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Research article

A morphometric approach and recircumscription of the *Stachytarpheta longispicata* complex (Verbenaceae)

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Abstract. The *Stachytarpheta longispicata* complex is a group of seven accepted infraspecific taxa endemic to the Brazilian Cerrado, defined by its pedicellate flowers with salmon or dark red corollas. Due to the great morphological variation and very brief original descriptions, these taxa have controversial circumscriptions. We evaluated the morphological variation through the morphometric analysis of 11 natural populations in addition to nomenclatural types to assess the current infraspecific circumscriptions and clarify the limits of these taxa. A set of 36 continuous vegetative and reproductive characters was measured for each of the 115 specimens sampled, encompassing the morphological variability in the group and its geographic distribution. A compiled data matrix formed the basis for the multivariate analysis (UPGMA, PCA, and DA). Our results recovered five consistent groups corresponding to the four subspecies, and all three recognised varieties treated in the same morphological group. Quantitative and qualitative characters not previously studied in detail are important to delimit the five groups. A taxonomic rearrangement is proposed for the complex, circumscribing five distinct species: *Stachytarpheta brevibracteata*, *S. longipedicellata*, *S. longispicata*, *S. minasensis*, and *S. ratteri*. The taxonomic treatment includes four new combinations and names at new rank, two new synonyms, and one lectotype. Descriptions, an identification key, geographical distribution map, illustrations, and provisional conservation assessments are also provided.

Keywords. Brazilian Cerrado, circumscription, conservation, Duranteae, species boundaries.

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Introduction

Stachytarpheta Vahl is the second largest genus of Verbenaceae J.St.-Hil., consisting of ca 120 species of herbs, sub-shrubs and shrubs (Cardoso *et al.* 2021b), with high endemism in Brazil (76 spp.) (Atkins 2005; Cardoso & Salimena 2020; Cardoso *et al.* 2021a). Phylogenetic studies have recovered the genus as monophyletic (Marx *et al.* 2010), with the androecium with two fertile stamens and two staminodia as its morphological synapomorphy (O'Leary *et al.* 2012a). Its members are between 0.2 and 4 m tall, with opposite or verticillate leaves, terminal inflorescences, bracteate, flowers embedded or not in the rachis, corolla frequently blue, pollen grains tricolpate with verrucose exine, and the fruit a schizocarp splitting into two cluses at maturity (Atkins 2005).

Pohl (1827) described *Melasanthus* Pohl in the Verbenaceae based on six species from Central Brazil. Among them, *M. longespicatus* Pohl was characterised by its pedicellate flowers laxly arranged along the inflorescence rachis and dark red corollas. Walpers (1845) reduced *Melasanthus* to a synonym of *Stachytarpheta*, providing all needed combinations. Nonetheless, a new name was provided for *M. longespicatus*, (*S. chamissonis* Walp.), without any explanation regarding this nomenclatural change (Walpers 1845). Later, Moldenke (1974, 1980, 1983) further investigated the morphological variation in this species, describing five new varieties: *Stachytarpheta chamissonis* var. *andersonii* Moldenke, *S. chamissonis* var. *brevibracteata* Moldenke, *S. chamissonis* var. *longipedicellata* Moldenke, *S. chamissonis* var. *longipetiolata* Moldenke, and *S. chamissonis* var. *parvifolia* Moldenke (Table 1).

Atkins (2005), who performed the taxonomic revision of the Brazilian *Stachytarpheta*, confirmed that the name *S. longispicata* was available in the genus, which rendered *S. chamissonis* a superfluous name. Thus, the author proposed the name *S. longispicata* (Pohl) S.Atkins and provided the needed new combinations (*Stachytarpheta longispicata* var. *andersonii* (Moldenke) S.Atkins, *S. longispicata* var. *longipedicellata* (Moldenke) S.Atkins, and *S. longispicata* var. *parvifolia* (Moldenke) S.Atkins). Furthermore, Atkins (2005) also described two new subspecies (*S. longispicata* subsp. *minasensis* S.Atkins and *S. longispicata* subsp. *ratteri* S.Atkins), raised *S. chamissonis* var. *brevibracteata* to a subspecies (*S. longispicata* subsp. *brevibracteata* (Moldenke) S.Atkins), and reduced *S. chamissonis* var. *longipetiolata* to a synonym of *S. longispicata* var. *longipedicellata* (Table 1).

The seven infraspecific taxa of *Stachytarpheta longispicata* are differentiated from the remaining species of *Stachytarpheta* by their pedicellate flowers with salmon or dark red corollas, constituting a morphologically cohesive group within the genus (Atkins 2005; Cardoso & Salimena 2020). They are endemic to the Brazilian Cerrado (Atkins 2005; Cardoso & Salimena 2020), the largest Neotropical savanna characterised by a mosaic of savannas, grasslands and forests (Ribeiro & Walter 2008), and recognised as a biodiversity hotspot of global importance that has already lost 46% of its native vegetation cover (Myers *et al.* 2000; Strassburg *et al.* 2017). These taxa are mostly distributed in the campos rupestres and open fields of the Central Brazil (Goiás and Distrito Federal States), Espinhaço Range (Serra do Cabral), and Serra da Canastra region (Atkins 2005).

The morphological characteristics were poorly explored in the brief circumscriptions provided for each subspecies and variety of *Stachytarpheta longispicata* (Moldenke 1974, 1980, 1983; Atkins 2005). A comparative table was presented by Atkins (2005) including only information on the plants' height, shape and size of the leaves, and length of the inflorescences, bracts, calyx, and corolla. In this table, the boundaries between the recognised taxa are indistinct. There is a great overlap in their morphological features, impairing their recognition. Most of the measurements provided by Atkins (2005) are punctual and, thus, lack minimum to maximum intervals. Furthermore, Atkins (2005) did not provide any diagnostic characteristic for each taxon or an identification key. Thus, for having a complicated taxonomy, this group is regarded as the *Stachytarpheta longispicata* complex.

Table 1. The chronological history of the published names, and the currently accepted taxa involved in the *Stachytarpheta longispicata* complex.

Pohl 1827	Walpers 1845	Moldenke 1974	Moldenke 1980	Moldenke 1983	Atkins 2005
Melasanthus longespicatus	*Stachytarpheta chamissonis*	*S. chamissonis* var. *andersonii*	*S. chamissonis* var. *brevibracteata*	*S. chamissonis* var. *longipetiolata*	*S. longispicata* subsp. *longispicata*
		S. chamissonis var. *longipedicellata*	*S. chamissonis* var. *parvifolia*		*S. longispicata* subsp. *brevibracteata*
					S. longispicata subsp. *minasensis*
					S. longispicata subsp. *ratteri*
					S. longispicata var. *andersonii*
					S. longispicata var. *longipedicellata*
					S. longispicata var. *parvifolia*

In herbaria, most specimens of *Stachytarpheta longispicata* are not identified to the infraspecific rank and tend to be still identified as *S. chamissonis* (P.H. Cardoso pers. obs.). In the recent taxonomic treatment of *Stachytarpheta* from Brazil, Cardoso & Salimena (2020) provisionally followed the circumscription of *S. longispicata* proposed by Atkins (2005), but stated that further studies were needed to clarify the group's taxonomy.

Morphometric analyses have shown to be useful tools in plant taxonomy, aiding in the morphological delimitation of complicated species and infraspecific taxa (e.g., Robyn *et al.* 2008; Sun *et al.* 2008; Bünger *et al.* 2016; Neves *et al.* 2018; Menini Neto *et al.* 2019). Multivariate analyses also prove to be valuable for species delimitation in Verbenaceae, in the genera *Aloysia* Paláu (Moroni *et al.* 2016), *Duranta* L. (Moroni *et al.* 2019), and *Lippia* L. (O'Leary *et al.* 2012b). In the present study, we assess the morphometric variation of the taxa included in the *Stachytarpheta longispicata* complex to shed light on its confusing current taxonomy. For this, we conducted an exploratory multivariate analysis of vegetative and floral traits. Given the morphological patterns observed, we provide an updated taxonomic treatment for the complex using qualitative characters together with our newly gathered quantitative data. Detailed descriptions, illustrations, distribution map, conservation assessments, and comments on the plants' taxonomy, nomenclature, and ecology are presented.

Material and methods

Sampling

Herbarium collections of *Stachytarpheta longispicata* and associated names available at Reflora and speciesLink databases, along with the taxonomic treatment provided by Atkins (2005) and Cardoso & Salimena (2020), were used to explore the geographic distribution and morphological variation of the infraspecific taxa and to guide our field efforts. Protologues (Pohl 1827; Moldenke 1974, 1980, 1983; Atkins 2005) and type specimens available at JSTOR (https://www.jstor.org) and JAQC (https://www.jacq.org/#database) were used for the recognition of taxa in the field.

Groups of geographically isolated individuals are treated as natural populations (Townsend *et al.* 2006). During fieldwork, we aimed to collect individuals that comprised all the observed morphological variation. Specimens were always collected to include the basalmost mature leaves in a branch and mature inflorescences with open corollas. Morphological, ecological and environmental data were annotated for all specimens, along with georeferencing and photographs during fieldwork. The collected specimens were deposited at the CESJ herbarium. Acronyms of herbaria follow Index Herbariorum (Thiers continuously updated).

We studied a total of 11 natural populations of *Stachytarpheta longispicata* complex between 2019 and 2021, covering the morphological variation found in all infraspecific taxa and its area of distribution in the states of Goiás, Distrito Federal, and Minas Gerais (Atkins 2005; Cardoso & Salimena 2020). The type specimens of all names in the *S. longispicata* were also inserted in our morphometric analysis, including *S. chamissonis* var. *longipetiolata*, considered a synonym of *S. longispicata* var. *longipedicellata* by Atkins (2005). Plant material used in this study is presented in Table 2.

Morphometrical analysis

The measurements were carried out using a digital calliper set for millimetres and two decimal places, using dried material. The type specimens were measured on the high-resolution images using JSTOR's measuring tool, also set for millimetres and two decimal places.

We measured 66 continuous characters (30 vegetative and 36 reproductive) for each of the 115 analysed specimens. The measurements were taken by the first author with great care, especially regarding the digital calliper and virtual ruler, to minimise human error. For each specimen, we measured: (1) six leaves (two basalmost, two from the midportion, and two uppermost), including the petiole length, total leaf-blade length, and leaf-blade width at base, mid-length and apex; (2) one inflorescence, including its length and width; (3) six flowers (two from the basalmost portion of the inflorescence, two from the midportion, and two from the terminal portion), including the distance between them, length of the pedicel, length and width of the bracts and calyx; and (4) the length of a sole corolla. Since corolla development and anthesis is gradual and unidirectional in each inflorescence, it is rare to find more than three flowers with open corolla per inflorescence (Atkins 2005). The characters that were measured on two different leaves/flowers in the same position were averaged before being included in the data matrix. The resulting matrix thus contains a total of 36 continuous characters for each specimen (15 vegetative and 21 reproductive) (Supp. file 1). The characters and their codes are listed in Table 3. All measurements were included in the data matrix without any prior identification of the taxa. To illustrate the variation within the 36 characters, we produced Jitter Plots graphs using PAST ver. 4.06b software (Hammer *et al.* 2001).

The 115 specimens were used as operational taxonomic units (OTUs) in the multivariate analyses. Multivariate statistical analyses were performed also using the PAST ver. 4.06b. For the Unweighted Pair Group Method with Arithmetic Average (UPGMA) and the Principal Component Analysis (PCA), the original measurement matrix was log-transformed to avoid scale distortions and normality issues. The UPGMA was employed on a similarity matrix calculated using Euclidean distance, and bootstrap support (BS) was estimated based on 1000 replicates. The Cophenetic Correlation Coefficient (CCC) was used to determine how well the hierarchical structure of the dendrogram represents actual distances. The PCA was used to summarise the morphological variations and discontinuities between the taxa on a variance-covariance matrix, without groups defined a priori. We also performed a Discriminant Analysis (DA) with the 11 natural populations as a priori groups for classification. To have the correct balance concerning the degrees of freedom, we used as input data the first 10 scores axes resulting from a preliminary PCA analysis over the original data matrix.

Taxonomic treatment and a new circumscription

After the morphometric analysis, groups were compared with type material and original descriptions to assign the correct nomenclature. The taxonomic species concept follows morphology, as explained by Stuessy (2009). Thus, each group of specimens supported by the multivariate analysis was considered a good species. The particular geographic patterns observed were also useful for circumscription.

We analysed specimens from CEN, CESJ, ESA, HUEFS, HUFU, K, MBM, NY, RB, SPF, UB, UEC, and UFG, using also the online databases Reflora and speciesLink. For a more robust taxonomic treatment, in addition to quantitative data, we also carefully studied qualitative characteristics aiming to detect

Table 2. Natural populations and nomenclatural types of the *Stachytarpheta longispicata* complex used in this study, including codes, number of specimens – sample size (N), vouchers or barcodes, and locality information. Vouchers were made from one specimen per population and are deposited at CESJ herbarium. Abbreviations: DF = Distrito Federal; GO = Goiás; MG = Minas Gerais.

Populations and types	Code	N	Voucher or barcode	Locality and/or geographic coordinates
Cristalina 1	CR1	10	*P.H. Cardoso et al. 46*	GO, Cristalina, 16º46′09″ S, 47º39′4″ W
Cristalina 2	CR2	10	*P.H. Cardoso et al. 48*	GO, Cristalina, 16º43′59″ S, 47º41′03″ W
Veadeiros 1	CV1	10	*P.H. Cardoso et al. 54*	GO, Alto Paraíso de Goiás, 14º4′40″ S, 47º30′9″ W
Veadeiros 2	CV2	10	*P.H. Cardoso et al. 59*	GO, Alto Paraíso de Goiás, 14º5′03″ S, 47º29′39″ W
Veadeiros 3	CV3	10	*P.H. Cardoso et al. 60*	GO, Alto Paraíso de Goiás, 14º6′27″ S, 47º32′48″ W
Veadeiros 4	CV4	10	*P.H. Cardoso et al. 62*	GO, Alto Paraíso de Goiás, 14º0′29″ S, 47º31′23″ W
Distrito Federal 1	DF1	10	*B. Schindler & M. Figueira 56*	DF, Brasília, 15º45′53″ S, 47º54′25″ W
Distrito Federal 2	DF2	7	*P.H. Cardoso et al. 51*	DF, Brasília, 15º52′50″ S, 47º51′27″ W
Serra da Canastra 1	SC1	10	*P.H. Cardoso & W.P. Leite 65*	MG, Delfinópolis, 20°8′36″ S, 46°53′22″ W
Serra da Canastra 2	SC2	10	*P.H. Cardoso & W.P. Leite 66*	MG, Delfinópolis, 20°8′21″ S, 46°54′17″ W
Serra do Cabral 1	CA1	10	*F.R.G. Salimena 4051*	MG, Joaquim Felício, 17º47′45″ S, 40º17′19″ W
Type subsp. *longispicata*	TSLONGSPI	1	BR0000008026668	"Habitat in montosis arids, ad Serra de Cristaes Capitaniae Goyas"
Type subsp. *brevibracteata*	TSBREV	1	NY00138063	MG, Morro das Pedras, ca 25 km N.E. of Patrocínio
Type subsp. *minasensis*	TSMINAS	1	K000065239	MG, Joaquim Felício, Serra do Cabral
Type subsp. *ratteri*	TSRAT	1	K00006516	DF, Fazenda Água Limpa, Universidade de Brasília
Type var. *andersonii*	TVANDER	1	LL00373686	GO, Serra Geral do Paraná, 4 km by road E of São João da Aliança
Type var. *longipedicellata*	TVLONGPED	1	LL00373687	GO, Chapada dos Veadeiros, 20 km by road N of Alto Paraíso de Goiás
Type var. *longipetiolata*	TVLONGPET	1	NY00138065	GO, Chapada dos Veadeiros, 40 km N of Alto Paraíso de Goiás
Type var. *parvifolia*	TVPARV	1	MICH1108415	GO, Chapada dos Veadeiros, 5 km E of Alto Paraíso de Goiás

Table 3. Characters used in a multivariate analysis with their codes. Asterisks (*) indicate characters that were averaged from two measurements (on two different leaves/flowers in the same position).

Character code	Detailed definition of character
LBLB	Length of the basalmost leaf-blade*
LBP	Length of the basalmost petiole*
WLBLB	Width of the lower portion of the basalmost leaf-blade*
WMBLB	Width at the middle of the basalmost leaf-blade*
WTBLB	Width of the top portion of the basalmost leaf-blade*
LMLB	Length of the mid-portion leaf-blade*
LMP	Length of the mid-portion petiole*
WLMLB	Width of the lower portion of the mid-portion leaf-blade*
WMMLB	Width at the middle of the mid-portion leaf-blade*
WTMLB	Width of the top portion of the mid-portion leaf-blade*
LALB	Length of the apical leaf-blade*
LAP	Length of the apical petiole*
WLALB	Width of the lower portion of the apical leaf-blade*
WMALB	Width at the middle of the apical leaf-blade*
WTALB	Width of the top portion of the apical leaf-blade*
LI	Length of the inflorescence
WI	Width of the inflorescence
DBF	Distance between the basalmost flowers
LBPE	Length of the basalmost pedicels*
LBB	Length of the basalmost bract*
WBB	Width of the basalmost bract*
LBC	Length of the basalmost calyx*
WBC	Width of the basalmost calyx*
DMF	Distance between the mid-portion flowers
LMPE	Length of the mid-portion pedicels*
LMB	Length of the mid-portion bract*
WMB	Width of the mid-portion bract*
LMC	Length of the mid-portion calyx*
WMC	Width of the mid-portion calyx*
DAF	Distance between the apical flowers
LAPE	Length of the apical pedicels*
LAB	Length of the apical bract*
WAB	Width of the apical bract*
LAC	Length of the apical calyx*
WAC	Width of the apical calyx*
LC	Length of the corolla

putative diagnostic characters and further morphological variations. The most taxonomically relevant and/or diagnostic characters were illustrated using photos taken under the stereo microscope (Zeiss-Stemi 508), plus photos of the plants in their natural habitat. In addition, to allow more reliable observations of pubescence, leaves and calyxes from herbarium samples were fixed in stubs using carbon tape, sputter coated with gold (Leica EM SCD050) and analysed using scanning electron microscopy (FEI – QuantaTM 250) to 15 Kv. Locality data are cited verbatim from the specimen labels (between double quotation marks).

The taxonomic descriptions follow Harris & Harris (2003), Atkins (2005), and Gonçalves & Lorenzi (2007). Distribution, ecological and phenological data were obtained from herbarium specimens, literature (Atkins 2005), and field observations.

Distribution map and conservation assessment

The analysed specimens were included in a database with the correct identification, locality, collectors, and GPS coordinates. For the specimens whose coordinates were not provided on their herbarium labels, but presented detailed locality information, coordinates were inferred using Google Earth or the geoLoc tool from speciesLink. Records with coordinates of a municipality centroid were only maintained for specimens lacking detailed locality information. A distribution map was prepared based on the clean specimen database, using the QGIS 3.8.1 software (https://www.qgis.org/pt_BR/site/).

The Extension of Occurrence (EOO) and Area of Occurrence (AOO) of the recognised taxa was calculated using GeoCAT (Bachmann *et al.* 2011), with area cells set to 4 km². Preliminary threat assessments were done following the categories and criteria provided by IUCN (2001), following the IUCN guidelines (IUCN 2022).

Results

The UPGMA recovered a dendrogram with a CCC of 0.79, revealing five major clusters (Fig. 1). The first two segregations represent the taxa originally described for the state of Minas Gerais. Group 1 includes all specimens collected at Serra do Cabral, including the type of *Stachytarpheta longispicata* subsp. *minasensis* (BS 89). Group 2 includes specimens collected at Serra da Canastra and the type of *S. longispicata* subsp. *brevibracteata* (BS 95). The following cluster includes the specimens from Central Brazil recovered in three groups. Group 3 includes specimens collected at Distrito Federal and the type of *S. longispicata* subsp. *ratteri* (BS 98). Group 4 includes specimens collected at the municipality of Cristalina, state of Goiás, and the type of *S. longispicata* subsp. *longispicata* (BS 87). Finally, Group 5 includes all the specimens collected at Chapada dos Veadeiros, state of Goiás, and all type specimens of the varieties described in the complex (i.e., *S. longispicata* var. *andersonii*, *S. longispicata* var. *longipedicellata*, *S. chamissonis* var. *longipetiolata*, and *S. longispicata* var. *parvifolia*) (BS 72).

In the PCA, the first three axes explained 81.12% of the observed variation (PC1 46.27%, PC2 24.88%, and PC3 10.97%). In the bidimensional space, when the first two components are plotted, the same five groups recovered by the UPGMA analysis can be observed (Fig. 2A). When plotting the PC1 and PC3, the differentiation is more evident between the Serra da Canastra and Serra do Cabral populations (Fig. 2B). The characters that contributed the most to recovering the groupings were: (1) inflorescence length and width of the leaf-blades for PC1; (2) length of the petiole and pedicel for PC2; (3) inflorescence length, calyx width and distance between the flowers for PC3 (Table 4).

In the DA, the first three axes explain 88.71% of the groups' variance (45.18%, 31.26%, and 12.27%, respectively). In the bidimensional space, axes 1 and 2 are able to separate five distinct groupings (Fig. 3A). Axis 1 separates mainly the Groups 1, 2, and 4; while axis 2 separates the Group 3 on the right and the Group 5 on the left. When plotting in the bidimensional space axes 1 and 3, we recover the same five distinct groupings (Fig. 3B). The classification matrix produced by the DA correctly classified 99.13% of the individuals within their groups and populations as defined a priori.

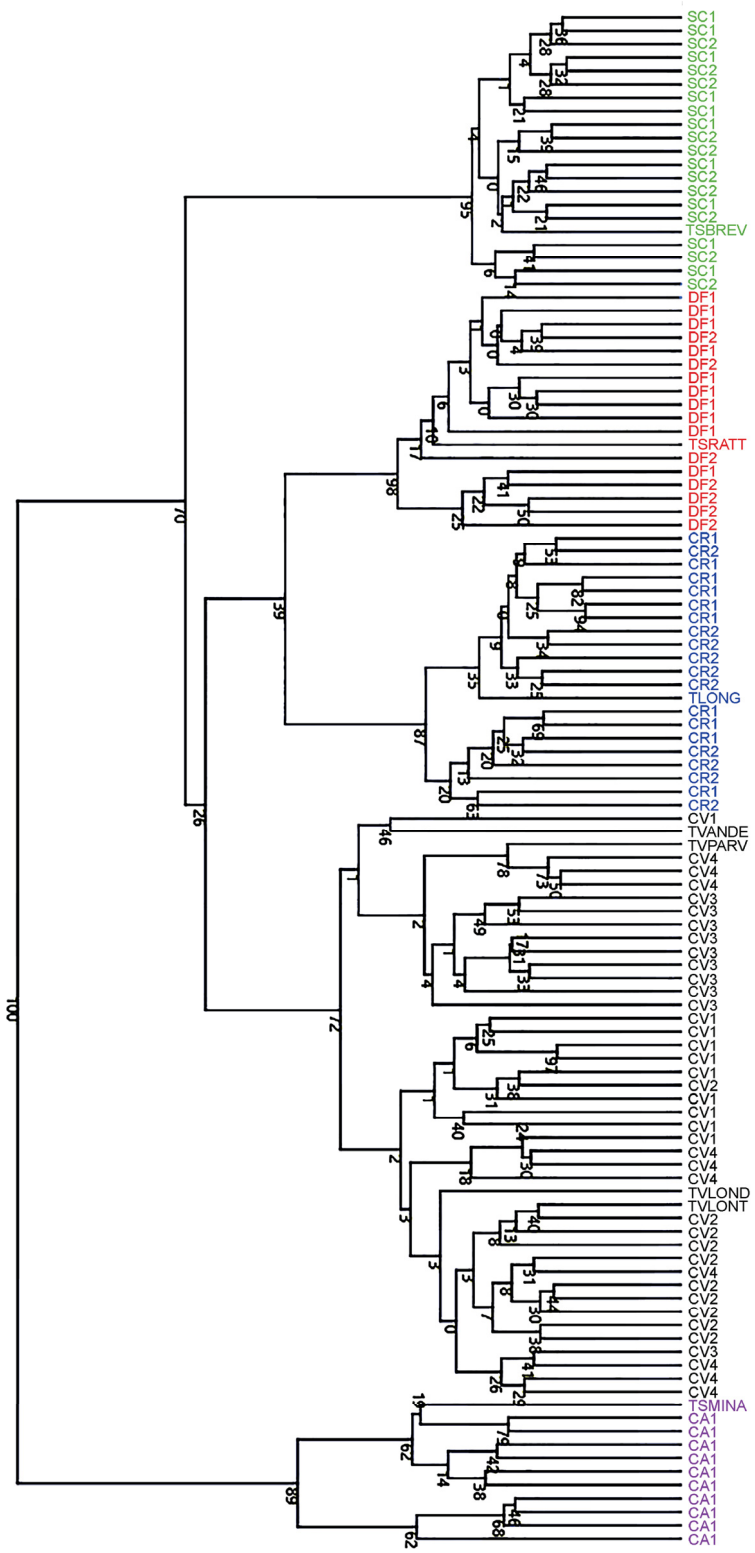

Fig. 1. Dendrogram recovered using the UPGMA method and based on the Euclidean Distance Coefficient with bootstrap values (after 1000 replicates) for the morphometric data of 11 populations and eight type specimens of the *Stachytarpheta longispicata* complex. For explanation of OTUs see Table 2

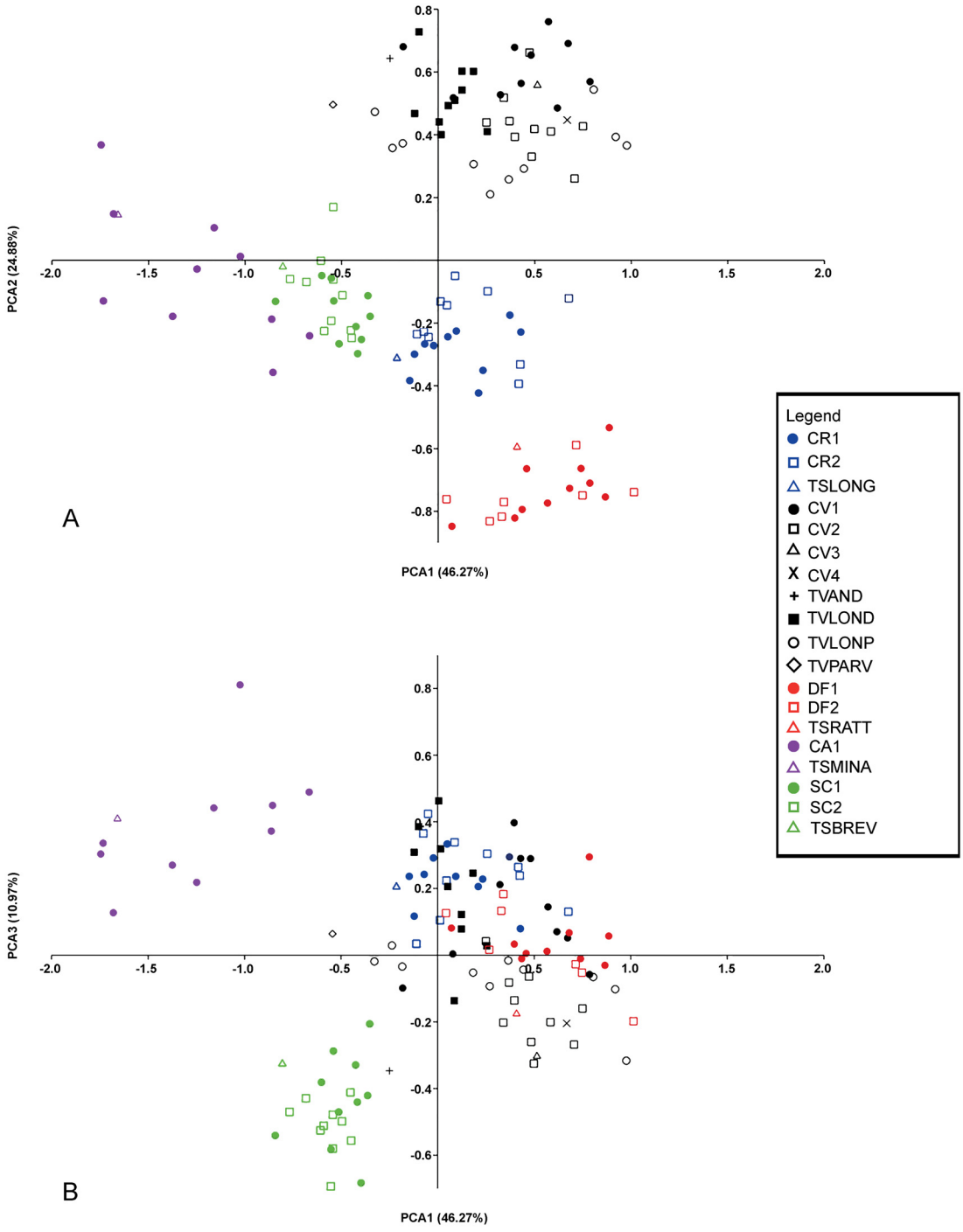

Fig. 2. Scatterplots derived from Principal Component Analysis of 11 natural populations and eight type specimens of the *Stachytarpheta longispicata* complex. **A**. Plot of principal component (PC) 1 vs PC2. **B**. Plot of PC1 vs PC3. For explanation of OTUs see Table 2.

Table 4. Results of Principal Components Analysis (PC1, PC2 and PC3). The five most important (largest) values for each component are in bold. The variable codes are explained in Table 3.

	PCA		
Variables	**PC1**	**PC2**	**PC3**
LBLB	0.1746	-0.014906	-0.24428
LBP	0.17855	**0.28674**	-0.14459
WLBLB	0.19893	-0.14226	-0.17451
WMBLB	0.20096	-0.12512	-0.21422
WTBLB	0.20978	-0.15577	-0.22139
LMLB	0.18866	-0.0041983	-0.16692
LMP	0.20047	**0.30194**	-0.092038
WLMLB	0.21364	-0.1381	-0.097412
WMMLB	**0.2186**	-0.11965	-0.12519
WTMLB	**0.22728**	-0.15687	-0.13054
LALB	0.17659	-0.015241	-0.14917
LAP	0.17954	0.27783	-0.089104
WLALB	**0.21865**	-0.16025	-0.044719
WMALB	0.21338	-0.13506	-0.082154
WTALB	**0.2223**	-0.17261	-0.096172
LI	**0.39139**	-0.057112	**0.35017**
WI	0.055756	0.0042423	0.088938
DBF	0.1826	0.058102	0.24585
LBPE	0.13135	**0.41326**	0.021694
LBB	0.14793	0.048399	0.12637
WBB	0.055188	-0.055098	0.18903
LBC	0.035697	-0.061903	0.02452
WBC	0.093819	-0.096719	**0.28321**
DMF	0.18001	0.015638	**0.2606**
LMPE	0.11377	**0.40296**	0.019081
LMB	0.14709	0.048053	0.12593
WMB	0.042203	-0.057127	0.17257
LMC	0.036351	-0.060325	0.020533
WMC	0.090658	-0.096298	**0.30114**
DAF	0.168	0.071461	0.11705
LAPE	0.10249	**0.38855**	-0.023671
LAB	0.13855	0.0493	0.13007
WAB	0.030233	-0.070956	0.16007
LAC	0.024335	-0.072968	0.0060484
WAC	0.082736	-0.098218	**0.27643**
LC	0.012367	-0.038233	-0.071522

The variation of the measured characters among different taxa is presented in Fig. 4. This dispersion graph highlights the characters that most significantly contributed to taxa differentiation, such as petiole length, leaf-blade size, pedicel length, and calyx width. It also evidences the minimum and maximum values of continuous characters selected for the morphometric analysis.

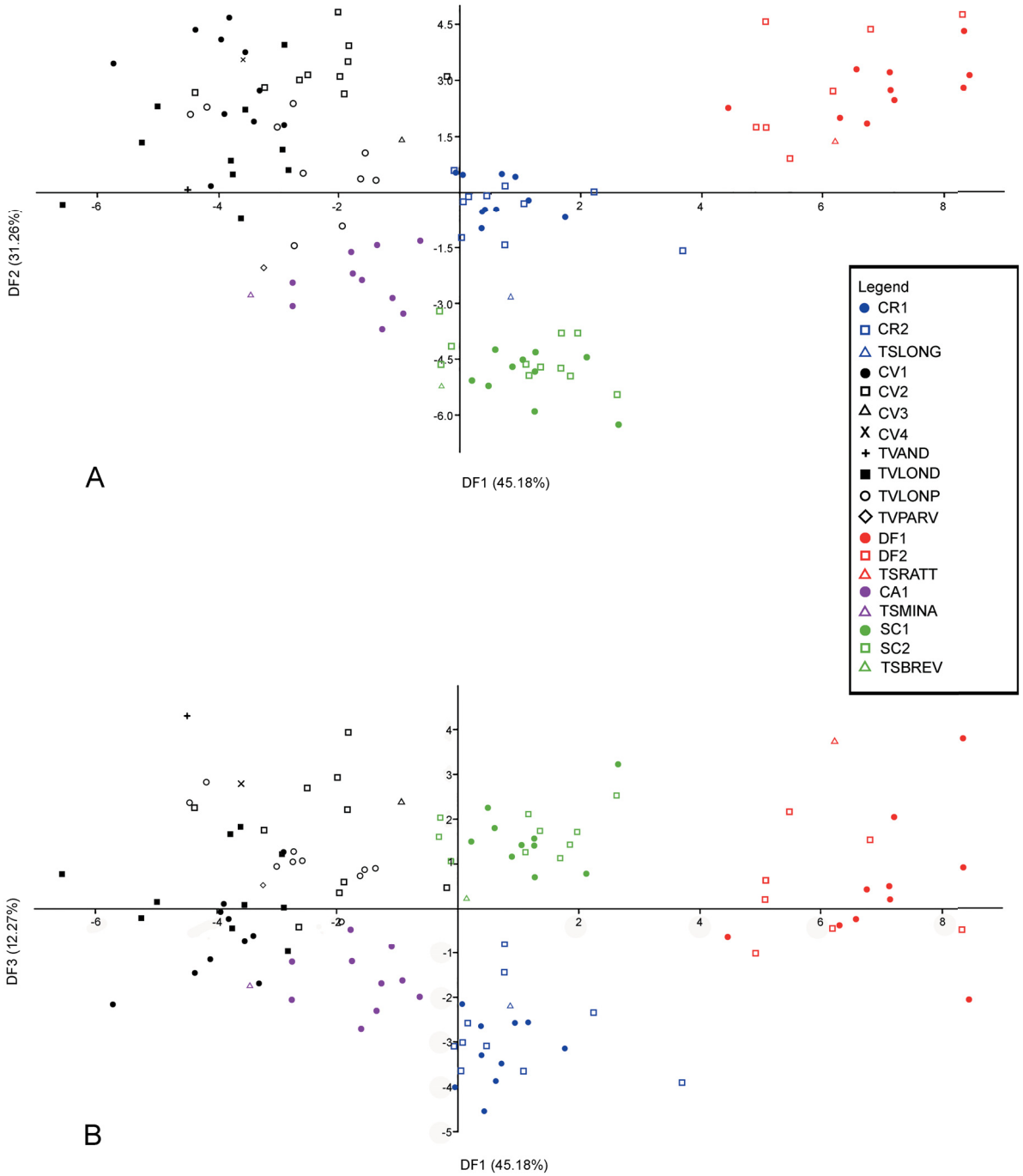

Fig. 3. Scatterplots derived from Discriminant Analysis of 11 natural populations and eight type specimens of the *Stachytarpheta longispicata* complex. **A**. Plot of Axis 1 vs Axis 2. **B**. Plot of Axis 1 vs Axis 3. For explanation of OTUs see Table 2.

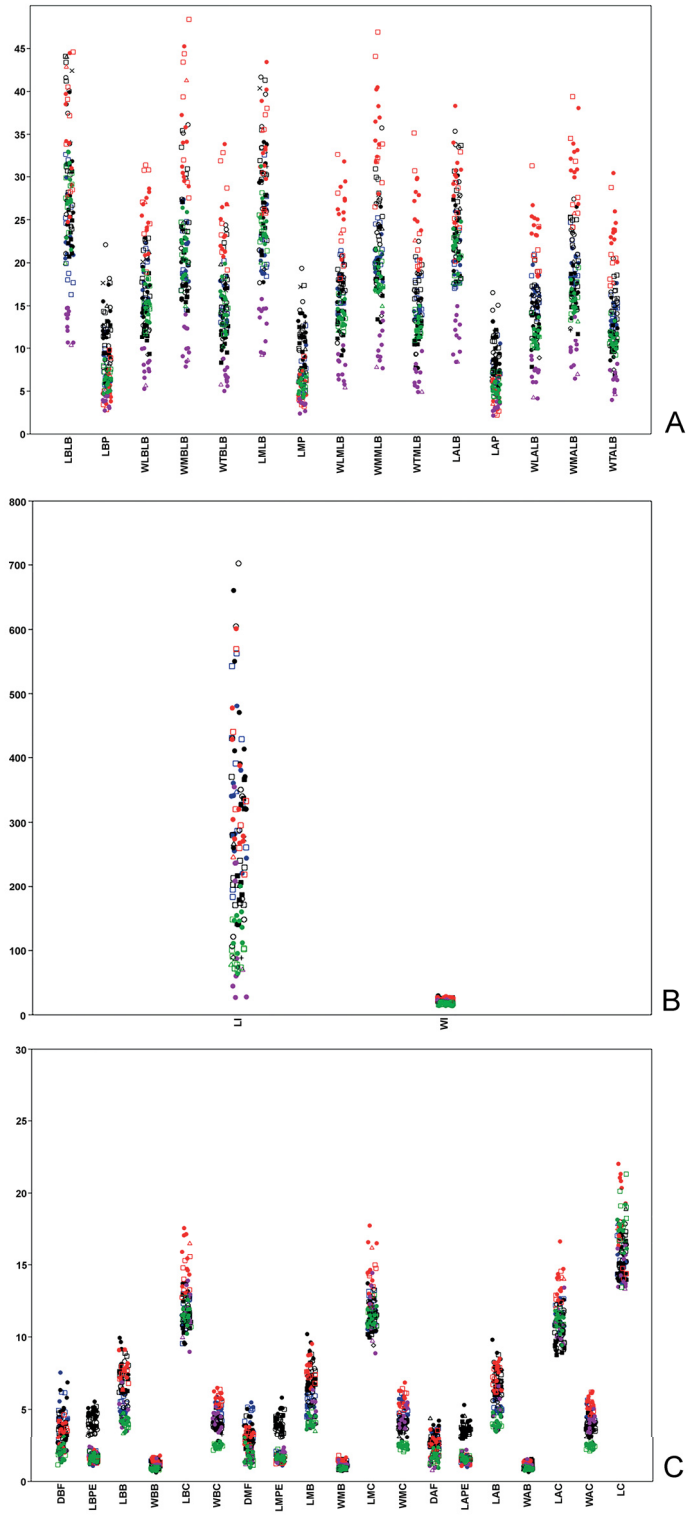

Fig. 4. Jitter Plots showing the variation in the *Stachytarpheta longispicata* complex of all characters selected for the morphometric analysis of the 115 sampled specimens (11 natural populations and eight type specimens of the *Stachytarpheta longispicata* complex). All measures are in millimetres. **A**. Leaf characters. **B**. Inflorescence characters **C**. Bracts and floral characters. For explanation of OTUs see Table 2; for character codes see Table 3.

The obtained results are congruent between all employed methods (UPGMA, PCA, and DA), evidencing a clear morphological discontinuity between the five groupings. Our taxonomic analysis showed that Group 1 corresponds to *S. longispicata* subsp. *minasensis*, Group 2 to *S. longispicata* subsp. *brevibractetata*, Group 3 to *S. longispicata* subsp. *ratteri*, Group 4 to *S. longispicata* subsp. *longispicata*, and Group 5 to *Stachytarpheta longispicata* var. *longipedicellata*, *S. longispicata* var. *andersonii*, *S. longispicata* var. *parvifolia*, and *S. chamissonis* var. *longipetiolata*.

In the light of the above, the *Stachytarpheta longispicata* complex is redefined to include five species. We provide below the necessary taxonomic and nomenclatural changes, based on the results of our morphometric analyses. The descriptions include quantitative data, as well qualitative characteristics gathered during herbarium and field studies. Illustrations and a map showing the geographic distribution (Fig. 5) are provided for species recognition.

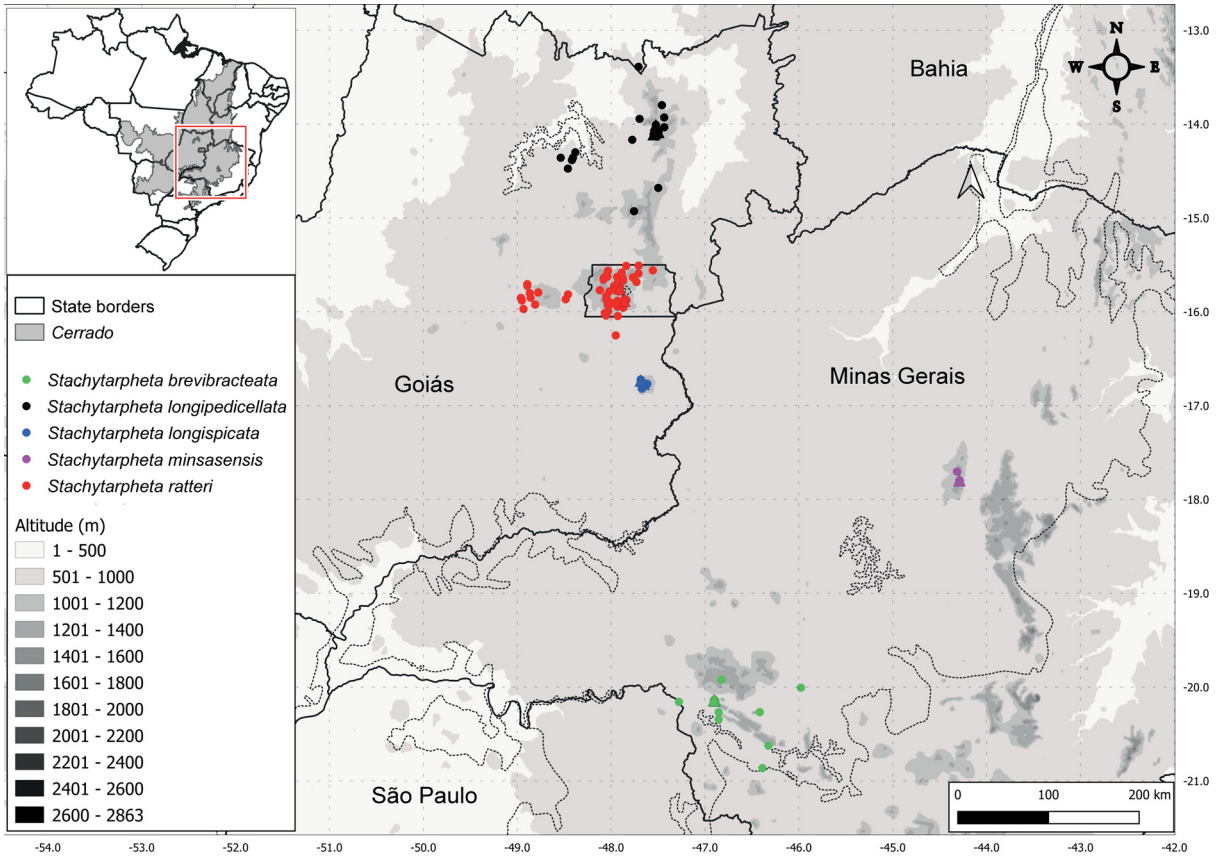

Fig. 5. Distribution map of the five species recognised in the *Stachytarpheta longispicata* complex in the present study. The triangles represent localities sampled during fieldwork for the morphometric analysis.

Taxonomic treatment

Class Magnoliopsida Brongn.
Order Lamiales Bromhead
Family Verbenaceae J.St.-Hil.

Genus ***Stachytarpheta*** Vahl

Key to the species of *Stachytarpheta* with pedicellate flowers

1. Pedicels longer than 2.4 mm; calyx externally lanuginose from base to apex .... ***S. longipedicellata*** (Moldenke) P.H.Cardoso comb. and stat. nov.
– Pedicels shorter than 2.4 mm; calyx externally tomentose from base to apex, or lanate or sericeous or tomentose-hirsutulous at base becoming strigose towards the apex 2

2. Leaves adaxially strigillose; calyx tube narrow throughout, 1.98–2.9 mm wide, externally tomentose from base to apex ..... ***S. brevibracteata*** (Moldenke) P.H.Cardoso comb. and stat. nov.
– Leaves adaxially strigose or sericeous; calyx tube narrow becoming broader towards the apex, 3.2–7.13 mm wide, lanate or sericeous or tomentose-hirsutulous at base becoming strigose towards the apex 3

3. Leaf-blades 8.15–15.88 mm long; adaxially sericeous, abaxially not foveolate (state of Minas Gerais) ..... ***S. minasensis*** (S.Atkins) P.H.Cardoso comb. and stat. nov.
– Leaf-blades 16.02–45.67 mm long; adaxially strigose, abaxially foveolate (states of Goiás and Distrito Federal) 4

4. Leaves ovate, subrhomboid to subrotund, blades 16.02–33.42 × 13.3–27.2 mm, base cuneate to attenuate; pedicel tomentose-hirsutulous; calyx tomentose-hirsutulous at base .... ***S. longispicata*** (Pohl) S.Atkins
– Leaves fan-shaped or obovate, blades 19.32–45.67 × 24.96–48.52 mm, base truncate, rarely cuneate; pedicel densely sericeous; calyx sericeous at base .... ***S. ratteri*** (S.Atkins) P.H.Cardoso comb. and stat. nov.

Stachytarpheta brevibracteata (Moldenke) P.H.Cardoso comb. and stat. nov.
Figs 6A–C, 7A–B, 8A–B, 9

Stachytarpheta chamissonis var. *brevibracteata* Moldenke, *Phytologia* 45: 38 (Moldenke 1980), basionym. – *Stachytarpheta longispicata* subsp. *brevibracteata* (Moldenke) S.Atkins, *Kew Bulletin* 60: 231 (Atkins 2005).

Material examined

Type

BRAZIL – **Minas Gerais** • Morro das Pedras, 25 km NE of Patrocínio; 28 Jan. 1970; *H.S. Irwin et al. 25457*; lectotype: NY[NY00138063] web!, designated by Cardoso *et al.* (2020); isolectotypes: MO[MO1254482] web!, UB web!.

Representative specimens

BRAZIL – **Minas Gerais** • "Bambuí, entre Bambuí e Patos de Minas"; 11 Feb. 2012; *J.F.B. Pastore et al. 4027*; HUEFS • "Delfinópolis"; 7 Sep. 1998; *V.C. Souza et al. 21233*; ESA • "Delfinópolis, estrada para casa branca"; 10 Apr. 2002; *R. Romero et al. 6255*; RB • "Delfinópolis, Fazenda Água da Serra"; 10 Mar. 2003; *R.A. Pacheco 483*; HUFU • "Delfinópolis, Condomínio de Pedra"; 17 May 2003; *R.L. Volpi*

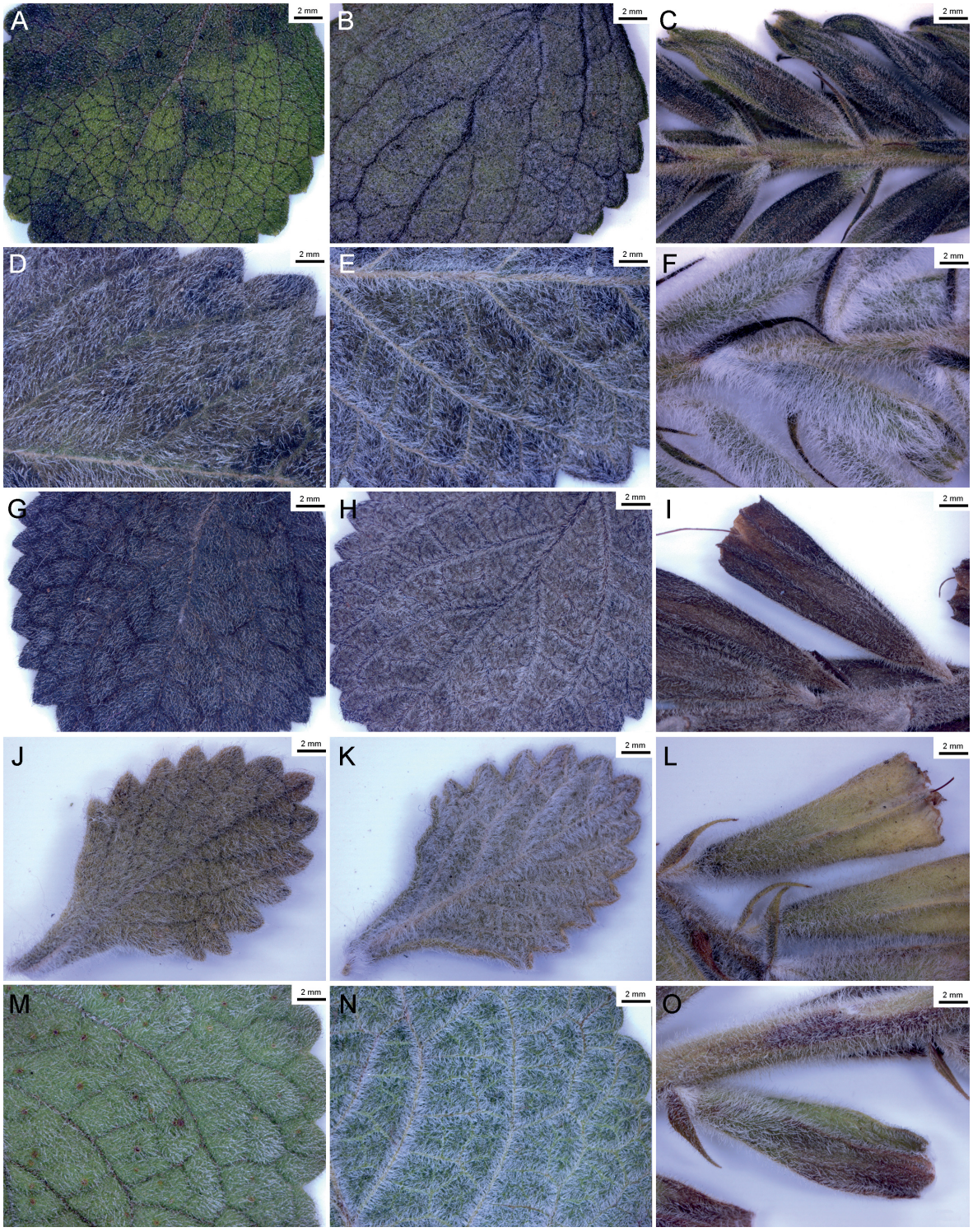

Fig. 6. Comparison between the main characteristics of the species used in the identification key (photos taken under the stereo microscope). **A, D, G, J, M**. Adaxial indumentum of the leaf-blade. **B, E, J, K, N**. Abaxial indumentum of the leaf-blade. **C, F, I, L, O**. Indumentum of the rachis, bracts, pedicel, and calyx. **A–C**. *Stachytarpheta brevibracteata* (Moldenke) P.H.Cardoso (*P.H. Cardoso & W.P. Leite 66*). **D–F**. *S. longipedicellata* (Moldenke) P.H.Cardoso (*P.H. Cardoso et al. 59*); **G–I**. *S. longispicata* (Pohl) S.Atkins (*P.H. Cardoso et al. 48*). **J–L**. *S. minasensis* (S.Atkins) P.H.Cardoso (*F.R.G. Salimena & P.H. Nobre 459*). **M–O**. *S. ratteri* (S.Atkins) P.H.Cardoso (*P.H. Cardoso et al. 51*).

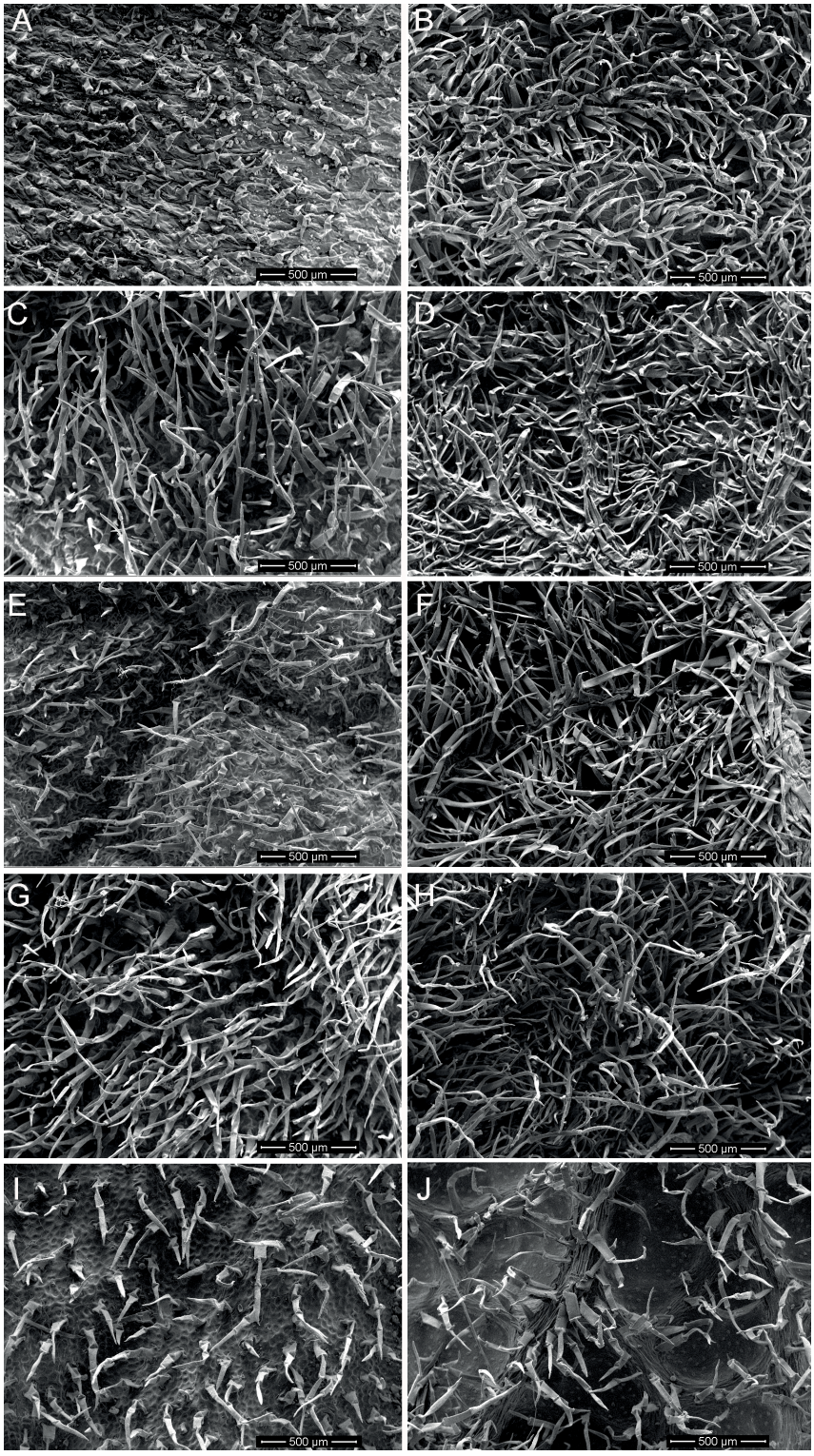

Fig. 7. Comparison between the pubescence of the leaves of the species (photos taken under electron microscope). **A, C, G, E, I**. Adaxial surface. **B, D, F, H, J**. Abaxial surface. **A–B**. *Stachytarpheta brevibracteata* (Moldenke) P.H.Cardoso (*P.H. Cardoso & W.P. Leite 66*). **C–D**. *S. longipedicellata* (Moldenke) P.H.Cardoso (*P.H. Cardoso et al. 59*). **E–F**. *S. longispicata* (Pohl) S.Atkins (*P.H. Cardoso et al. 48*). **G–H**. *S. minasensis* (S.Atkins) P.H.Cardoso (*F.R.G. Salimena & P.H. Nobre 459*). **I–J**. *S. ratteri* (S.Atkins) P.H.Cardoso (*P.H. Cardoso et al. 51*).

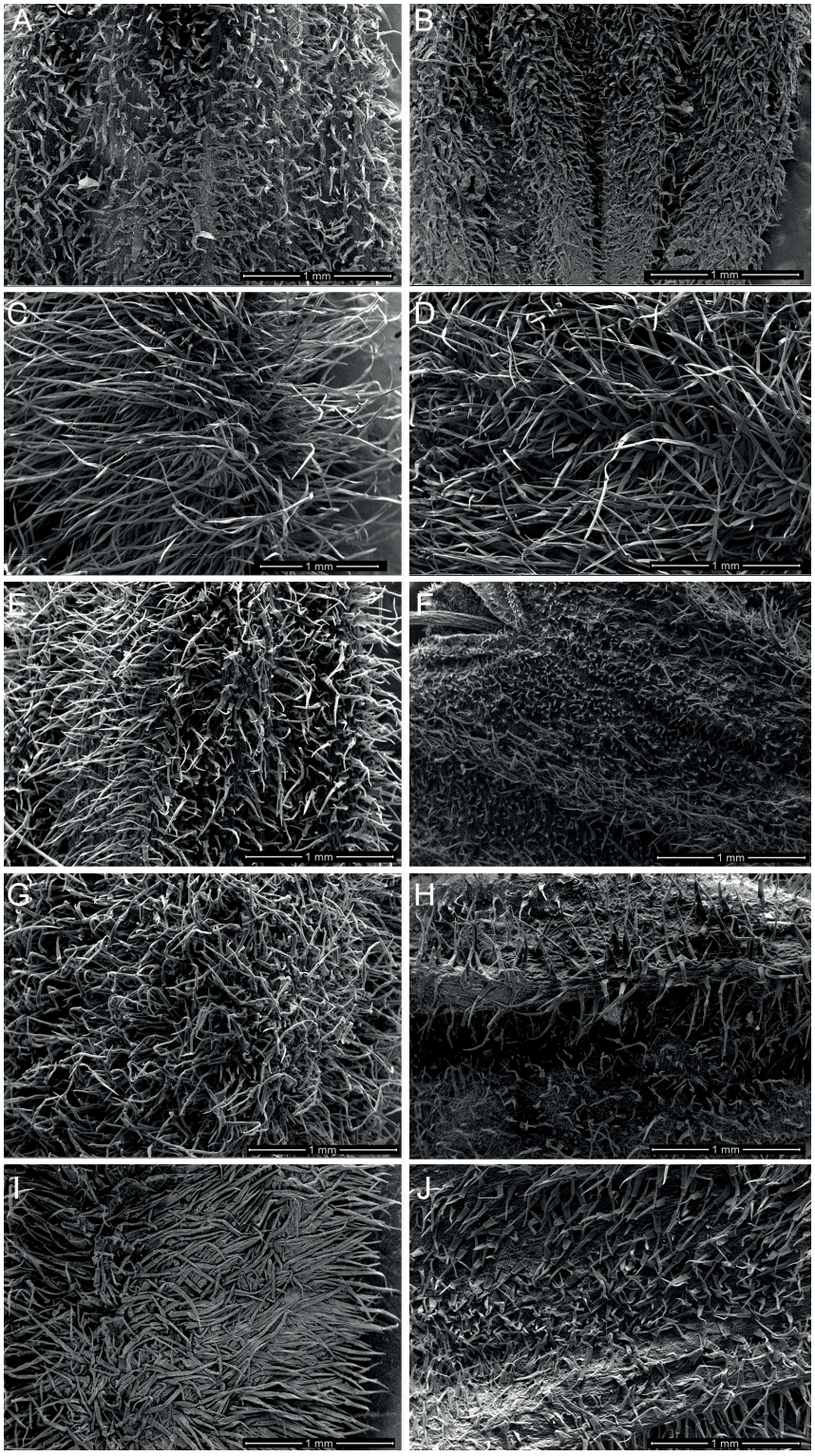

Fig. 8. Comparison between the pubescence of the calyx of the species (photos taken under electron microscope). **A, C, G, E, I**. The most basal part. **B, D, F, H, J**. The most apical part. **A–B**. *Stachytarpheta brevibracteata* (Moldenke) P.H.Cardoso (*P.H. Cardoso & W.P. Leite 66*). **C–D**. *S. longipedicellata* (Moldenke) P.H.Cardoso (*P.H. Cardoso et al. 59*). **E–F**. *S. longispicata* (Pohl) S.Atkins (*P.H. Cardoso et al. 48*). **G–H**. *S. minasensis* (S.Atkins) P.H.Cardoso (*F.R.G. Salimena & P.H. Nobre 459*). **I–J**. *S. ratteri* (S.Atkins) P.H.Cardoso (*P.H. Cardoso et al. 51*).

675; HUFU • "Furnas"; 16 Nov. 1977; *N.D. da Cruz et al. 6212*; MBM • "São Roque de Minas"; 21 Mar. 1998; *P.T. Sano et al. 963*; SPF • "São Roque de Minas, Parque Nacional da Serra da Canastra (PNSC), estrada para a Serra das Sete Voltas"; 19 Mar. 1995; *R. Romero et al. 2026*; CESJ, HUFU • "PNSC, estrada São Roque para Sacramento a 2 km da portaria Sacramento"; 14 Apr. 2017; *F.R.G. Salimena & P.H. Nobre 3989*; CESJ • "PNSC, estrada São Roque – Sacramento km 60"; 22 Feb. 1997; *J.N. Nakajima et al. 2265*; CESJ, HUFU • "PNSC, Guarita de Sacramento"; 29 Jun. 1994; *R. Romero & J.N. Nakajima 1086*; CESJ, HUFU • "PNSC, Guarita de Sacramento"; 17 Oct. 1997; *J.N. Nakajima et al. 2883*; CESJ, HUFU • "PNSC, Guarita de Sacramento"; 14 Jul. 1995; *J.N. Nakajima et al. 1180*; CESJ, HUFU • "PNSC, guarita de Sacramento"; 11 Jan. 1998; *R. Romero et al. 4991*; CESJ, HUFU • "PNSC, Sacramento, próximo do Morro da Guarita 1"; 23 Feb. 1994; *J.N. Nakajima & R. Romero 180*; CESJ, HUFU • "PNSC, 3 km da Guarita de Sacramento"; 19 Aug. 1997; *R. Romero et al. 4418*; CESJ, HUFU • "PNSC, 5 km da Guarita de Sacramento"; 19 Mar. 1995; *R. Romero et al. 2035*; CESJ, HUFU • "PNSC, próximo a nascente do Rio das Velhas"; 22 Nov. 1996; *R. Romero & J.N. Nakajima 3818*; CESJ, HUFU • "PNSC, próximo à Guarita de Sacramento"; 6 May 2021; *P.H. Cardoso & W.P. Leite 65*; CESJ • "PNSC, próximo à Guarita de Sacramento"; 6 May 2021; *P.H. Cardoso & W.P. Leite 66*; CESJ. – **São Paulo** • "Pedregulho"; 24 May 2003; *D. Sasaki 534*; SPF.

Description

Shrubs 0.8–2 m tall, erect, much-branched, stems cylindrical, tomentose, xylopodium present. Leaves opposite, patent to suberect, not conduplicate, sometimes with smaller leaves on the axils, deciduous at maturity, petiolate; petioles 3.57–9.2 mm long, tomentose; blades 17.1–36.73 × 12.21–27.31 mm, ovate or subrotund, thickly-chartaceous, slightly discolorous, base cuneate or attenuate, decurrent into

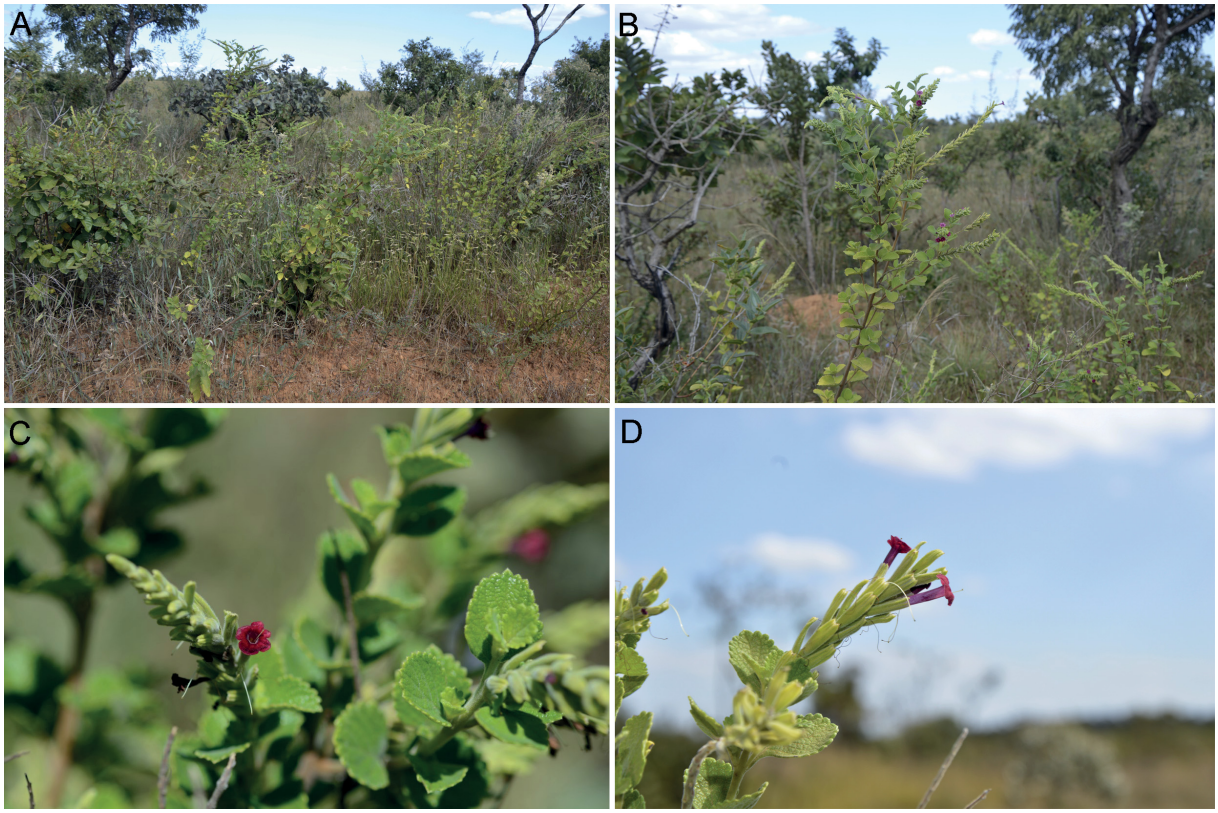

Fig. 9. *Stachytarpheta brevibracteata* (Moldenke) P.H.Cardoso comb. and stat. nov. **A**. Habitat. **B**. Habit. **C–D**. Individuals showing details of the leaves and inflorescences, highlighting the short pedicels, bracts, calyxes and corollas. Photos by Pedro Henrique Cardoso (A–B) and Pedro Henrique Nobre (C).

petiole, apex acute, obtuse or rounded, margin entire near the base, crenate-serrate towards the apex, revolute, abaxially not foveolate, tomentose, veins evident, adaxially strigillose. Inflorescences 64.22–200.61 × 14.52–19.89 mm, pendulous or not at the apex, rachis visible, tomentose; bracts 3.31–5.13 × 0.68–1.07 mm, light green, linear-triangular, apex acute or acuminate, abaxially tomentose. Flowers pedicellate, pedicel 1.21–2.23 cm long, tomentose; calyx tube narrow throughout, not widened at the apex, 9.01–13.03 × 1.98–2.9 mm, light green, externally tomentose from base to apex, 5-toothed; corolla dark red, tube 13.43–21.31 mm long, externally with pedicellate glandular trichomes. Fruits 0.41–0.58 mm long, castaneous, external surface reticulate, with thin and flat commissure, apex rounded with short stylopodium, prominent attachment scar, separating into two cluses, covered by the persistent calyx.

Distribution, habitat and phenology

Stachytarpheta brevibracteata is endemic to the Cerrado of the states of Minas Gerais and São Paulo (Fig. 5). It is found growing in campos rupestres, campos limpos (grasslands), and campos sujos (shrubby grasslands), forming dense but fragmented populations. Found fertile throughout the year, except in December.

Proposed conservation status

Stachytarpheta brevibracteata has an EOO of 7 507.461 km^2 and an AOO of 32 km^2. Despite occurring inside a protected area, the Parque Nacional da Serra da Canastra, its distribution is mostly restricted to roadsides. It is subjected to the increase of unorderly tourist activity, the suppression of native vegetation by invasive species, and mostly by illegal fires (IBAMA 2005). Therefore, *S. brevibracteata* should be considered "Endangered" (EN), based on criteria B2ab(i,ii,iii,iv) (IUCN 2022), due to its AOO < 500 km^2, fragmented populations, and a continuous decline of habitat quality.

Notes

Atkins (2005) described *S. longispicata* subsp. *brevibracteata* as subshrubs up to 1 m tall, branched, leaves ovate or subrotund, blades 12–25 × 5–12 mm, base attenuate, inflorescence 70–80 mm long, bracts linear and up to 3 mm long, calyx up to 12 mm long, covered by short hairs, and corolla dark red. The subspecies was established based solely on the type specimen and characterised by its short leaves and inflorescences (Atkins 2005). When comparing our current circumscription with the one proposed by Atkins (2005), it is possible to observe differences regarding plant stature, leaf-blade size, and length of the inflorescence, bract, calyx and corolla. Atkins (2005) provides smaller measurements for leaves' length and width. However, this is most likely associated with smaller axillary leaves, which are only analysed as qualitative characters in the present study.

Based on our morphometric analysis, plus qualitative data and distribution, *Stachytarpheta longispicata* subsp. *brevibracteata* is recognised by us at the species rank. Therefore, *S. brevibracteata* differs from the remaining species of *Stachytarpheta* with pedicellate flowers due to its branches, abaxial surface of the leaves, rachis, bracts and calyx tomentose, adaxial surface of the leaves strigillose, and narrow calyx (not enlarged towards the apex, equal or narrower than 2.9 mm width).

Stachytarpheta longipedicellata (Moldenke) P.H.Cardoso comb. and stat. nov.
Figs 6D–F, 7C–D, 8C–D, 10

Stachytarpheta chamissonis var. *longipedicellata* Moldenke, *Phytologia* 28: 467 (Moldenke 1974), basionym. – *Stachytarpheta longispicata* subsp. *longipedicellata* (Moldenke) S.Atkins, *Kew Bulletin* 60: 230 (Atkins 2005).

Stachytarpheta chamissonis var. *andersonii* Moldenke, *Phytologia* 28: 467 (Moldenke 1974), basionym. – *Stachytarpheta longispicata* var. *andersonii* (Moldenke) S.Atkins, *Kew Bulletin* 60: 230 (Atkins 2005). – **Type**. BRAZIL – **Goiás** • 4 km by road east of São João da Aliança, Serra Geral do Paraná;

24 May 1973; *W.R. Anderson et al. 7893*; holotype: LL[LL00373686] web!; isotypes: F[F0074448F] web!, NY[NY00138062] web!, U[U0007044] web!. **syn. nov.**

Stachytarpheta chamissonis var. *parvifolia* Moldenke, *Phytologia* 45: 39 (Moldenke 1980), basionym. – *Stachytarpheta longispicata* var. *parvifolia* (Moldenke) S.Atkins, *Kew Bulletin* 60: 230 (Atkins 2005). – **Type**. BRAZIL – **Goiás** • Alto Paraíso, Chapada dos Veadeiros; 14 Feb. 1979; *Gates & Estabrook 176*; lectotype: NY[NY00138066] web!, designated by Cardoso *et al.* (2020); isolectotypes: MICH[MICH1108415] web!, UB web!. **syn. nov.**

Stachytarpheta chamissonis var. *longipetiolata* Moldenke, *Phytologia* 52: 414 (Moldenke 1983). – **Type**. BRAZIL – **Goiás** • Chapada dos Veadeiros, about 50 km north of Alto Paraíso; 24 Mar. 1971; *H.S. Irwin et al. 33117*; holotype: NY[NY00138065] web!; isotype: K[K000065450] web!.

Material examined

Type

BRAZIL – **Goiás** • Chapada dos Veadeiros, 20 km by road north of Alto Paraíso; 6 Mar. 1973; *W.R. Anderson et al. 6460*; holotype: LL[LL00373687] web!; isotypes: F[F0074449F] web!, K[K000065450] web!, NY[NY00138064] web!.

Representative specimens

BRAZIL – **Goiás** • "Água Fria de Goiás, Estação Repetidora da Telebrasília de Roncador"; 8 Feb. 1994; *G. Hatschbach et al.* 60021; MBM • "Alto Paraíso de Goiás, Córrego Piçarrão"; 8 Nov. 1991; *G. Hatschbach et al. 55932*; MBM • "Alto Paraíso de Goiás"; 28 Feb. 1982; *P.I. Oliveira 377*; SPF • "Alto Paraíso de Goiás"; 30 May 1994; *J.A. Ratter & S. Bridgewater 4271*; UFG • "Alto Paraíso de Goiás, Fazenda Água Fria"; 15 Mar. 2020; *P. H. Cardoso et al. 54*; CESJ • "Alto Paraíso de Goiás, trilha para a Cachoeira Água Fria"; 15 Mar. 2020; *P.H. Cardoso et al. 59*; CESJ • "Alto Paraíso de Goiás, entrada do aeroporto em direção ao Rio dos Couros"; 16 Mar. 2020; *P.H. Cardoso et al. 60*; CESJ • "Alto Paraíso de Goiás, RPPN Cara Preta"; 16 Mar. 2020; *P.H. Cardoso et al. 62*; CESJ • "Chapada dos Veadeiros, ca 6 km E de Alto Paraíso de Goiás"; 14 Feb. 1979; *S.M. Sano & T.S. Filgueiras 47*; K, NY, UB • "Cavalcante, Parque Nacional da Chapada dos Veadeiros"; 15 Apr. 2009; *G. Martinelli 16467*; SPF • "Macedo, ca 15 km N of Niquelândia"; 21 Apr. 1988; *R.R. Brooks et al. 157*; NY • "Niquelândia, 1 km após a mina da companhia de níquel Tocantins (CNT)"; 12 Apr. 1996; *R.C. de Mendonça 2428*; NY • "Niquelândia, Return to 'ponte alta' área"; 5 Feb. 2005; *R.D. Reeves 3030*; CEN • "Niquelândia, ca 20 km de Niquelândia, estrada de terra que vai para a mina de níquel"; 21 Jun. 1995; *M.L. Fonseca et al. 375*; UFG.

Description

Clump-forming shrubs 0.5–2 m tall, erect, much-branched, stems cylindrical, when young sericeous, when old puberulent to hirsutulous, xylopodium present. Leaves opposite, patent, not conduplicate, with smaller leaves on the axils, petiolate; petioles 4.76–24.19 mm long, sericeous; blades 16.78–46.15 × 11.43–40.29 mm, ovate, thickly-chartaceous, slightly discolorous, base cuneate or attenuate, rarely obtuse, decurrent into petiole, apex acute or obtuse, margin entire near the base, crenate-serrate towards the apex, revolute, abaxially not foveolate, sericeous, veins evident, adaxially sericeous. Inflorescences 89.14–702.35 × 16.99–26.83 mm, pendulous at the apex, rachis visible, lanuginose; bracts 4.29–10.49 × 0.6–1.67 mm, light green, triangular or narrowly triangular, apex caudate, abaxially sparsely lanuginose. Flowers pedicellate, pedicel 2.43–6.91 mm long, lanuginose; calyx tube narrow, slightly widened at the apex, 8.29–14.22 × 2.73–5.44 mm, light green, externally lanuginose from base to apex, 5-toothed; corolla salmon, tube 13.88–18.91 mm long, externally with pedicellate glandular trichomes. Fruits 0.32–0.5 cm long, castaneous, external surface reticulate, with thin and flat commissure, apex rounded with short stylopodium, prominent attachment scar, separating into two cluses, covered by the persistent calyx.

Distribution, habitat and phenology

Stachytarpheta longipedicellata is endemic to the Cerrado of Goiás State, being mostly found in the northern mesoregion and in the Chapada dos Veadeiros (Fig. 5). Dense, but locally restricted populations are found in these areas, growing in campos rupestres, campos limpos (grasslands), and campos sujos (shrubby grasslands). Found fertile from February to June, and in November.

Proposed conservation status

Stachytarpheta longipedicellata has an estimated EOO of 11 592.019 km^2 and AOO of 72 km^2. Its populations are abundant, but locally restricted. Although this species occurs within a protected area (Chapada dos Veadeiros National Park), most collection records are from farms, crops, pastures, or mining areas. Several extinction threats are found in the Chapada dos Veadeiros region, such as the tourism increase in recent years, agriculture expansion, cattle ranching, and illegal fires (Barbosa 2008; Silva *et al.* 2018; Matos *et al.* 2020). Additionally, populations from Niquelândia are threatened by mining and recent soybean crops (Leite & Steinberger 2015; Moretto 2016). Thus, *S. longipedicellata* can be regarded as "Endangered" (EN) based on the B2ab(i,ii,iii) criteria and subcriteria (IUCN 2022) due to its AOO < 500 km^2, locally restricted populations, and continuous decline of habitat quality.

Notes

Atkins (2005) characterised *Stachytarpheta longispicata* var. *longipedicellata* from Chapada dos Veadeiros as a shrub up to 2 m tall, ramified, with leaf-blades ovate, 25–55 × 10–25 mm, base attenuated, inflorescence up to 170 mm long, bracts linear up to 7 mm long, calyx up to 12 mm long, densely

Fig. 10. *Stachytarpheta longipedicellata* (Moldenke) P.H.Cardoso comb. and stat. nov. **A**. Habitat. **B**. Habit. **C–D**. Individuals showing details of the inflorescences, highlighting the pubescence of the inflorescence, long pedicels, bracts, calyxes, and corollas. Photos by Pedro Henrique Cardoso.

covered with uniseriate hairs pointing in all directions, and corolla salmon pink. This author states that this variety is similar to *S. longispicata* var. *andersonii*, only differing in the salmon pink corolla (vs red orange corolla in *S. longispicata* var. *andersonii*). This latter was described for the São João da Aliança municipality, less than 70 km from the Chapada dos Veadeiros, within the same geomorphological unit (Martins-Ferreira & Campos 2017). On the other hand, according to Atkins (2005), *S. longispicata* var. *longipedicellata* and *S. longispicata* var. *andersonii* were distinguished from the *S. longispicata* subsp. *longispicata* by the ovate leaves and shorter inflorescences (vs leaves fan-shaped and longer inflorescences in *S. longispicata* subsp. *longispicata*).

The morphological characters used by Atkins (2005) to distinguish *Stachytarpheta longispicata* var. *longipedicellata* from *S. longispicata* var. *andersonii* seem to be based solely on specimens' label annotations, which described the salmon colouration differently. Although the corolla colour distinguishes some species groups within *Stachytarpheta* (e.g., groups with black, bright red, or blue corolla), no taxon is solely distinguished based on this character (Atkins 2005; Cardoso & Salimena 2020). In this case, corolla colour is a weak character since it heavily relies on the collector's point of view, and it is not always included in the specimens labels.

Stachytarpheta chamissonis var. *longipetiolata* was treated as a synonym of *S. longispicata* var. *longipedicellata* by Atkins (2005), while *S. longispicata* var. *parvifolia* was characterised as shrubs up to 50 cm tall, ramified, leaf-blades ovate, 15–30 × 9–14 mm, bracts narrowly-triangular up to 5 mm long, calyx up to 10 mm long, densely hairy, with hairs pointing to all directions, and corolla red (Atkins 2005). In the PCA and DA (Figs 2–3), the type specimen of *Stachytarpheta longispicata* var. *parvifolia* represents a variation extreme in its grouping. This can be explained by the specimen consisting of an immature branch with short leaves and inflorescences, plus not fully developed flowers. *Stachytarpheta chamissonis* var. *longipetiolata* is supported as a synonym of *S. longispicata* var. *longipedicellata* in our analyses by its type specimen being grouped with the populations collected in Chapada dos Veadeiros, with long pedicels and petioles. The same is observed regarding the placement of the type specimen of *S. longispicata* subsp. *andersonii*. It was characterised by its "distinctly pedicellate flowers", while *S. longispicata* var. *longipedicellata* was similarly characterised by its "long-pedicellate flowers" (Moldenke 1974). This equal characterisation of both taxa was an early indication of weak taxonomic boundaries.

Thus, based on the morphometric results, it is possible to recognise all accepted varieties of *S. longispicata* that have sympatric distributions as a single taxonomic entity. In its current circumscription, *Stachytarpheta longispicata* var. *longipedicellata* is elevated to the species level and two new synonyms are proposed (*S. longipicata* var. *andersonii* and *S. longispicata* var. *parvifolia*). The name *Stachytarpheta longipedicellata* was chosen to represent this species, with the specific epithet referring to its main diagnostic feature (longer length of the pedicels).

Stachytarpheta longipedicellata is distinguished from the remaining taxa of this complex mainly by its flowers with pedicels equal to or longer than 2.43 mm, rachis, calyx, and pedicel lanuginose, with the hairs conferring a whitish aspect to the inflorescences. Regarding the observed variations on the analysed specimens, contrasting with Atkins (2005) circumscription, this species is a clump-forming shrub, 0.8–2 m tall, with leaf-blades 16.78–46.15 × 11.43–40.29 mm, inflorescences 89.14–702.35 mm long, bracts 4.29–10.49 mm long, calyx 8.29–14.22 mm long, and corolla 13.88–18.91 mm long. According to Atkins (2005), the leaves can be up to 55 mm long, but this measurement would also encompass the petiole, and in this study the petioles and leaf-blades were separately measured. Inflorescence length in the three varieties demonstrated by Atkins (2005) varied from 70 to 170 mm. However, we verified that inflorescences might be up to 700 mm long, being the longest ones from this species complex. When inflorescences are shorter than 90 mm, the specimens most likely represent young individuals. Furthermore, we observed that some specimens from Niquelândia have a more sparse indumentum on the leaves and inflorescences.

Stachytarpheta longispicata (Pohl) S.Atkins
Figs 6G–I, 7E–F, 8E–F, 11

Kew Bulletin 60: 229 (Atkins 2005). – *Melasanthus longespicatus* Pohl, *Plantarum Brasiliae Icones et Descriptiones* 1: 77, tab. 61 (Pohl 1827), basionym. – *Stachytarpheta chamissonis* Walp., *Synopsis Verbenacearum, Myoporinearum, Selaginearum, Stilbinearum, Globulariearum et Plantaginearum. Repertorium Botanices Systematicae* 4: 10 (Walpers 1845). **nom**. **illeg**. [superfluous name].

Material examined

Type

BRAZIL – **Goiás** • "Habitat in montosis arids, ad Serra de Cristaes [Serra dos Cristais] Capitaniae Goyas [Goiás]"; 1818; *J.B.E. Pohl s.n.*; lectotype: W[W0073831] web!, designated by Cardoso *et al.* (2020); isolectotypes: BR[BR0000008026668] web!, W[W0073832] web!.

Representative specimens

BRAZIL – **Goiás** • "Cristalina"; 21 Feb. 1992; *R. Mello-Silva et al. 559*; SPF • "Cristalina"; 4 Feb. 1987; *J.R. Pirani et al. 1523*; SPF • "Cristalina"; 4 Feb. 1987; *J.R. Pirani et al. 1613*; SPF • "Cristalina, beira de estrada"; 21 Apr. 2008; *J.F.B. Pastore & J.B.A. Bringel 2581*; HUEFS • "Cristalina, BR-040, 2 km L de Cristalina"; 13 Aug. 1980; *G. Hatschbach et al. 43059*; MBM • "Cristalina, BR-251"; 22 Jan. 1997; *G. Hatschbach et al. 66127*; ESA, MBM, SPF • "Cristalina, estrada para Salto do Arrojado"; 22 Jan. 1997; *G. Hatschbach et al. 66127*; MBM • "Cristalina, Linda Serra dos Topázios"; 13 Jun. 2004; *J.F.B. Pastore 1005*; CEN • "Cristalina"; 10 Sep. 1998; *V.C. Souza et al. 21465*; ESA • "Cristalina, RPPN Linda Serra dos Topázios"; 15 Dec. 1996; *C.E.B. Proença 1660*; UB • "Cristalina, Serra dos Cristais"; 8 Mar. 1966; *H.S. Irwin et al. 13774*; NY, RB • "Cristalina, Serra dos Cristais, 9 km by road S of Cristalina on road to Catalão"; 4 Apr. 1973; *W.R. Anderson 8104*; NY • "Cristalina, entrada para a RPPN Linda Serra dos Topazios"; 11 Mar. 2020, *P.H. Cardoso et al. 46*; CESJ • "Cristalina, RPPN Linda Serra dos Topazios"; 12 Mar. 2020; *P.H. Cardoso et al. 48*; CESJ.

Description

Clump-forming shrubs 0.7–1.2 m tall, erect, branched or unbranched, stems cylindrical, strigose to tomentose-hirsutulous, xylopodium present. Leaves opposite, patent, sometimes conduplicate, sometimes with smaller leaves on the axils, petiolate; petioles 3.7–14.22 mm long, strigose; blades 16.02–33.42 × 13.3–27.2 mm, ovate, subrhomboid or subrotund, thickly-chartaceous, slightly discolorous, base cuneate or attenuate, decurrent into petiole, apex acute, obtuse or rounded, margin entire near the base, crenate-serrate towards the apex, revolute, abaxially foveolate, tomentose-hirsutulous, veins evident forming a reticulate network, adaxially strigose. Inflorescences 183.22–562.61 × 17.95–24.5 mm, pendulous at the apex, rachis visible, tomentose-hirsutulous; bracts 4.3–6.79 × 0.91–1.51 mm, light green, triangular or narrowly triangular, apex caudate, abaxially tomentose-hirsutulous. Flowers pedicellate, pedicel 0.92–2.2 mm long, tomentose-hirsutulous; calyx tube narrow, widened at apex, 9.37–13.42 × 3.64–6.17 mm, light green, externally tomentose-hirsutulous at base, becoming strigose at apex, 5-toothed; corolla salmon, tube 13.66–17.88 cm long, externally with pedicellate glandular trichomes. Fruits 0.3–0.55 cm long, castaneous, external surface reticulate, with thin and flat commissure, apex rounded with short stylopodium, prominent attachment scar, separating into two cluses, covered by the persistent calyx.

Distribution, habitat and phenology

Stachytarpheta longispicata is endemic to the Serra dos Cristais region in the Cerrado domain of Goiás State (Fig. 5). It forms small and locally restricted populations growing in campos limpos (grasslands) and campos sujos (shrubby grasslands). Found fertile from January to April, and in June, August, September, and December.

Proposed conservation status

Stachytarpheta longispicata is endemic to the Serra dos Cristais region, with an estimated EOO of 38.121 km^2 and AOO of 30 km^2. It is not found inside protected areas, and its populations are clearly under anthropic influence, especially due to soybean and *Eucalyptus* crops and livestock (Ignácio 2014; Carvalho 2018). Furthermore, the municipality of Cristalina is the world's greatest quartz reserve and Brazil's largest gem commercial centre (Martinelli & Moraes 2013). Thus, *S. longispicata* should be

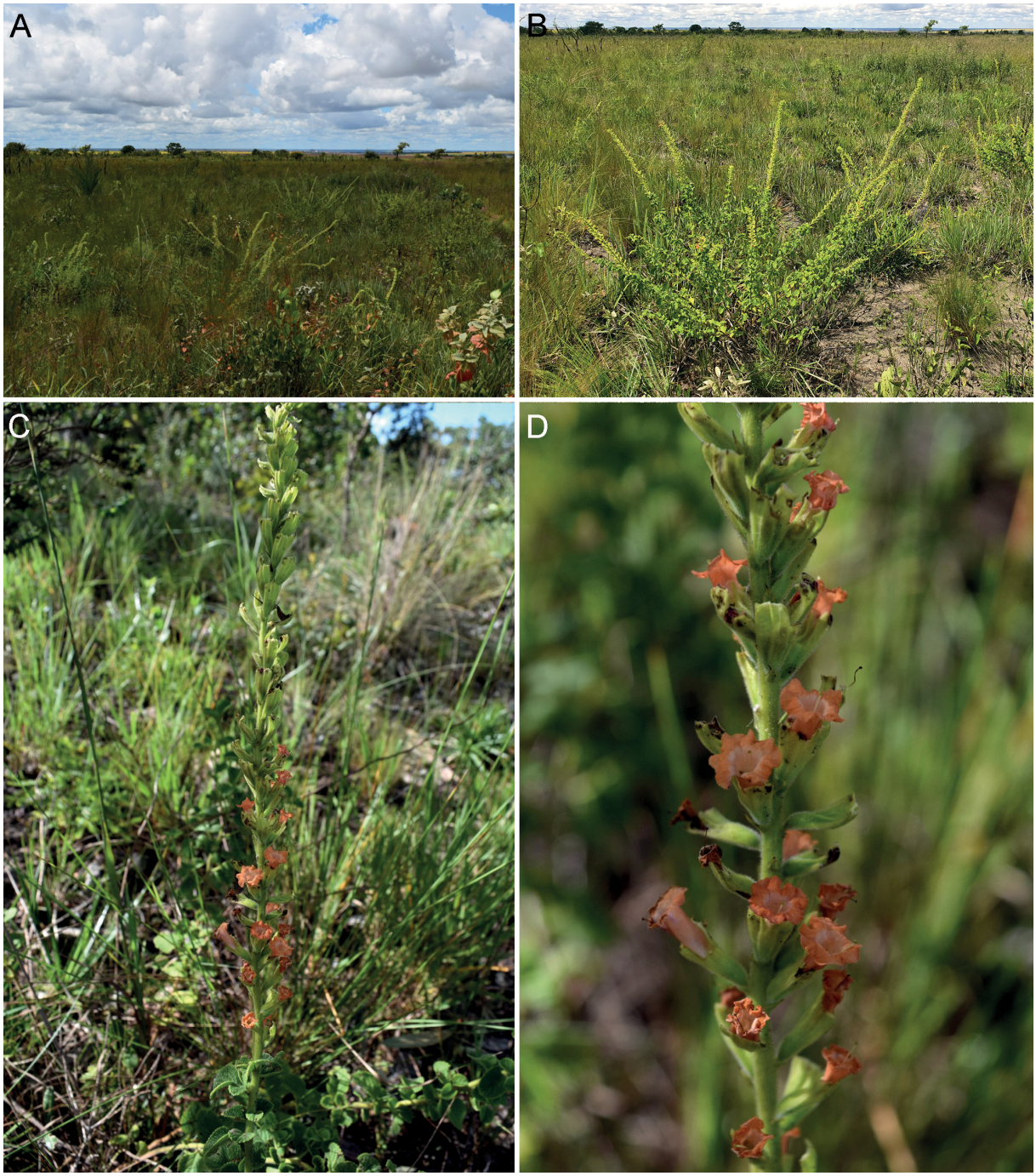

Fig. 11. *Stachytarpheta longispicata* (Pohl) S.Atkins. **A**. Habitat. **B**. Habit. **C–D**. Individuals showing details of the leaves and inflorescences, highlighting the short pedicels, bracts, calyxes, and corollas. Photos by Marcelo Trovó.

considered "Critically Endangered" (CR), based on the B2ab(i,ii,iii,iv) criteria, due to its EOO <100 km^2, fragmented distributions, number of known collections, and continuous decline in habitat quality (IUCN 2022).

Notes

Atkins (2005) characterised *Stachytarpheta longispicata* subsp. *longispicata* as a clump-forming shrub up to 1 m tall, branched, with a xylopodium, petiolate leaves, with small leaves on the leaf axils, leaf-blades fan-shaped, 15–4 × 12–30 mm, apex obtuse to rounded, base truncate to cuneate, inflorescence 250–330 mm long, pendulous at apex, rachis visible between the flowers, bracts narrowly triangular, ca 6 mm long and densely covered with uniseriate hairs, calyx ca 12 mm long, and corolla ca 18 mm long, ranging from orange to red. Despite not being the taxon most commonly and historically associated with the name *S. longispicata*, it certainly matches the species originally described by Pohl (1827) from Serra dos Cristais (Atkins 2005).

When comparing our current circumscription with the one proposed by Atkins (2005), it is possible to observe differences regarding plant stature, leaf-blade size, and length of the inflorescences, bracts, calyx and corolla. Atkins (2005) presents longer measurements for the leaves, which most likely represents the combined petiole and leaf-blade length. However, we presently provide the length of both structures independently. According to Atkins (2005), the leaves of *S. longispicata* subsp. *longispicata* are fan-shaped with a truncate or cuneate base. All specimens studied by the author were also analysed by us, where we observed ovate, subrotund and subrhombic leaves, with a cuneate or attenuate base, which is in agreement with the protologue: "*folia subrhombea, indivisa, crenata, ciliata, apice rotundata, integerrima, base cuneiformia, angustata*" (Pohl 1827).

Based on our morphometric analysis, plus qualitative data and distribution, it is possible to recognise *Stachytarpheta longispicata* subsp. *longispicata* exclusively at the species rank. *Stachytarpheta longispicata* is disjunct from the remaining pedicellate species of the genus, being restricted to the Serra dos Cristais, Goiás State. It is characterised by its ovate, subrhombic or subrotund leaves, 16.02–33.42 × 13.3–27.2 mm, flowers laxly arranged along the rachis, and calyx 9.37–13.42 mm long, tomentose-hirsutulous at base, becoming strigose towards the apex.

Despite Atkins (2005) citing this species as restricted to the Serra dos Cristais region, she provides a specimen list including collections from the municipality of Niquelândia. In the present study, these specimens from Niquelândia are recognised as *Stachytarpheta longipedicellata* due to their long pedicels and distribution in the same geographic area.

Stachytarpheta minasensis (S.Atkins) P.H.Cardoso comb. and stat. nov.
Figs 6J–L, 7G–H, 8G–H, 12

Stachytarpheta longispicata subsp. *minasensis* S.Atkins, *Kew Bulletin* 60: 231 (Atkins 2005), basionym.

Material examined

Type

BRAZIL – **Minas Gerais** • Serra do Cabral, Joaquim Felício; 15 Apr. 1996; *G. Hatschbach et al. 64789*; lectotype: MBM[MBM409619] web!, **designated here**; isolectotypes: CTES[CTES0013844] web!, K[K000065239] web!, K[K000065396] web!, MBM[MBM193011] web!.

Representative specimens

BRAZIL – **Minas Gerais** • "Joaquim Felício, Parque Estadual da Serra do Cabral"; 14 Sep. 2019; *F.R.G. Salimena & P.H. Nobre 4051*; CESJ • "Serra do Cabral, 85 km N de Corinto"; 13 May 1977; *P.E. Gibbs et al. 5059*; MBM, UEC • "Serra do Cabral, Joaquim Felício"; 15 May 2001; *G. Hatschbach et al. 72033*; MBM, RB.

Description

Shrubs 0.35–1 m tall, erect, much-branched, stems cylindrical when young, lanate, puberulent when old, xylopodium present. Leaves opposite, patent, flat, sometimes with smaller leaves on the axils, deciduous in maturity, petiolate; petiole 1.93–4.79 mm long, lanate; blade 8.19–15.88 × 6.32–14.35 cm, ovate or fan-shaped, thickly-chartaceous, slightly discolorous, base attenuate, apex obtuse or rounded, margin entire near the base, serrate towards the apex, revolute, abaxially not foveolate, lanate, veins prominent, adaxially sericeous. Inflorescences 27.04–237(–354.53) × 18.39–23.5 mm, pendulous or not at the apex, rachis visible, lanate; bracts 3.23–6.97 × 0.83–1.59 mm, light green, triangular, apex acuminate or caudate, abaxially sparsely lanate. Flowers pedicellate, pedicel 1.15–2.39 mm long, lanate; calyx tube widened at the apex, 8.21–14.55 × 3.2–5.29 mm, light green, lanate at base and along nerves, becoming strigose at apex, briefly 5-toothed; corolla salmon, tube 13.36–16.35 mm long, externally with pedicellate glandular trichomes. Fruits 3.8–5 mm long, castaneous, external surface reticulate, with thin and flat commissure, apex rounded with short stylopodium, prominent attachment scar, separating into two cluses, covered by the persistent calyx.

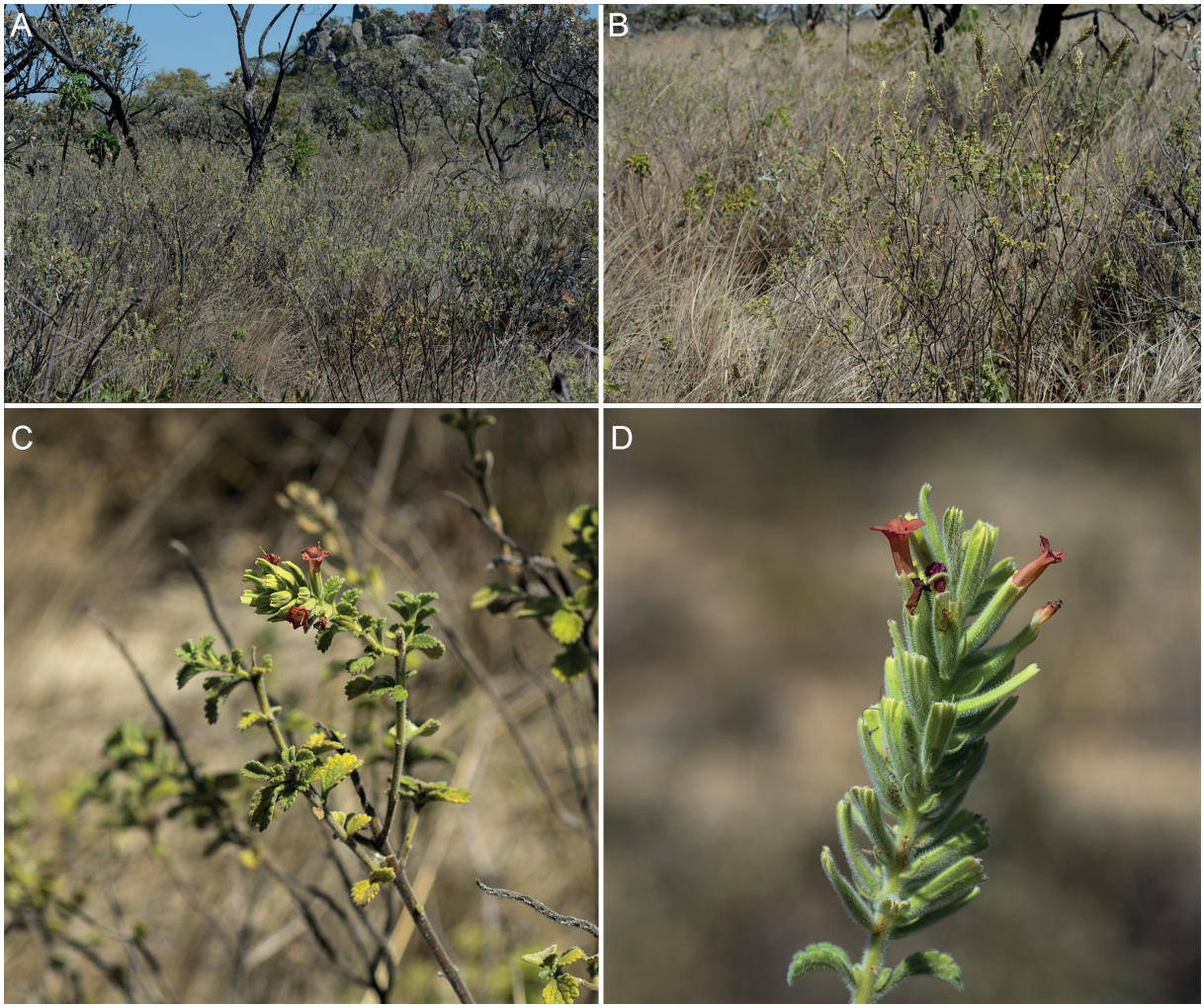

Fig. 12. *Stachytarpheta minasensis* (S.Atkins) P.H.Cardoso comb. and stat. nov. **A**. Habitat. **B**. Habit. **C–D**. Individuals showing details of the leaves and inflorescences, highlighting the short pedicels, bracts, calyxes, and corollas. Photos by Pedro Henrique Nobre.

Distribution, habitat and phenology

Stachytarpheta minasensis is endemic to the Cerrado domain in the Serra do Cabral region, state of Minas Gerais (Fig. 5). It forms large-sized but restricted populations in campos rupestres. Found fertile in April, May and September.

Proposed conservation status

Stachytarpheta minasensis is known from only two localities in Serra do Cabral, in the municipality of Joaquim Felício, with an AOO smaller than 10 km^2. Despite being found inside a protected area (Parque Estadual da Serra do Cabral), it is threatened by the continuous decline in habitat quality, especially due to livestock stomping and illegal fires, which prevail due to lack of inspection, warning and clarification (IEF 2013). Therefore, *S. minasensis* should be considered "Critically Endangered" (CR), based on the B2ab(i,ii,iii) criteria of IUCN (2022) due to its restricted AOO, fragmented distributions, number of known populations, and continuous decline in habitat quality.

Notes

Atkins (2005) indicated that the holotype of *Stachytarpheta longispicata* subsp. *minasensis* (*Hatschbach et al. 64789*) was housed at MBM. However, there are two different specimens of *Hatschbach et al. 64789* at MBM; in this framework it is not possible to ascertain which one is explicitly the holotype referred to by Atkins (2005) since she did not provide a clear indication of it. Therefore, we designate as the lectotype the specimen in which the inflorescences are complete and still present corollas.

Atkins (2005) characterised *Stachytarpheta longispicata* subsp. *minasensis* as a shrub 35 cm tall, with a xylopodium, branched, spathulate or ovate leaves, blades 5–20 × 3–10 mm, inflorescences 40–70 mm long, linear bracts up to 4 mm long, and calyx up to 10 mm long with uniseriate mostly patent hairs. According to Atkins (2005), this taxon has a micro-endemic distribution, being recognised by its very small leaves. When comparing the circumscription proposed by Atkins (2005), it is possible to observe differences regarding plant stature, size of the leaf-blades, and the length of the inflorescences, bracts, calyx and corolla. Regarding the size of the leaves, Atkins (2005) provides greater measurement ranges for length. However, these measurements are most likely associated with the smaller leaves on the axil of larger leaves (for which we only recorded their presence or absence), as well as the combined values for petiole and leaf-blade length (instead of being presented separately). Atkins (2005) described the leaves as spathulate to ovate. Nonetheless, the author sometimes applied the term spathulate to describe leaves that are considered fan-shaped (P.H. Cardoso pers. obs.).

Based on our morphometric analysis, as well as qualitative characters and geographic distribution, *Stachytarpheta longispicata* subsp. *minasensis* is elevated to the species rank. Therefore, *S. minasensis* differs from the remaining species of *Stachytarpheta* with pedicellate flowers due to its diminutive leaves (8.19–15.88 × 6.32–14.35 cm), ovate or fan-shaped, with attenuate base and conspicuously serrate margin.

Stachytarpheta ratteri (S.Atkins) P.H.Cardoso comb. and stat. nov.
Figs 6M–O, 7I–J, 8I–J, 13

Stachytarpheta longispicata subsp. *ratteri* S.Atkins, *Kew Bulletin* 60: 231 (Atkins 2005), basionym.

Material examined

Type

BRAZIL – **Distrito Federal** • Fazenda Água Limpa near Vargem Bonita; 15 Mar. 1976; *J.A. Ratter & S.F. da Fonseca 2775*; holotype: K[K000065168] web!; isotypes: NY[NY00956498] web!, UB web!, UEC n.v.

Representative specimens

BRAZIL – **Distrito Federal** • "Brasília área do Zoobotânico"; 10 Jan. 1967; *A.P. Duarte 10163*; RB • "Brasília, between University of Brasília and Lago Paranoá"; 11 Apr. 1968; *D. Philcox & E. Onishi 4767*; K, UB • "Brasília, Chapada Contagem"; 5 Feb. 1987; *J.R. Pirani et al. 1650*; K, SPF • "Brasília, estrada da Península perto do Clube do Congresso"; 29 May 1965; *D. Sucre 25*; RB • "Brasília, campus da Universidade"; 29 Sep. 1975; *F.H. F. Oldenburger 1627*; SPF • "Brasília, Fazenda Sucupira"; 6 May 1999; *J.G. Faria 107*; CEN • "Brasília, Fazenda Sucupira"; 18 Apr. 2007; *G.D. Vale 457*; RB • "Brasília, Fazenda Sucupira"; 13 Jan. 1998; *A.B. Sampaio et al. 153*; CESJ • "Brasília, Jardim Botânico de Brasília"; 13 Mar. 2020; *P.H. Cardoso et al. 51*; CESJ • "Brasília, Brasília, Parque Ecológico Burle Marx"; 7 Mar. 2021; *B. Schindler & M. Figueira 56*; CEN, CESJ • "Brasília, Jardim Botânico"; 10 Nov. 2009; *W. Alkimim & J.B.A. Bringel 86*; UB • "Brasília, Parque Boca da Mata"; 14 Jul. 1995; *J.M. de Rezende 4*; CESJ • "Brasília, Parque Nacional"; 22 Jan. 1978; *A. Krapovickas et al. 33180*; K • "Brasília, Parque Nacional de Brasília"; 14 Dec. 1990; *P.C.M. Ramos 482*; UB • "Brasília, Parque Nacional de Brasília"; 4 Nov. 1992; *M. Barros et al. 2220*; HUEFS, K • "Brasília, Reserva do CPAC"; 31 Jan. 2009; *D.M. Ramos 1*; CEN • "Brasília, Reserva Ecológica do IBGE"; 29 Mar. 2014; *V.C. Souza et al. 38219.0*; ESA • "Brasília, Reserva Ecológica do IBGE"; 24 Mar. 2016; *V.C. Souza et al. 40214*; RB • "Brasília, Planaltina, CPAC – Embrapa"; 5 May 1980; *J.A. da Silva 116*; CEN • "Brasília, Reserva Biológica de Contagem"; 5 Mar.

Fig. 13. *Stachytarpheta ratteri* (S.Atkins) P.H.Cardoso comb. and stat. nov. **A**. Habitat. **B**. Habit. **C–D**. Individuals showing details of the leaves and inflorescences, highlighting the short pedicels, bracts, calyxes, and corollas. Photos by Pedro Henrique Cardoso (A–B, D) and Maurício Mercadante (C).

2012; *M.R.V. Zanatta 1230*; RB • "Brasília, rodovia Brasília-Sobradinho"; 1 Apr. 1992; *R.F. Vieira 1223*; CEN • "Brasília, Rodovia Sobradinho/DF"; 15 Aug. 1999; *G. Pereira-Silva 4234*; CEN • "Brasília, Saia Velha"; 21 Feb. 2003; *F. França et al. 4600*; HUEFS. – **Goiás** • "Cocalzinho de Goiás"; 20 May 2006; *L.B. Bosquetti 305*; ESA • "Cocalzinho de Goiás, Serra dos Pireneus"; 24 Nov. 2007; *P.G. Delprete 10414*; NY • "Corumbá de Goiás, estrada velha da cidade eclética para Anápolis"; 31 Nov. 1990; *R.F. Vieira 625*; CEN • "Luziânia, estrada Brasília-Luziânia"; 20 Jul. 1990; *E. de Melo 314*; CEN • "Pirenópolis, Fazenda Lavras do Abade"; 8 Dec; 2018; *G.M. Antar 2532*; CEN • "Pirenópolis, Serra dos Pireneus"; 15 Jan. 1972; *H.S. Irwin et al. 34156*; NY • "Pirenópolis, Parque Estadual da Serra dos Pireneus"; 24 Feb. 2009; *F. Almeda et al. 9520*; UEC • "Planaltina"; 21 Apr. 2007; *H.D. Ferreira 4589*; UFG • "Planaltina, Rod. Go-118"; 12 Jun. 1993; *G. Hatschbach et al. 59296*; MBM.

Description

Clump-forming shrubs 0.5–2 m tall, erect, much-branched or unbranched, stems cylindrical, pubescent-tomentose, xylopodium present. Leaves opposite, patent, often conduplicate, sometimes with smaller leaves on the axils, petiolate; petiole 1.98–11.35 mm long, woolly; blade 19.32–45.67 × 24.96–48.52 mm, fan-shaped or obovate, coriaceous, slightly discolorous, base truncate, rarely cuneate, decurrent into petiole, apex obtuse to rounded, sometimes emarginate, margin entire near the base, crenate-serrate towards the apex, lightly revolute, abaxially foveolate, tomentulose, veins evident forming a reticulate network, adaxially strigose with abundant small brown nectaries. Inflorescences 218.9–601.04 × 19.97–28.44 mm, pendulous at the apex, rachis visible, pubescent-tomentose or lanate; bracts 6.13–9.51 × 1.11–1.77 mm, light green, triangular or narrowly triangular, apex acuminate or caudate, abaxially sericeous. Flowers pedicellate, pedicel 1.03–2.27 mm long, sericeous; calyx tube widened at the apex, 11.72–17.59 × 4.49–7.13 mm, light green, externally sericeous at base, becoming strigose at apex, 5-toothed; corolla salmon, tube 14.06–22.02 mm long, externally with pedicellate glandular trichomes. Fruits 0.42–0.5 cm long, castaneous, external surface reticulate, with thin and flat commissure, apex rounded with short stylopodium, prominent attachment scar, separating into two cluses, covered by the persistent calyx.

Distribution, habitat and phenology

Stachytarpheta ratteri is endemic to the Cerrado domain in the states of Goiás and Distrito Federal (Fig. 5), growing in campos rupestres, campos sujos (shrubby grasslands), campos limpos (grasslands), and disturbed areas. Its populations are generally large-sized, but fragmented. Found fertile throughout the year, except in October.

Proposed conservation status

Stachytarpheta ratteri has an estimated EOO of 7 537.960 km^2 and AOO of 224 km^2. Its populations are generally large-sized, but fragmented. The species is recorded for several regions in Distrito Federal and some municipalities of Goiás, west of Brasília, including protected areas (Parque Estadual da Serra dos Pireneus and Parque Nacional de Brasília). In the state of Goiás, the increased frequency of illegal fires for agricultural purposes, mining activities, unorderly touristic activities, and invasive species represent the greatest threats for *S. ratteri* (Salmona *et al.* 2014; Santos 2018; Castro 2019). In Brasília, the constant urban expansion (Anjos 2015) is the most important threat to this species. Therefore, *S. ratteri* should be considered "Endangered" (EN), based on the B2ab(i,ii,iii) criteria (IUCN 2022), due to its AOO $<$ 500 km^2, fragmented populations, and threats causing the continuous decline of its AOO, EOO and habitat quality.

Notes

Atkins (2005) characterised *Stachytarpheta longispicata* subsp. *ratteri* as a clump-forming shrub up to 2 m tall, with a xylopodium, unbranched, petiolate leaves, blades 30–50 × 25–40 mm, inflorescences up to 730 mm long, rachis not visible at apex, linear bracts ca 7 mm long, calyx ca 16 mm long, corolla orange

to rusty, and tube ca 20 mm long. According to Atkins (2005), it represents the taxon most commonly associated with the name *S. longispicata*, with large leaves, long inflorescences, and restricted to Distrito Federal. When comparing our present circumscription with the one proposed by Atkins (2005), it is possible to observe differences in the size of the leaves and length of the inflorescences, bracts, calyx, and corolla. Once again, these inconsistencies about the size of the leaves are caused by the petiole and leaf-blade lengths being combined by Atkins (2005), while we present them separately. The author also described the inflorescences as being up to 730 mm long and the rachis not visible at the apex. However, during the analysis of the specimens cited by Atkins (2005), we observed that the inflorescences reach only up to 600 mm in length and that despite the flowers being more congested at the inflorescence apex (compared with *S. longispicata*), the rachis is always visible.

Based on our morphometric analysis as well as qualitative characters, and geographic distribution, *Stachytarpheta longispicata* subsp. *ratteri* is elevated to the species rank. Therefore, *S. ratteri* can be differentiated from the remaining species of *Stachytarpheta* with pedicellate flowers by its leaf-blades large (19.32–45.67 × 24.96–48.52), coriaceous, with base frequently truncate, rarely cuneate, abundant small brown nectaries adaxially, sericeous pedicels, and calyx externally sericeous at base, becoming strigose towards the apex. Its distribution is expanded to the state of Goiás (Atkins 2005; Cardoso & Salimena 2020).

Discussion

Atkins (2005) recognised seven infraspecific taxa for *Stachytarpheta longispicata* s. lat., all poorly delimited. Our morphometric analyses proved to be valuable for the taxonomy of the *S. longispicata* complex, highlighting existing morphological discontinuities across the four subspecies and indicating that it is better to treat the three varieties recognised by Atkins (2005) as a single taxon.

There is a continuous confusion regarding the recognition of infraspecific taxa in literature, and on the other hand, different areas of biological knowledge have used the species as a basic study unit (van Steenis 1955; Hamilton & Reichard 1992; de Queiroz 2007; Knapp 2008). In this context, our results strongly support the recognition of five distinct species within the *S. longispicata* complex under the morphological species concept (Stuessy 2009).

Considering the five species recognised in this study, the main morphological differences between them are: regarding the pubescence, *S. longipedicellata* is distinguished by lanuginose calyxes, while *S. brevibracteata* has tomentose calyxes. The leaves are adaxially strigillose in *S. brevibracteata*, sericeous in *S. minasensis*, while in *S. longispicata* and *S. ratteri* they are strigose. Such characteristics were not properly detailed in previous descriptions (Atkins 2005; Cardoso & Salimena 2020). Regarding the leaves, *Stachytarpheta minasensis* comprises specimens with smaller leaf-blades compared to other species in the complex, while *S. ratteri* has wider leaf-blades. This is in agreement with Atkins (2005), who differentiated *S. longispicata* subsp. *minasensis* from *S. longispicata* subsp. *longispicata* by its smaller leaves, and *S. longispicata* subsp. *ratteri* by its longer and wider leaves. Regarding the inflorescences, *S. brevibracteata* and *S. minasensis* seem to be more closely related to each other due to their much shorter racemes. However, the first presents more delicate bracts of smaller size, aside from its narrower calyx tube. *Stachytarpheta longispicata* has flowers more laxly arranged along the inflorescences compared to other species. Pedicel length was not explored by Atkins (2005), but this feature is taxonomically important for the complex. All varieties recognised by Atkins (2005) were united as a single taxon, *S. longipedicellata*, mainly due to their longest pedicels. Thus, the main diagnostic characteristics for species distinction are related to leaf size, pedicel length, calyx width and shape, as well as leaf and calyx pubescence.

Other studies on species complexes in Verbenaceae demonstrate the importance of using various evidence to support taxonomic decisions (O'Leary *et al.* 2012b; Moroni *et al.* 2016, 2019). In this context, the combination of morphometric and morphological data warrants the recircumscription of the *Stachytarpheta longispicata* complex. Our study improves the knowledge on the richness of *Stachytarpheta* in Brazil, with a special contribution to the flora of the Cerrado, as these five recognised species are endemic to this biodiversity hotspot and considered as endangered.

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Supplementary file

Supp. file 1. Matrix with the studied specimens and the quantitative characters measured for the morphometric analysis of the *Stachytarpheta longispicata* complex. For explanation of OTUs see Table 2; for character codes see Table 3.
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