides* Kunt and *Stachytarpheta cayennensis*, exhibit a wide distribution across the Americas (Salimena et al. 2024). *Lippia organoides* was not documented in the ENP by Batalha and Martins (2002). It is an intriguing species complex, currently with 29 heterotypic synonyms, and requires further investigation to reevaluate its taxonomic boundaries (O'Leary et al. 2012; Cardoso and Santos-Silva 2022). The same applies to *Lippia stachyoides*, which currently encompasses three varieties. These taxa belong to the *Lippia* sect. *Goniostachyum* Schauer, which is characterized by having tetrastichous floral bracts (Schauer 1847; O'Leary et al. 2012). Future taxonomic studies aiming to delimit taxa within this section may uncover new arrangements, potentially reshaping the diversity of Verbenaceae in the ENP.

Another taxon not recorded in ENP by Batalha and Martins (2002) is *Lippia filifolia*. It is a sticky subshrub or shrub densely covered by glandular trichomes, with filiform leaves, entire at margins, hypodromous venation, many-flowered inflorescences, green and ovate bracts, and yellow corollas that sometimes can turn slightly orange after maturity (Salimena et al. 2016; Salimena and Cardoso 2024, Fig. 1D). This species has been recorded from various localities in Minas Gerais state, particularly along the Espinhaço Range and in the Serra da Canastra region (Cardoso et al. 2020a,b; Salimena and Cardoso 2024, Fig. 1A). However, Salimena et al. (2016) reported its first occurrence in the state of

Goiás based on a single specimen from the ENP (*T.S. Filgueiras 2314*), collected in 1992. Notably, this record expanded the known distribution of *Lippia filifolia* to its westernmost limit (Fig. 1A). It is important to emphasize that the label of this specimen includes the following field note: “erect herb with reddish flowers. Locally rare.” Despite this, Salimena et al. (2016) described the corollas of *Lippia filifolia* as yellow, overlooking the red coloration observed in the species. Furthermore, the distribution of *Lippia filifolia* in Goiás state has not been documented by Salimena and Cardoso (2024). Recently, a subpopulation of *Lippia filifolia* from ENP was found, and new gatherings were made (voucher *I.L. Morais 10092*). This subpopulation contained dozens of individuals with red corollas (Fig. 1C), as previously reported on the label of the specimen *T.S. Filgueiras 2314*. However, until then, this trait had not been included in taxonomic descriptions of the species (Salimena et al. 2016; Salimena and Cardoso 2024).

The observation of *Lippia filifolia* with red corollas in ENP holds both taxonomic and ecological significance, offering new insights into the species’ variation and potentially its adaptation to local environments. Within *Lippia*, red corollas are uncommon. To date, only *Lippia macrophylla* Cham. is known to have red bracts and corollas (Salimena and Cardoso 2024). Overall, the presence of red corollas is more common within *Lantana* L., as seen in *Lantana camara*, *Lantana caudata*, and *Lantana tiliaefolia* Cham. (Cardoso et al. 2021; Silva et al. 2024). Regarding this, it is important to note that both *Lantana* and *Lippia* are not monophyletic, and in the future, they may be treated as a single genus, or several smaller genera could be segregated (Lu-Irwing et al. 2021). The significant morphological similarity shared between these two genera, along with the difficulty in separating them, suggests that a single, larger genus might be more taxonomically appropriate.

Casselia glaziovii, *Lippia hoehnei*, *Lippia nana*, and *Lippia primulina* have xylopodium and were collected after the passage of fire in the ENP. According to Ramos-Neto and Pivello (2000) and França et al. (2007), the biodiversity within ENP, as it exists today, reflects a long history of coexistence with fire. This ecological phenomenon is highly complex, influenced by historical processes, demographic and phenological traits of plant populations, nutrient and water dynamics, and the physical characteristics of the environment (Coutinho 1982; Antar et al. 2022). While natural fire plays an important role in promoting biodiversity within the Cerrado domain, human-induced fires can lead to local biodiversity loss (Durigan and Ratter 2015). Between 1973 and 1994, large-scale anthropogenic fires dominated in the

ENP, with uncontrollable fires affecting its entire area in both 1978 and 1994 (França et al. 2007). Currently, controlled fire is frequently employed in the ENP as a management tool (*I.L. Morais*, personal observation). This underscores the importance of conducting periodic collections of the park’s flora to document its species richness and advancing conservation efforts aimed at maintaining its ecological integrity.

TAXONOMIC TREATMENT

Identification key for the taxa of Verbenaceae in the Emas National Park

1. Flowers pedicellate; corollas funnelform, with purplish nectar guides; fruits partially covered by the persistent and enlarged calyx *Casselia glaziovii*
1. Flowers sessile; corollas tubulose, usually with a coloured throat; fruits fully covered by the persistent and enlarged calyx 2
2. Flowers with conspicuous calyces; corollas not bilabiate; androecium with 2 fertile stamens and 2 staminodes, thecae divergent 3
2. Flowers with inconspicuous calyces; corollas bilabiate; androecium with 4 fertile stamens, thecae parallel 4
3. Branches not winged; calyces 4-toothed, immersed in the depressions of the rachis; corollas barely exerted from the calyces, tube 0.5–1 cm long, slightly curved, with a lilac or white throat *Stachytarpheta cayennensis*
3. Branches usually winged; calyces 5-toothed, free; corollas well-exserted from the calyces, tube 1.3–2 cm long, bent, with a yellow throat *Stachytarpheta gesnerioides*
4. Corollas yellow, orange, or red 5
4. Corollas pink, lilac, white, or cream 6
5. Monoecious subshrubs or shrubs 0.5–1 m tall; leaf blades filiform with hypodromous venation *Lippia filifolia*
5. Dioecious subshrubs up to 20 cm tall; leaf blades oblanceolate or obovate with pinnate venation *Lippia nana*
6. Inflorescence 1–2 per leaf axil or forming panicles; bracts spiraled and broad (> 0.6 cm wide), all free 7
6. Inflorescences 2 or more per leaf axil; bracts tetrastichous and narrow (< 0.5 cm wide), the basal ones connate 9
7. Leaves petiolate, concentrated at the apex of the branches, strongly bullate on adaxial surface *Lippia lindimannii*
7. Leaves sessile or subsessile, well distributed along the branches; slightly bullate on adaxial surface 8

8. Shrubs 1–1.7 m tall; inflorescences 1–2 per leaf axil or forming panicles; bracts with acute, acuminate, or caudate apices *Lippia hoehnei*
- 8'. Shrubs ca. 0.4 m tall; inflorescences 1 per leaf axil; bracts with obtuse or rounded apices *Lippia primulina*
9. Leaves opposite, with similar size along the branches, with those subtending the inflorescences not reduced
..... *Lippia organoides*
- 9'. Leaves 3–4-verticillate and opposite, decreasing in size from the base towards the apex, with those subtending the inflorescences becoming reduced 10
10. Branches densely lanate-tomentose; bracts lanceolate or linear, 0.5–0.7 cm long, apices acuminate or caudate; corolla tubes 0.6–0.8 cm long
..... *Lippia stachyoides* var. *stachyoides*
- 10'. Branches sparsely or densely strigose; bracts ovate or broad-ovate, 0.25–0.3 cm long, apices acute or obtuse; corolla tubes 0.25–0.45 cm long 11
11. Leaf blades cuneate at bases, both surfaces minutely strigose or puberulent, abaxial surface not canescent
..... *Lippia stachyoides* var. *guajajarana*
- 11'. Leaf blades cordate, rounded, obtuse, or truncate at bases, adaxial surface velutinous, abaxial surface tomentose-canescens *Lippia stachyoides* var. *martiana*

1. *Casselia glaziovii* (Briq. & Moldenke) Moldenke, Phytologia 5: 132. 1955. (Fig. 2A).

It is characterized by its subshrub habit with xylopodium; strigose-pubescent branches; entire leaf blades, conspicuously dentate or crenate-serrate at margins; racemes with 4 or less flowers, well-distributed along the branches, with peduncles measuring 0.8–1.2 cm in length, these not surpassing the leaves; pedicellate flowers; calyx teeth measuring 0.15–0.25 cm in length; funnelform, lilac corollas adorned with purplish nectar guides; and drupaceous fruits partially covered by the persistent and enlarged calyces. It is endemic to Brazil, occurring in the Distrito Federal, Goiás, and Minas Gerais, within the Cerrado domain (O'Leary et al. 2024; Cardoso et al. 2024b). In ENP, *Casselia glaziovii* was found in burned *campo limpo*.

Specimens examined

BRAZIL. Goiás. Chapadão do Céu, Parque Nacional das Emas, 1 km do portão Jacuba, 11 October 2006, *J. Paula-Souza et al.* 8391 (SPF); Chapadão do Céu, Parque Nacional das Emas, 5 October 1999, *M.A. Batalha* 3908 (CESJ); Mineiros, Parque Nacional das Emas, 3 km do

portão Jacuba (17°55'05,42" S, 53°00'27,04" W), 08 September 2023, *I.L. Morais* 8898 (JAR), 13 km do portão Jacuba (17°54'34,99" S, 53°00'13,37" W), 3 October 2023, *I.L. Morais* 9006 (JAR), 25 km do portão Jacuba (18°00'16,57" S, 52°56'31,97" W), 19 April 2024, *I.L. Morais* 9765 (JAR).

2. *Lippia filifolia* Mart. & Schauer, Prodr. [A. P. de Candolle] 11: 586. 1847. (Figs. 1C, 2B).

It is characterized as monoecious subshrubs or shrubs 0.5–1 m tall, with abundant glandular trichomes on branches, leaves, and bracts; sticky, sessile leaves; filiform leaf blades, entire at margins, with hypodromous venation; spikes 1 per leaf axil; bracts measuring 0.3–4 × 0.3 cm, spiraled, free, green, ovate, acute or obtuse at apices; sessile flowers with inconspicuous calyces; bilabiate, tubulose, yellow, orange or red corollas, androecium with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. It is endemic to Brazil, occurring in the states of Goiás and Minas Gerais, within the Cerrado domain (Salimena et al. 2016; Salimena and Cardoso 2024). In ENP, *Lippia filifolia* was found with red corollas growing in *campo limpo* and *campo sujo*.

Specimens examined

BRAZIL. Goiás. Mineiros, Parque Nacional das Emas, 27 April 1992, *T.S. Filgueiras* 2314 (CESJ, IBGE, RB); Mineiros, Parque Nacional das Emas, 25 km do portão Jacuba (18°00'16,57" S, 52°56'31,97" W), 22 June 2024, *I.L. Morais* 10092, 10095, 10103, 10104 (JAR).

Additional specimens examined

BRAZIL. Minas Gerais Buenópolis, Parque Estadual da Serra do Cabral, Lapa Pintada, 12 October 2002, *F.R.G. Salimena* 4134 (CESJ); Delfinópolis, Condomínio de Pedras, 17 May 2003, *R.A. Pacheco et al.* 611 (HUFU); Diamantina, 25 January 2004, *J.R. Pirani* 5279 (SPF); Diamantina, estrada Conselheiro da Mata, 3 March 2012, *A.I.M.R. Machado et al.* 91 (HUFU); Itacambira, 8 January 1986, *M. Meguro* CFCR9069 (SPF); Joaquim Felício, Serra do Cabral, *T.B. Cavalcanti* CFCR8042 (SPF); São Roque de Minas, trilha para a cachoeira da Casca D'Anta, Guarita 3, 22 November 1995, *R. Romero* 3201 (CESJ, HUFU); Santana de Pirapama, Serra do Cipó, 24 March 1982, *I. Cordeiro* CFSC9417 (SPF).

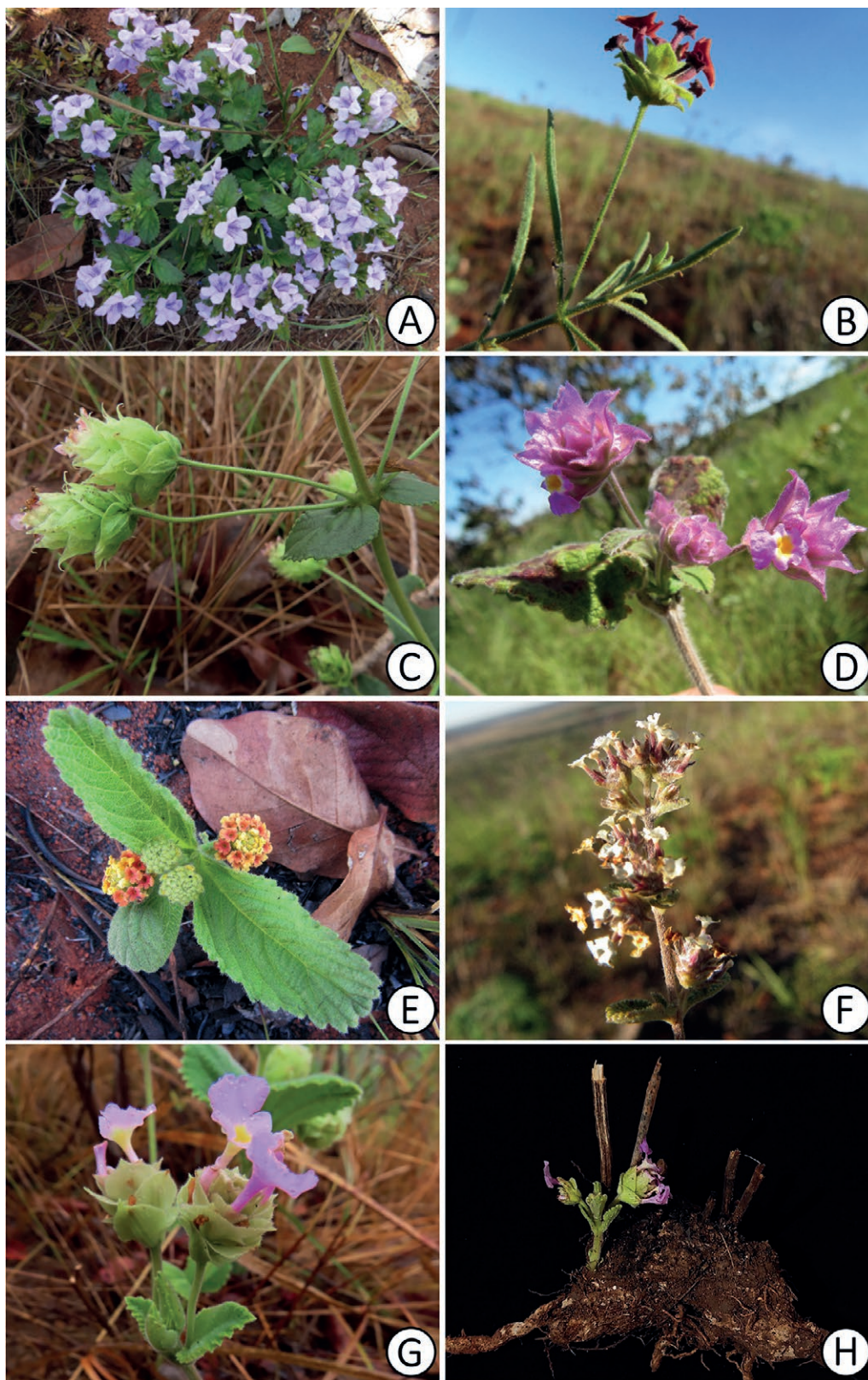


Figure 2. Photographs of Verbenaceae taxa occurring in Emas National Park, Goiás state, Brazil. (A) *Casselia glaziovii*. (B) *Lippia filifolia*. (C) *Lippia hoehnei*. (D) *Lippia lindmanii*. (E) *Lippia nana*. (F) *Lippia origanoides*. (G and H) *Lippia primulina*. Photos by Isa Lucia de Moraes.

3. *Lippia hoehnei* Moldenke, *Phytologia* 1: 467. 1940. (Fig. 2C).

It is characterized as monoecious shrubs 1–1.7 m tall, with xylopodium; leaves well distributed along the branches, sessile or subsessile; ovate or elliptic, coriaceous leaf blades, serrate or crenate at margins, slightly bullate on adaxial surface, reticulate veined and foveolate on abaxial surface; spikes 1–2 per leaf axil or forming panicles; bracts measuring $0.7\text{--}1 \times 0.8$ cm, spiraled, free, pink or green, membranaceous, ovate, acute, acuminate, or caudate at apices; sessile flowers with inconspicuous calyces; bilabiate, tubulose, pink corollas, with yellow throat, androecium with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. It is endemic to Brazil, occurring in the states of Goiás, Mato Grosso, and Mato Grosso do Sul, within the Cerrado and Amazon Forest domains (Salimena et al. 2016; Salimena and Cardoso 2024). In ENP, *Lippia hoehnei* was found with green bracts growing in burned *campo limpo*.

Specimens examined

BRAZIL. Goiás. Chapadão do Céu, Parque Nacional das Emas, 1 km do portão Jacuba, 11 October 2006, *J. Paula-Souza et al.* 8298 (SPF); Chapadão do Céu, Parque Nacional das Emas, 3 November 1998, *M.A. Batalha* 2248 (UEC); Mineiros, Parque Nacional das Emas, 17 July 1990, *H.D. Ferreira* 2315 (UFG); Mineiros, Parque Nacional das Emas, 27 km do Portão Jacuba ($17^{\circ}58'04,46''$ S, $52^{\circ}54'52,43''$ W), 30 May 2024, *I.L. Morais* 9977, 9993 (JAR); 40 km do Portão Jacuba, próximo ao ponto Y ($18^{\circ}15'19,907''$ S, $52^{\circ}53'16,636''$ W), 12 October 2024, *I.L. Morais* 10728 (JAR).

4. *Lippia lindmanii* Briq., *Ark. Bot.* 2, no. 10: 20. 1904. (Fig. 2D).

It is characterized as monoecious shrubs 0.8–3 m tall; with leaves concentrated at the apex of the branches, petiolate; ovate-elliptic or subrotund, chartaceous or coriaceous leaf blades, crenate at margins, strongly bullate on adaxial surface, often canescent on abaxial surface; spikes 1 per leaf axil; bracts measuring $0.8\text{--}1.5 \times 0.8\text{--}1$ cm, spiraled, free, pink, membranaceous, ovate or ovate-elliptic, acute or obtuse at apices; sessile flowers with inconspicuous calyces; bilabiate, tubulose, pink corollas, with yellow throat, androecium with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. It is endemic to Brazil, occurring in the states of Goiás, Mato Grosso,

and Mato Grosso do Sul, within the Cerrado and Amazon Forest domains (Salimena et al. 2016; Salimena and Cardoso 2024). In ENP, *Lippia lindmanii* was found in burned *campo limpo*.

Specimens examined

BRAZIL. Goiás. Mineiros, Parque Nacional das Emas, 36 km do portão Jacuba ($17^{\circ}59'56,278''$ S, $52^{\circ}55'19,776''$ W), 21 June 2024, *I.L. Morais* 10079, 10083 (JAR); 12 October 2024, *I.L. Morais* 10753 (JAR).

5. *Lippia nana* Schauer, *Prodr.* [A. P. de Candolle] 11: 582. 1847. (Fig. 2E).

It is characterized as dioecious subshrubs up to 20 cm tall, with xylopodium; pubescent branches; opposite and sessile leaves; oblanceolate or obovate, chartaceous leaf blades, with pinnate venation; spikes 1 per leaf axil; bracts measuring $0.3\text{--}0.5 \times 0.2$ cm, spiraled, free, green, membranaceous, lanceolate or ovate, acute at apices; sessile flowers with inconspicuous calyces; bilabiate, tubulose, yellow or orange corollas, staminate flowers with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. It is endemic to Brazil, occurring in the Distrito Federal, Goiás and Minas Gerais, within the Cerrado domain (Cardoso et al. 2020b; Salimena and Cardoso 2024). In ENP, *Lippia nana* was found in burned *campo sujo* with sandy-clay soil.

Specimens examined

BRAZIL. Goiás. Chapadão do Céu, Parque Nacional das Emas, 11 October 2006, *J. Paula-Souza* 8342 (SPF); Mineiros, Parque Nacional das Emas, próximo ao portão Jacuba, 23 October 2021, *J. Paula-Souza* 11876 (FLOR); Mineiros, Parque Nacional das Emas, 28 km do Portão Jacuba ($18^{\circ}00'16,65''$ S, $52^{\circ}56'34,64''$ W), 19 April 2024, *I.L. Morais* 9754 (JAR); 32 km do Portão Jacuba ($17^{\circ}57'50,42''$ S, $52^{\circ}54'36,37''$ W), 31 May 2024, *I.L. Morais* 10012 (JAR).

6. *Lippia origanoides* Kunth, *Nov. Gen. Sp.* [H.B.K.] 2: 267. 1818. (Fig. 2F).

It is characterized as monoecious shrubs 1–2.5 m tall; opposite leaves, well distributed along the branches, petiolate; chartaceous leaf blades, with similar size along the branches, with those subtending the inflorescences not reduced; spikes 2–10 per leaf axil; bracts measuring $0.3\text{--}0.5 \times 0.15\text{--}0.2$ cm, tetrastichous, ovate or lanceolate, green or green-reddish, membranaceous, the basal ones

connate; sessile flowers with inconspicuous calyces; bilabiate, tubulose, white or cream corollas, base of the tubes sometimes reddish, usually with yellow throat, androecium with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. It has a wide distribution across the Americas (O'Leary et al. 2012; Salimena and Cardoso 2024). In ENP, *Lippia origanoides* was found in *campo sujo*.

Specimens examined

BRAZIL. Goiás. Mineiros, Parque Nacional das Emas, 13 July 1990, *H.D. Ferreira 2513* (UFG); Mineiros, Parque Nacional das Emas, 20 km do Portão Jacuba (17°59'58,04" S, 52°56'29,84" W), 20 April 2024, *I.L. Morais 9781, 9783* (JAR); 28 km do Portão Jacuba (18°0'3,964" S, 52°55'59,357" W), 31 May 2024, *I.L. Morais 10014, 10021, 10038, 10045* (JAR); 25 km do Portão Jacuba (17°57'56,34" S, 52°54'50,55" W), 02 August 2024, *I.L. Morais 10330* (JAR).

7. *Lippia primulina* S.Moore, Trans. Linn. Soc. London, Bot. ser. 2, 4: 436 (1895). (Fig. 2G, H).

It is characterized as monoecious shrubs ca. 0.4 m tall, with xylopodium; leaves well distributed along the branches, subsessile; ovate or subrotund, subcoriaceous leaf blades, crenate-serrate at margins, slightly bullate on adaxial surface; spikes 1 per leaf axil; bracts measuring 0.7–1.2 × 0.8–1.5 cm, spiraled, free, green or pink, membranaceous, ovate or subrotund, obtuse or rounded at apices; sessile flowers with inconspicuous calyces; bilabiate, tubulose, pink corollas, with yellow throat, androecium with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. In ENP, *Lippia primulina* was found with green bracts growing in burned *campo limpo*.

Specimens examined

BRAZIL. Goiás. Mineiros, Parque Nacional das Emas, 28 km do Portão Jacuba (18°0'11,209"S, 52°55'54,378" W), 31 May 2024, *I.L. Morais 10039* (JAR); 25 km do portão Jacuba, 21 September 2024, *I.L. Morais 10627, 10647* (JAR); 35 km do portão Jacuba, 10 October 2024, *I.L. Morais 10708, 10709, 10710, 10714, 10727* (JAR).

8. *Lippia stachyoides* var. *guajajarana* P.H.Cardoso & Salimena, Phytotaxa 447(4): 284. 2020.

It is characterized as monoecious shrubs ca. 0.6 m tall, with the main branches developing secondary

branches apically; sparsely strigose branches; 3-verticillate and opposite leaves, decreasing in size from the base towards the apex, with those subtending the inflorescences becoming reduced; oblong or narrow-elliptic leaf blades, cuneate at bases, minutely strigose or puberulent on both surfaces; spikes 4-5 per leaf axil; bracts measuring 0.25–0.3 × 0.1–0.2 cm, tetrastichous, green, membranaceous, ovate or broad-ovate, the basal ones connate, acute or obtuse at apices; sessile flowers with inconspicuous calyces; bilabiate, tubulose, white corollas, tubes 0.25–0.35 cm long, androecium with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. It is endemic to the ENP, Cerrado domain (Cardoso et al. 2020c). In ENP, *Lippia stachyoides* var. *guajajarana* was found in *campo sujo*.

Specimens examined

BRAZIL. Goiás. Chapadão do Céu e Mineiros, Parque Nacional das Emas, 10 December 1998, *M.A. Batalha 2415* (CESJ); Chapadão do Céu e Mineiros, Parque Nacional das Emas, 4 February 1999, *M.A. Batalha 2922* (SP).

9. *Lippia stachyoides* var. *martiana* (Schauer) Salimena & Múlgura, Bot. J. Linn. Soc. 170(2): 215. 2012. (Fig. 3A).

It is characterized as monoecious shrubs 0.8–2 m tall, with the main branches developing numerous secondary branches apically; densely strigose branches; 3-verticillate and opposite leaves, decreasing in size from the base towards the apex, with those subtending the inflorescences becoming reduced; ovate, broad-ovate, subrotund, or rarely oblong leaf blades, cordate, rounded, obtuse, or truncate at bases, velutinous on adaxial surface and tomentose-canescens on abaxial surface; spikes 3-8 per leaf axil; bracts measuring 0.2–0.3 × 0.2–0.3 cm, tetrastichous, green, membranaceous, broad-ovate, the basal ones connate, acute at apices; sessile flowers with inconspicuous calyces; bilabiate, tubulose, white corollas, tubes 0.3–0.45 cm long, androecium with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. It is endemic to Brazil, found in Distrito Federal, Goiás, and Minas Gerais, within the Atlantic Forest and Cerrado domains (O'Leary et al. 2012; Salimena and Cardoso 2024). In ENP, *Lippia stachyoides* var. *martiana* was found in *campo sujo*.

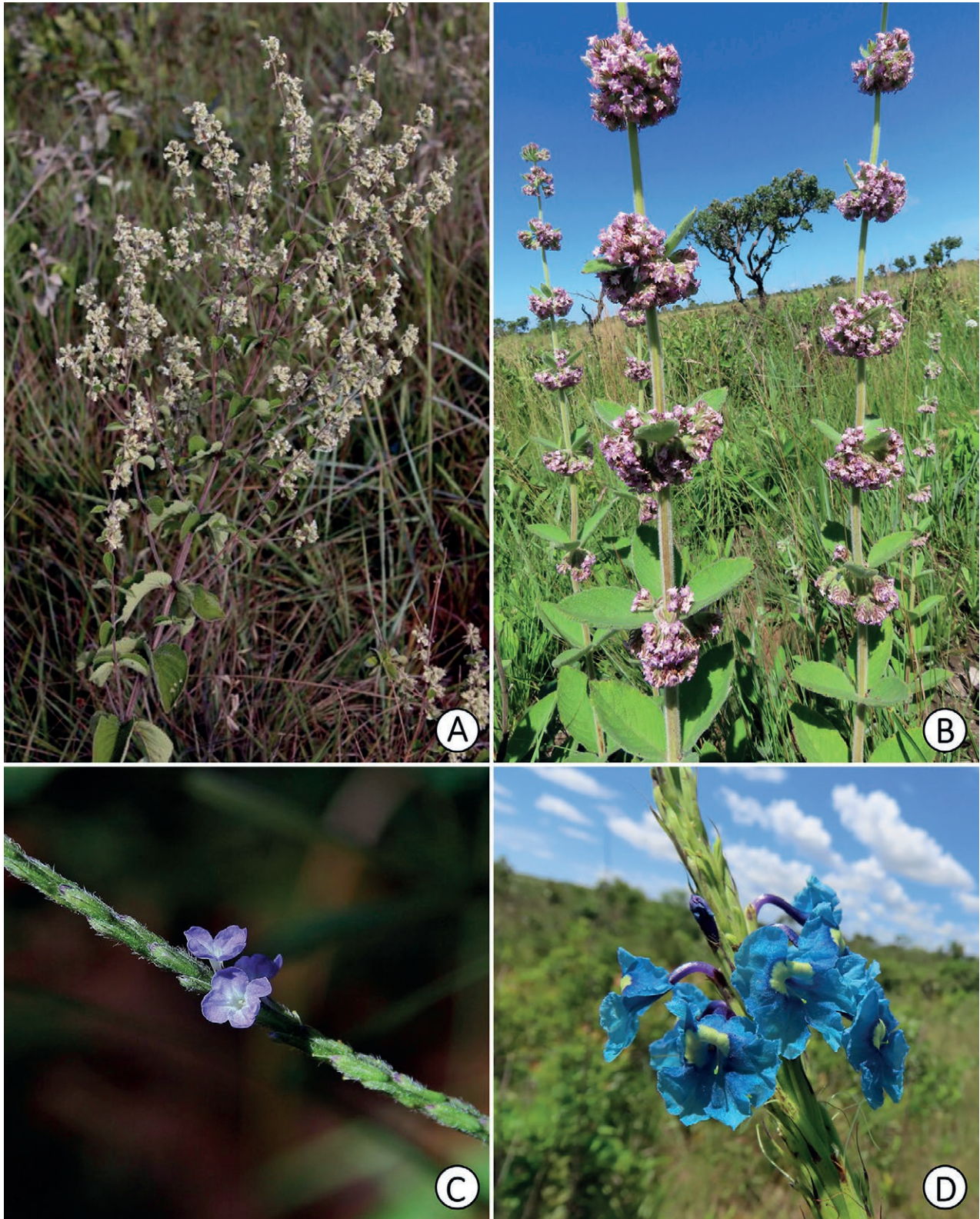


Figure 3. Photographs of Verbenaceae taxa occurring in Emas National Park, Goiás state, Brazil. (A) *Lippia stachyoides* var. *martiana*. (B) *Lippia stachyoides* var. *stachyoides*. (C) *Stachytarpheta cayennensis*. (D) *Stachytarpheta gesnerioides*. Photos A and C by Maurício Mercadante, B and E by Isa Lucia de Moraes.

Specimens examined

BRAZIL. Goiás. Chapadão do Céu e Mineiros, Parque Nacional das Emas, 3 November 1998, M.A. Batalha 2254 (CESJ). Mineiros, Parque Nacional das Emas, 18 February 1990, H.D. Ferreira 2519 (UFG).

10. *Lippia stachyoides* Cham. var. *stachyoides*, Linnaea 7(2): 227. 1832. (Fig. 3B).

It is characterized as monoecious shrubs 0.3–1 m tall, often unbranched; densely lanate-tomentose branches; 3–4-verticillate and opposite leaves, decreasing in size from the base towards the apex, with those subtending the inflorescences becoming reduced; ovate or elliptic leaf blades, cuneate or attenuate, rarely obtuse at bases, lanate-tomentose on adaxial surface and densely lanate-tomentose and canescent on abaxial surface; spikes 4–12 per leaf axil; bracts measuring $0.5\text{--}0.7 \times 0.05\text{--}0.15$ cm, tetrastichous, green-purplish, membranaceous, linear or lanceolate, the basal ones connate, caudate at apices; sessile flowers with inconspicuous calyces; bilabiate, tubulose, often lilac or purplish, rarely white corollas, tubes 0.6–0.8 cm long, androecium with 4 fertile stamens, parallel thecae; and schizocarp fruits fully covered by the persistent and enlarged calyx. It is endemic to Brazil, occurring in the states of Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, and São Paulo, within the Cerrado domain (O’Leary et al. 2012; Salimena and Cardoso 2024). In ENP, *Lippia stachyoides* var. *stachyoides* was found in *campo sujo*.

Specimens examined

BRAZIL. Goiás. Mineiros, Parque Nacional das Emas, 8 km do Portão Jacuba ($17^{\circ}55'40,40''\text{S}$, $52^{\circ}58'04,72''\text{W}$), 16 February 2024, I.L. Morais 9513 (JAR).

11. *Stachytarpheta cayennensis* (Rich.) Vahl, Enum. Pl. [Vahl] 1: 208. 1804. (Fig. 3C).

It is characterized by its not winged branches; opposite and petiolate leaves; membranaceous leaf blades; terminal spikes; sessile flowers with conspicuous calyces, immersed in the depressions of the rachis, 4-toothed; 5-lobed, not bilabiate corollas, tubes 0.5–1 cm long, slightly curved, barely exerted from the calyces, lilac or white with a lilac or white throat, androecium with 2 fertile stamens and 2 staminodes, thecae divergent; and schizocarp fruits fully covered by the persistent and enlarged calyx. It has a wide distribution across the

Americas (Atkins 2005). In ENP, *Stachytarpheta cayennensis* was found in anthropized areas.

Specimens examined

BRAZIL. Goiás. Chapadão do Céu e Mineiros, Parque Nacional das Emas, 10 December 1998, M.A. Batalha 2401 (CESJ).

12. *Stachytarpheta gesnerioides* Cham., Linnaea 7(2): 245. 1832. (Fig. 3D).

It is characterized by its winged branches; opposite and sessile leaves; coriaceous leaf blades; terminal spikes; sessile flowers with conspicuous calyces, not immersed in the depressions of the rachis, 5-toothed; 5-lobed, not bilabiate corollas, tubes 1.3–2 cm long, bent, with a yellow throat, well-exserted from the calyces, blue with a yellow throat, androecium with 2 fertile stamens and 2 staminodes, thecae divergent; and schizocarp fruits fully covered by the persistent and enlarged calyx. It occurs in South America (Atkins 2005). In ENP, *Stachytarpheta gesnerioides* was found in *campo limpo*.

Specimens examined

BRAZIL. Goiás. Chapadão do Céu e Mineiros, Parque Nacional das Emas, 7 March 1999, M.A. Batalha 2968 (CESJ); Mineiros, Parque Nacional das Emas, próximo ao Rio Formoso, 15 February 1995, J.B. Cassimiro 30 (CESJ); Mineiros, Parque Nacional das Emas, 30 October 2001, H.D. Ferreira et al. 2515 (UFG); Mineiros, Parque Nacional das Emas, 6 km do Portão Jacuba ($17^{\circ}55'32,30''\text{S}$, $52^{\circ}58'10,26''\text{W}$), 27 January 2024, I.L. Morais 9308 (JAR); 8 km do Portão Jacuba ($17^{\circ}55'40,40''\text{S}$, $52^{\circ}58'04,72''\text{W}$), 16 February 2024, I.L. Morais 9513 (JAR); 5 km do Portão Jacuba ($17^{\circ}55'29,55''\text{S}$, $52^{\circ}58'16,52''\text{W}$), 17 February 2024, I.L. Morais 9551 (JAR).

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