

UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL  
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**TAXONOMIA E BIOGEOGRAFIA DE ESPÉCIES SUBTROPICAIS DE  
*SINNINGIA* (GESNERIACEAE)**

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Dissertação apresentada ao Programa de Pós-Graduação em Botânica como um dos requisitos para obtenção do grau de Mestre em Botânica, pela Universidade Federal do Rio Grande do Sul.

Orientador: Prof. Dr. Jorge Luiz Waechter

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**SUMÁRIO**

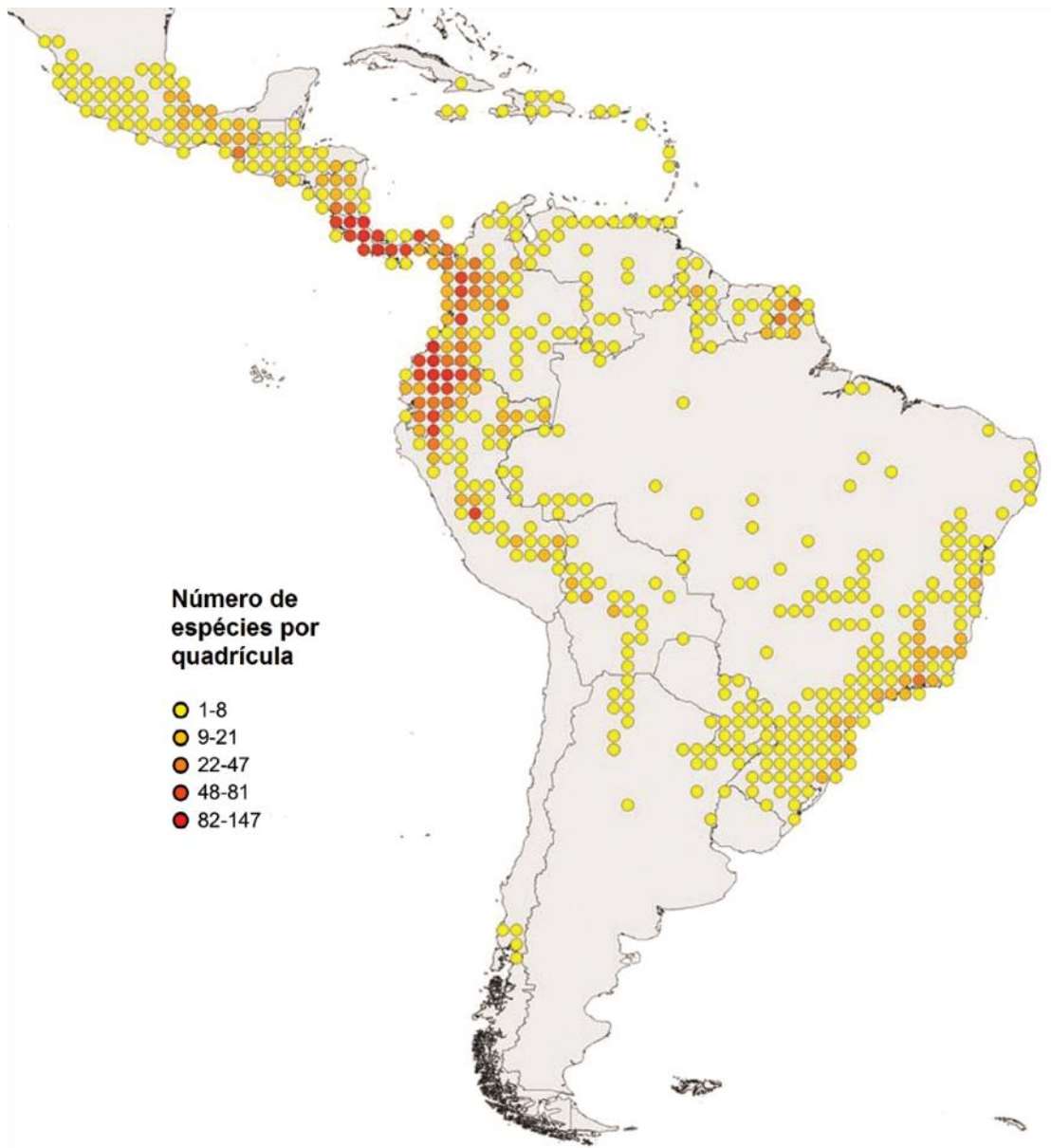
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## **INTRODUÇÃO GERAL**

A família Gesneriaceae possui cerca de 150 gêneros e 3200 espécies e apresenta distribuição essencialmente pantropical, ocorrendo poucas espécies nas zonas temperadas. Em sistemas atuais a família é dividida em duas subfamílias, Gesnerioideae e Didymocarpoideae (Weber 2004, Möller et al. 2009). Gesnerioideae, com mais de 1000 espécies, ocorre principalmente nos neotrópicos, porém Coronanthereae, ocorre disjunta entre os Andes temperados e a Australasia. (Möller et al. 2009, Perret et al. 2013). Didymocarpoideae, com mais de 85 gêneros e 2200 espécies, ocorre nos paleotrópicos e apresenta suas relações filogenéticas ainda pouco resolvidas (Möller 2009).

A maior diversidade da família situa-se na província Pacífica de Cabrera & Willink (1980), mais precisamente no sul da América Central (Costa Rica – Panamá) até o noroeste da América do Sul (Colômbia – Equador) (Fig. 1) (Wiehler 1983, Skog & Boggan 2007, Perret et al. 2013). No Brasil ocorrem cerca de 30 gêneros e 215 espécies, sendo que aproximadamente dois terços destes táxons se encontram na província Atlântica, com uma importante concentração e forte endemismo na região Sudeste, habitando principalmente a Mata Atlântica (Araújo & Chautems 2013). As espécies Amazônicas ainda são pouco conhecidas, devido principalmente aos baixos dados de coletas em uma superfície muito grande.



**FIGURA 1.** Distribuição e riqueza de espécies de Gesneriaceae na América (modificado de Perret et al. 2013).

A família ocupa uma variedade extremamente ampla de habitats, ocorrendo desde o nível do mar até ca. 3000 m de altitude. Entretanto, ainda não é possível definir padrões gerais de habitat, embora um único fator ambiental seja recorrente, a alta umidade (Weber 2004).

Gesneriaceae teve uma provável origem no Cretáceo Superior na América do Sul, na região compreendida entre os Andes temperados e a Floresta Amazônica. O tempo estimado de divergência entre Didymocarpoideae e Gesnerioideae é de 44,7 milhões de anos atrás, portanto não suportando uma hipótese de que a diversificação da família tenha

acontecido por um evento de vicariância no Cretáceo, com a ruptura de Gondwana (Perret et al. 2013).

Embora Gesneriaceae tenha recebido considerável atenção referente à morfologia, filogenia e classificação, pouca importância tem sido dada à biogeografia da família ou dos principais clados. Assim como acontece com muitos táxons tropicais, as gesneriáceas ainda são mal compreendidas no que diz respeito à história biogeográfica, pois não há estudos que explorem as possíveis explicações dos padrões de distribuição dos clados no Novo Mundo. Parte da dificuldade em entender a origem e os padrões biogeográficos globais em Gesneriaceae é a falta de pólen fóssil ou microfósseis (Roalson et al. 2008).

*Sinningia* Nees pertence à tribo Sinningieae, juntamente com *Paliavana* Vandelli e *Vanhouttea* Lemaire, sendo que somente o primeiro ocorre no Rio Grande do Sul. *Sinningia* é um gênero neotropical que inclui cerca de 75 espécies (Skog & Boggan 2007). Perret et al. (2003) demonstraram que *Sinningia* é um gênero parafilético que, para se tornar monofilético, teria que incluir *Paliavana* e *Vanhouttea*. Neste caso *Paliavana* teria prioridade nomenclatural (Buzzato & Singer 2012). Assim, provavelmente será proposta uma nova circunscrição visando principalmente a estabilidade nomenclatural (Chautems com. pess.).

O gênero é distribuído do México ao norte da Argentina, com o centro de diversidade na Floresta Atlântica brasileira (Perret et al. 2006). No Brasil ocorrem 67 espécies de *Sinningia*, sendo 56 endêmicas, além de nove espécies de *Vanhouttea* e seis de *Paliavana*, todas endêmicas (Araújo & Chautems 2013). O centro de diversidade é o Sudeste do Brasil (Wiehler 1983, Chautems et al. 2010). Um grande número de espécies é encontrado ao longo de cadeias montanhosas dentro da Mata Atlântica brasileira e um número menor de espécies ocorre em áreas ocupadas por vegetação sazonal, como as florestas decíduas da bacia do rio Paraná-Paraguai, o cerrado do Brasil Central, e as caatingas do nordeste do Brasil. Apenas seis espécies se estendem além dos limites do Brasil e duas são completamente extrabrasileiras (Perret et al. 2006, Chautems et al. 2010).

As espécies de *Sinningia* são arbustivas, subarbustivas ou herbáceas, frequentemente com tubérculos, destacando-se pela variabilidade de ambientes ou substratos que ocupam. Podem ocorrer em diversos tipos vegetacionais, como florestas pluviais, montanas e estacionais, restingas, estepes, savanas, campos rupestres e campos de altitude. Quanto ao substrato, as espécies nativas no estado podem ser terrícolas, paludícolas, rupícolas ou epifíticas (Chautems 2008, Araújo & Chautems 2013).



Na concepção atual de *Sinningia*, existem três clados principais. Segundo Perret et al. (2006), o clado *Corytholoma* teve sua diversificação ao norte da Floresta Atlântica, enquanto o clado *Dircaea* diversificou-se no área compreendida pela bacia do rio Paraná. A migração de *Corytholoma* para o sul da Floresta Atlântica e do clado *Dircaea* para o norte pode ter sido interrompida por uma barreira ecofisiológica, como uma região mais árida, referida como uma das causas para as diferenças florísticas ao longo da Mata Atlântica costeira (Brown 1987, Oliveira-Filho & Fontes 2000, Behling & Negrelle 2001).

O objetivo deste trabalho foi realizar um estudo taxonômico e biogeográfico do gênero *Sinningia* para a região Subtropical da América do Sul. Na abordagem taxonômica foram elaboradas descrições morfológicas, chaves dicotômicas e ilustrações diagnósticas das espécies nativas. Na abordagem biogeográfica, foram detectados padrões de distribuição das espécies e da riqueza de espécies, com base em regiões fisiográficas, climáticas e geomorfológicas, compiladas em um sistema que leva em consideração todos estes fatores.

Os dados referentes às espécies e suas ocorrências foram buscados através de três fontes principais: pesquisas bibliográficas, consultas a herbários e coletas próprias. As pesquisas bibliográficas foram buscadas nos meios de divulgação científica, que continham informações taxonômicas, ecológicas e fitogeográficas dos táxons. Foram revisados os principais herbários nacionais e internacionais digitalizados: B, G, G-DC, HAS, HBR, HPL, HUICS, ICN, K, MBM, PACA, US e R. Os dados levantados incluíram 10 variáveis geográficas e ecológicas para as espécies, que por sua vez formam plotados em uma matriz binária. Essas matrizes foram analisadas usando métodos multivariados.

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## APRESENTAÇÃO

Esta dissertação é composta por dois capítulos e seus respectivos artigos:

### **Capítulo 1. Estudo taxonômico de *Sinningia* Nees (Gesnerioideae: Gesneriaceae) no Rio Grande do Sul, Brasil**

Artigo 1. *Sinningia* ×*vacariensis* (Gesneriaceae) from Southern Brazil, the first natural hybrid described for the genus. O manuscrito segue o formato da revista *Phytotaxa*, na qual foi publicado em conjunto com Jorge Luiz Waechter e Alain Chautems.

Artigo 2. *Sinningia ramboi* (Gesneriaceae) a new species from South Brazil. O manuscrito segue o formato da revista *Systematic Botany*, na qual foi aceito em conjunto com Jorge Luiz Waechter e Alain Chautems.

Artigo 3. A new striking disjunct record of *Sinningia bullata* Chautems & M. Peixoto (Gesneriaceae) in South Brazil. O manuscrito segue o formato da revista *Phytotaxa*, para a qual será submetido em conjunto com Alain Chautems e Jorge Luiz Waechter.

Artigo 4. Taxonomy of *Sinningia* (Gesneriaceae) in Rio Grande do Sul, South Brazil. O manuscrito segue o formato da revista *Phytotaxa*, para a qual será submetido em conjunto com Alain Chautems e Jorge Luiz Waechter.

### **Capítulo 2. Biogeografia do gênero *Sinningia* Nees (Gesneriaceae) na América do Sul Subtropical**

Artigo 5. Subtropical species of *Sinningia* (Gesneriaceae): distribution patterns and limiting environmental factors. O manuscrito segue as instruções de formato da revista *Annals of Botany*, na qual será submetido em conjunto com Pedro M. A. Ferreira, Alain Chautems e Jorge Luiz Waechter.

**Capítulo 1. Estudo taxonômico de *Sinningia* Nees (Gesnerioideae: Gesneriaceae) no Rio Grande do Sul, Brasil**

## Artigo 1.

### ***Sinningia* × *vacariensis* (Gesneriaceae) from Southern Brazil, the first natural hybrid described for the genus**

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#### **Abstract**

In this paper we describe and illustrate *Sinningia* × *vacariensis* a naturally occurring hybrid between *S. lineata* and *S. macrostachya*, from rocky outcrops inside an Araucaria forest in Rio Grande do Sul, Brazil.

#### **Resumo**

Neste trabalho, descreve-se e ilustra-se *Sinningia* × *vacariensis*, um híbrido natural entre as espécies *S. lineata* e *S. macrostachya*, ocorrendo em afloramentos rochosos no interior da floresta com Araucária no Rio Grande do Sul, Brasil.

**Keywords:** Gesneriaceae, rocky outcrop, hybridization, clade Dircaea.

#### **Introduction**

Hybrids between species of the Gesneriaceae family are easy to produce and numerous crosses were obtained by horticulturists and plant growers as appears in the list kept by the Gesneriad society ([http://www.gesneriadsociety.org/ir\\_ges/index.htm](http://www.gesneriadsociety.org/ir_ges/index.htm)). Interspecific hybrids also have been used in an effort to delimit cenospecies and improve classification within the genus *Sinningia* Nees (1825: 297) (Clayberg 1996). Naturally occurring hybrids can also occur, but are rarely reported (Puglisi *et al.* 2011). In Brazil some hybridization events were strongly suspected, based on morphological observation in the field or on herbarium specimens for *Nematanthus* Schrader (1821: 718) (Araújo *et al.* 2005, Chautems 1988, Chautems & Kiyama 2003) and *Vanhouttea* Lemaire (1845: 346) (Chautems 2002, SanMartin-Gajardo 2005).

For *Sinningia*, a few examples of individuals intermediate between two parent species were observed in the field (Chautems, pers. obs.), but never formally registered or published. A first case is here documented involving two species of this genus that counts over 60 species of shrubs, sub-shrubs or tuberous herbs occurring in a broad range of geographic regions and growing under distinct ecological conditions (Araújo & Chautems 2012, Chautems 2010). Based on morphological studies of herbarium, living material and field studies, we describe a new hybrid species between *S. lineata* (Hjelmquist 1937: 302) Chautems (1990: 385) and *S. macrostachya* (Lindley 1828: 1202) Chautems (1990: 386), from rocky outcrops inside an *Araucaria* forest in Rio Grande do Sul, Brazil.

***Sinningia* ×*vacariensis* G.E. Ferreira, Waechter & Chautems *nothosp. nov.* Fig. 1  
A–F**

Type:—BRAZIL. Rio Grande do Sul: Vacaria, Afloramento rochoso no interior da Floresta com Araucária, próximo ao Rio Pelotas, 28°12'42"S, 50°45'35"W, 660 m, 18 November 2012, G.E. Ferreira and C. Vogel-Ely 235 (holotype ICN, isotype G).

**Plants rupicolous** with erect stems arising from tubers; **Stems** 80–100 cm long, pilose, green with reddish streaks. **Leaves** opposite-decussate, subequal, petiole 1.5 cm long, tomentose, concolorous; blade ovate–elliptic, 8–15 cm long, 7–12 cm wide, obtuse at the apex, cordate or sometimes unequal at the base, margin irregularly crenate, 4–5 pairs of veins, above strigillose, below whitish-tomentose. **Inflorescences** cymose, composed of pair-flowered cymes, borne in the axils of bracts or upper leaf pairs over the ca. 30 cm long apex of the axis; peduncles 0.5–2 cm long, green with reddish streaks, hirsute; pedicels ascending 0.5–2 cm long, green with reddish streaks, hirsute. **Calyx** ovate, tube 2–3 mm long, hoary-tomentose, lobes linear-lanceolate, 4–6 mm long, acuminate, margin entire, green, pilose. **Corolla** erect in calyx, tubular, 2.5–3 cm long, red, pilose, base with 5 gibbositities between the calyx lobes, tube constricted above base, 3–4 mm wide, then expanding gradually to 5–7 mm wide at throat, limb spreading, lobes 5, with many dark red dots, unequal, ca. 4 × 4 mm; **Stamens** 4, included, filaments 2.9–3.2 cm long, glabrous, anthers coherent, rectangular, pollen white, nectary consisting of two separate dorsal glands; **Ovary** 6 mm long, 2 mm wide, hispid, style 2 cm long, green, pubescent. Fruit a dry two-valved capsule, 0.9–1.1 cm long, and 0.4–0.6 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, brown.

**Distribution and habitat:**—This hybrid occurs in the Vacaria municipality in Rio Grande do Sul, next to the Pelotas River. We located only one individual, growing on basaltic rock outcrops within an Araucaria forest, close to streams or in shaded habitats, between 600 and 800 m in elevation (Fig. 2).

**Etymology:**—The name of the nothospecies is derived from the municipality “Vacaria” where the plant was first encountered.

### **Discussion**

In the framework of a taxonomic and biogeographic survey of tribe Sinningieae in Rio Grande do Sul we came across a plant that drew our attention by its inflorescence and flower structure intermediate between *S. lineata* and *S. macrostachya*, (Fig. 3 A–F). Detailed observations led us to conclude that we had found a case of natural hybrid between these species.

As for morphological characters, *S. macrostachya* has opposite leaves, ovate to elliptic, 8–15 × 5–9.5 cm, petiole 2.5 cm, distributed in 4–7 whorls, (frondo)-bracteose florescence with cymes (Chautems & Weber 1999), peduncle up to 1 cm, corolla 2.8 cm, orange to red, with few vinose dots mostly on ventral and lateral lobes. *S. lineata* has opposite leaves, elliptical to ovate, 9.5–15 × 7–14 cm, disposed in 1–2 whorls, petiole 4.5 cm, shoot reduced to frondose florescence with a well-developed pair-flowered cymes (Chautems & Weber 1999), peduncle 7–15 cm, corolla 2.8–3.5 cm, orange to reddish, all lobes with vinose dots. *S. ×vacariensis* clearly presents morphological characteristics intermediate between the two species: leaves opposite-decussate, ovate to elliptic, 8–15 × 7–12 cm, distributed in 3 whorls, petiole 1.5 cm long, frondo-(bracteose) florescence

with cymes, peduncle 0.5–2 cm long, corolla 2.5–3 cm long, lobes with vinose dots on ventral and lateral lobes and dark red dots on dorsal lobes.

*S. macrostachya* is a species that has a rather wide distribution in southern Brazil and a neighbouring area in Uruguay (Grela & Brussa 2005), occurring in sunny rock outcrops from sea level to an altitude of 1000 m, whereas *S. lineata* has a restricted distribution, occurring in shaded rock outcrops in the forests and steep slopes along the Pelotas, Canoas, Uruguay and Antas rivers. As both species inhabit different environments, the likelihood of hybridization can be considered as low. However, the hybrid *S. ×vacariensis* was collected where the areas of occurrence of the two species overlap, on a rocky outcrop within a forest, at the mouth of the Socorro River, which flows into the Pelotas River. At this site, the two habitats of both parental species are in close proximity (ca. 300 m). Probably this hybrid has originated from cross-pollination by hummingbirds, since the two species have the same pollination syndrome. This hybridization event is not surprising as the two parent species are phylogenetically closely related as inferred from their sister position within clade Dircaea in recent molecular studies (Perret *et al.* 2003; 2007).

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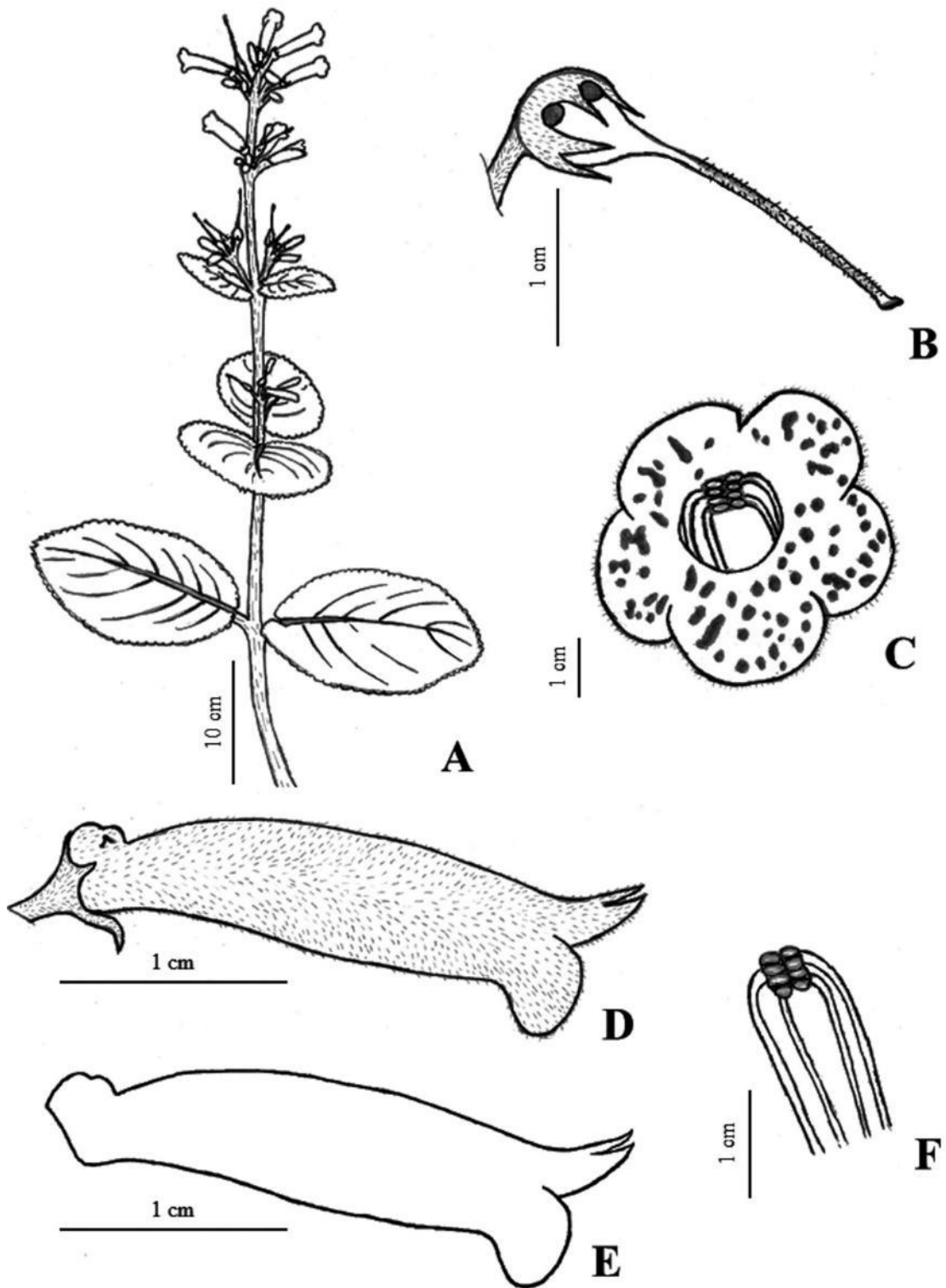
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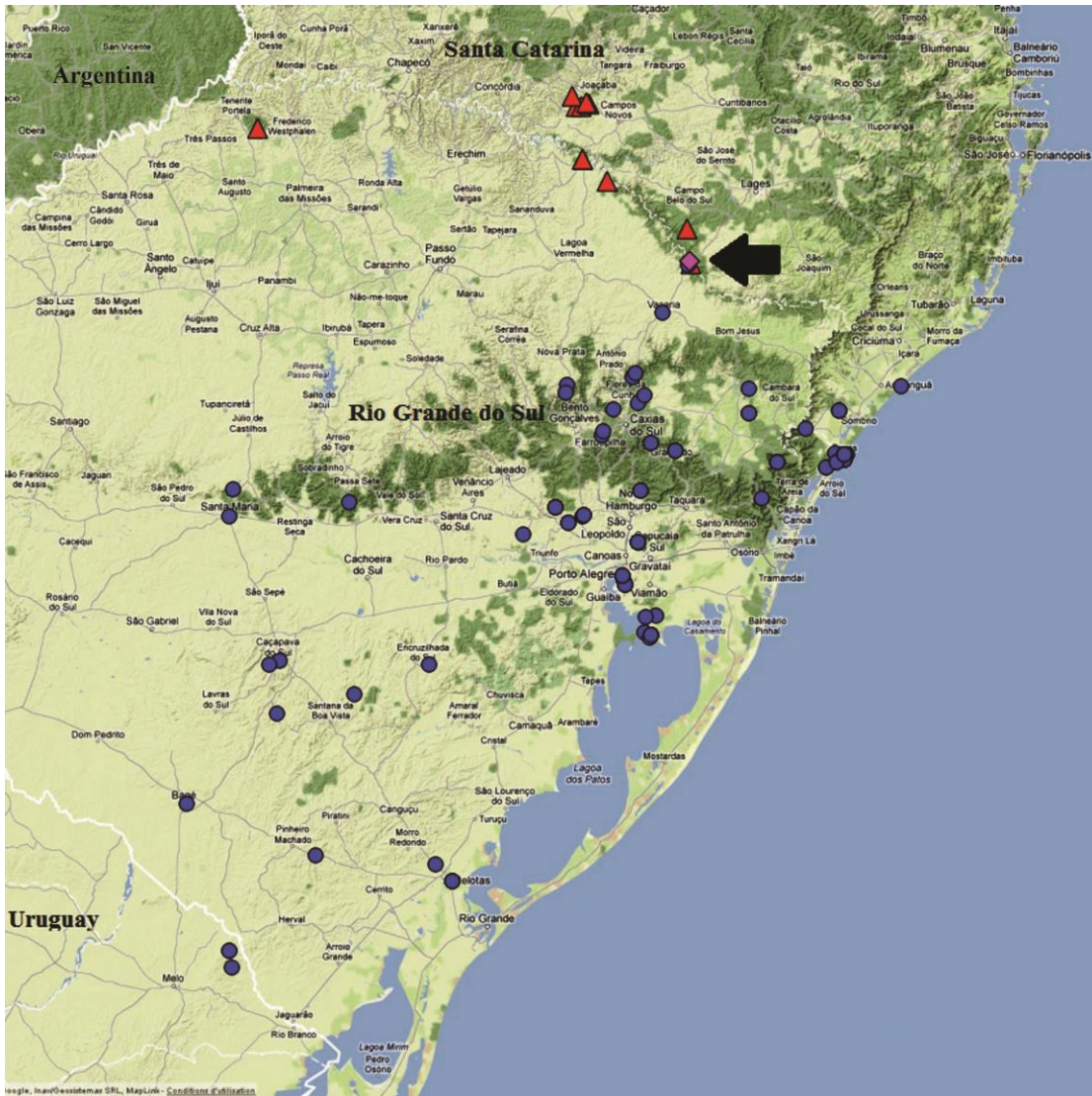
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**FIGURE 1.** A–F. *Sinningia*  $\times$  *vacariensis* (from the holotype). A. Habit. B. Ovary with calyx. C. Corolla opening, front view. D. Calyx with corolla. E. Corolla without calyx and trichomes. F. Anthers details with front view.



**FIGURE 2.** Distribution of *Sinningia macrostachya*, *S. lineata* and *S. xvacariensis* in South America, showing the overlapping area. Blue circle. *S. macrostachya*. Red triangle. *S. lineata*. Pink lozeng. *S. xvacariensis*.



**FIGURE 3.** A–F. Comparison between the two species and the hybrid. A–B. *Sinningia macrostachya*. A. Habit. B. Detail of flower. C–E. *S. x vacariensis*. C. Habit. D. Detail of inflorescence. E. Detail of flower F–G. *S. lineata*. F. Habit. G. Detail of flower.

## **Artigo 2.**

FERREIRA ET AL.: NEW SPECIES OF SINNINGIA

### ***Sinningia ramboi* (Gesneriaceae) a New Species From South Brazil**

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**Abstract**—In this paper we describe and illustrate *Sinningia ramboi* (Gesneriaceae), a new species occurring on rocky outcrops in the upper parts of the canyons cutting the plateau of high altitude grasslands in Rio Grande do Sul, Brazil. This new species bears some similarity to *S. polyantha*, *S. nivalis*, and *S. douglasii*, but is readily distinguished by opposite leaves and a much shorter main axis of the inflorescence. Ecological and distributional data, as well as a key to distinguish these related species, are also presented.

**Keywords**—Endemism, Rio Grande do Sul, rocky outcrops, Sinningieae, taxonomy.

*Sinningia* Nees (Sinningieae: Gesneriaceae), is a genus with ca. 70 species of tuberous herbs or subshrubs distributed from southern Mexico to northern Argentina (Chautems et al. 2010). The center of diversity for the genus lies in southeast Brazil (Perret et al. 2007; Araujo and Chautems 2013). The largest number of species is found along mountain ranges within the Brazilian Atlantic Rain Forest but a lower number of species also occurs in areas occupied by seasonal vegetation, such as the semi-deciduous forests of the Paraná-Paraguay river basin, the cerrados of central Brazil, and the caatingas of northeastern Brazil (Chautems 2008; Perret et al. 2013).

In the framework of a taxonomic and biogeographic survey of tribe Sinningieae in Rio Grande do Sul we came across a plant that drew our attention by its leaves, inflorescence, and flower structure that differ from other related species, especially *S. nivalis* Chautems, a species that also occurs along several canyons that cut the high plateau in the north of the state. A similar plant had appeared in 2001 among seed of *S. polyantha* (DC) Wiehler (known at this time as *S. "Waechter"*) distributed by the Gesneriad Society Seed Fund that was received and grown by Mr. Alan LaVergne near San Francisco, California. Observing that the seed produced a plant not typical for *S. polyantha*, and different from any previously known *Sinningia*, Mr. LaVergne distinguished this morphologically divergent plant under the name *Sinningia "Desafinado,"* as reported in his website <http://www.burwur.net/sinns/0desafin.htm>. Material of this accession was then cultivated in the greenhouse at the Conservatoire et Jardin Botaniques

de la Ville de Genève (under #AC-3515). Based on morphological studies of dry herbarium specimens and living material in natural habitats and cultivated collections, we describe here this new species.

#### MATERIALS AND METHODS

Specimens were collected during field work carried out at the Canyons Fortaleza and Itaimbézinho, in Cambará do Sul, Rio Grande do Sul, Brazil, in November of 2012. Living specimens were photographed in the field using a digital camera (Nikon Coolpix P-100). All pressed material is deposited in the ICN and G herbaria and living material is kept in the living collection at the Conservatoire et Jardin Botaniques de la Ville de Genève (under #AC-3515), in the greenhouse of Mr. Mauro Peixoto, near Mogi das Cruzes, Brazil, and in Alan LaVergne's private collection near San Francisco, California, U. S. A. Some flowers were preserved in 70% ethanol and used to draw floral features. Additional collections from B, G, HAS, HPL, ICN, MBM, and PACA were also studied.

#### TAXONOMIC TREATMENT

***Sinningia ramboi*** G. E. Ferreira, Waechter and Chautems, sp. nov.—TYPE: BRAZIL. Rio Grande do Sul: Cambará do Sul, Cânion Fortaleza, afloramento rochoso próximo a escarpa do cânion, 14 Nov 2012, *G. E. Ferreira and C. Vogel-Ely* 236 (holotype: ICN!; isotype: G!).

Planta rupicola, tota villosa, foliis paribus oppositis venae purpureis vel vinaceis; *S. douglasii* et *S. nivalis* affinis sed petiolis magis longis et inflorescentia



non pseudo-umbellata super brevem axem 3-6 cm; corolla carmesina cum punctis vinaceis versus ostium differt.

Rupicolous herbs, perennial, with erect stems arising from tubers, stems 7–20 cm long, unbranched, pilose, green to reddish. Leaves opposite, arranged in 1–2 nodes, subequal, internode 0.2–0.8 cm, petiole 1.5–3 cm long, pilose, vinaceous; blade ovate–elliptic, 6–11 × 4–8 cm, acute at the apex, obtuse or slightly cordate or unequal at the base, margin irregularly serrate, 6–7 pairs of veins, adaxial surface green and puberulent, abaxial surface green to purplish and pubescent, with midrib and major veins reddish to vinaceous. Inflorescences terminal, with a short main axis 3–6 cm, ramified in 3–5 peduncles bearing pair-flowered cymes; peduncles 1–3 cm long, reddish, pilose; pedicels ascending 1–3 cm long, reddish, pilose; flowers protandrous. Calyx campanulate, tube 2–4 mm long, lobes 6–8 mm long, triangular at base, subulate at the apex, margin entire, reddish to vinaceous, pilose. Corolla erect in calyx, tubular, 2.2–2.8 cm long, dark pink to crimson with vinaceous streaks and dots toward the upper half, puberulent to pilose, pubescent, 2–3 mm wide at base, enlarged in nectary chamber formed by five gibbosities, the two dorsal ones larger than the other three that are barely visible, tube constricted above base, then expanding gradually to 4–6 mm wide at throat, limb spreading, lobes 5, unequal, ventral and lateral lobes 3–4 × 4 mm, the two dorsal ones 2–3 × 4 mm, overlapping slightly. Stamens 4, included, filaments 2–2.5 cm long, glabrous, anthers coherent, rectangular, pollen white; nectary consisting of two separate dorsal glands, ca. 2

mm long, whitish. Ovary superior,  $8 \times 3$  mm, hispid, style 2.1–2.6 cm long, reddish, puberulent; stigma slightly capitate. Fruit a dry two-valved capsule,  $1.1\text{--}1.5 \times 0.5\text{--}0.7$  cm, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid,  $0.5\text{--}0.6$  mm long, brown. Figures 1, 2.

***Distribution and Ecology***—*Sinningia ramboi* is known only from Cambará do Sul, a municipality in the northeastern highlands of Rio Grande do Sul state (Fig. 3). The major vegetation types in this region are araucaria forests and montane grasslands of the Atlantic Forest biome. *Sinningia ramboi* occurs predominantly on rocky outcrops near the abrupt escarpments of the canyons (Fig. 2F) at ca. 1000 m elevation, but can also grow epiphytically in the nearby forests. The species has a relatively large population around the upper edges of Fortaleza canyon.

***Phenology***—Flowers from September to December, fruits from November to March.

***Etymology***—The name “*ramboi*” refers to Father Balduino Rambo (1906–1961), a well known botanist of Rio Grande do Sul and active defender of the forest and grassland landscapes of the northeast highlands. Rambo also collected the earliest herbarium specimen of this new species.

***Conservation Status***—Endangered (EN) B1ab, according to the IUCN criteria, based on the extent of occurrence estimated to be less than 5,000 km<sup>2</sup> in only two locations (IUCN 2013).

***Diagnostic Characters and Relationships***—*Sinningia ramboi* is

morphologically similar to *S. polyantha*, *S. douglasii*, and *S. nivalis*, species that all belong to the clade Dircaea and are nested within a larger group of species that all possess tubular corollas (Perret et al. 2003, 2006). All four species have a terminal inflorescence composed of pink flowers with vinaceous streaks and dots inside their corolla tube, as well as the lobes. We can separate *S. ramboi* from the above mentioned species by its opposite leaves that are arranged in 1–2 nodes versus whorled leaves; ovate blades with a cordate base that are green to purplish and puberulent abaxially, with all the major veins vinaceous; an inflorescence with a shorter main axis (3–6 versus greater than 7 cm in the other three taxa); terminal inflorescence with the main axis ramified in 3–5 peduncles bearing pair-flowered cymes (Chautems and Weber 1999); and dark-pink to crimson flowers versus the light-pink flowers of other species (Table 1).

Two major lines of evidence suggest that *S. ramboi* is a distinct species and not a result of hybridization among similar species from the region: 1) the morphological characteristics that distinguish *S. ramboi* (i.e. opposite leaves and short inflorescences) occur consistently in large populations in the natural habitat; opposite leaves may occur rarely in *S. polyantha* and then only in juvenile plants; 2) although on a small scale distribution map the three species appear sympatric, they are in fact not co-occurring in the same habitat; *S. nivalis* occurs farther north mostly at higher elevations (1200–1500m), while *S. douglasii* occurs at lower elevations (0–800m), when found at the latitude of *S. ramboi*.

Among these morphologically related species, *S. douglasii* has the widest

distribution as it occurs epiphytically in humid forests on mountain slopes between 300 and 1,200 m elevation from Minas Gerais to Rio Grande do Sul and part of Misiones in Argentina (Fig. 3).

Local habitat use seems to have occurred in relation to the steep escarpments around the canyons in southern Santa Catarina and northeastern Rio Grande do Sul. On and around the higher altitude grasslands and rocky outcrops, *S. ramboi* occurs in the Fortaleza and Itaimbezinho canyons, whereas *S. nivalis* occurs around the Monte Negro canyon and neighbouring regions on the Serra Geral plateau. In contrast, *S. polyantha* occupies habitats near the coast, occurring among scrubby and herbaceous vegetation on sand dunes that is commonly called “restinga” in Brazil (Fig. 4). The time of divergence of the four species can be estimated to have occurred between three and one million years ago (Perret et al. 2013), suggesting that these species are derived from the most recent radiation events within genus *Sinningia*.

KEY TO DISTINGUISH *SINNINGIA RAMBOI* FROM RELATED SPECIES

- 1. Leaves opposite; leaf-blades green to purplish, with vinaceous veins on the lower surface, main inflorescence axis short (3–6 cm), corollas dark-pink to crimson with vinaceous streaks ..... *S. ramboi*
- 1. Leaves typically whorled; leaf blades entirely green or greenish, with green to pinkish veins on the lower surface, main inflorescence axis more than 7 cm long, corolla light pink with vinaceous streaks ..... 2
  - 2. Leaves arranged in 3–4 nodes, clearly separated along the erect stems; plants mostly terrestrial in coastal sandy dunes in restinga vegetation ..... *S. polyantha*

2. Leaves arranged in 1–2 nodes, closely grouped at the apex of the erect stems ..... 3
3. Calyx lobes 5–7 mm long; pedicels hirsute; petioles 0.3–2.5 cm long; plants usually rupicolous, rarely epiphytic ..... *S. nivalis*
3. Calyx lobes 2–3 mm long; pedicels puberulent; petioles 2.5–6 cm long; plants usually epiphytic, rarely rupicolous ..... *S. douglasii*

**Additional Specimens Examined**—BRAZIL. Rio Grande do Sul: Cambará do Sul, Cânion Itaimbézinho, in araucarieto, ad arbores, (fr.), 18 Dec. 1950, *B. Rambo* 49387 (B); Cânion Itaimbézinho, in araucarieto, epiphyta, 3 Nov. 1954, *B. Rambo* 56197 (B, HBR); Cânion Itaimbézinho, afloramento rochoso próximo a escarpa do cânion, 18 Nov 2012, *G. E. Ferreira and C. Vogel-Ely* 237 (G, ICN); Cânion Fortaleza, rupícola, flor vermelha com manchas vinosas, paredão rochoso, 19 Nov. 2008, *J. M. Silva et al.* 7379 (MBM); Cânion Fortaleza, alto do morro sobre pedras, Mar. 1987, *J. Mattos et al.* 30993 (HAS); Cânion Fortaleza, junto aos peraus da fortaleza, Sept 1981, *O. Bueno* 3062 (HAS); fundo da cascata do Rio das Antas, estrada para a S. Rocinha, Sept 1975, *C. R. Dillenburger s. n.* (HAS); Rupestre, Formação campestre, 06 Oct 2012, *M. H. Nervo*, 779 (ICN); Faxinal, erva em interior de mata, Dec. 1983, *M. Sobral and J. R. Stehmann* 2794 (ICN); beira de peraus, nas pedras, flores vermelhas, Oct 1993, *N. Silveira* 11619 (HAS); na mata, 8 Nov. 1986, *R. Wasum and alunos s. n.* (HUCS, US).

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TABLE 1. Comparisons of morphological characters for *Sinningia ramboi* and related species.

Traits/Species	<i>S. douglasii</i>	<i>S. nivalis</i>	<i>S. polyantha</i>	<i>S. ramboi</i>
<b>Number of nodes</b>	1–2	1–2	3–4	1–2
<b>Leaf arrangement</b>	6-whorled	6-whorled	3-whorled	Opposite
<b>Petiole length (cm)</b>	2.5–6	0.3–2.5	0.2–3	1.5–3
<b>Leaf blade, abaxial</b>	Pubescent	Tomentose	Tomentose	Puberulent
<b>Main inflorescence axis (cm)</b>	7–28	7–17	10–26	3–6
<b>Pedicel</b>	Puberulent	Hirsute	Tomentose	Pilose
<b>Calyx lobes (mm)</b>	2–3	5–7	3–4	6–8
<b>Corolla color</b>	Light pink with vinaceous streaks	Light pink with vinaceous streaks	Light pink with vinaceous streaks	Dark pink to crimson with vinaceous streaks
<b>Corolla length (cm)</b>	3.5–5	2.8–3.3	3–3.5	2.2–2.8
<b>Corolla lobe length (mm)</b>	6–7	6	3–4	3–4
<b>Nectary glands</b>	2 dorsal separate	2 dorsal separate	2 dorsal united basally	2 dorsal separate
<b>Habitat</b>	Slopes of mata atlântica	High altitude grasslands	Restinga	High altitude grasslands
<b>Substrate</b>	Epiphytic, rarely rupicolous	Rupicolous	Sandy soil, rarely rupicolous or epiphytic	Rupicolous, rarely epiphytic

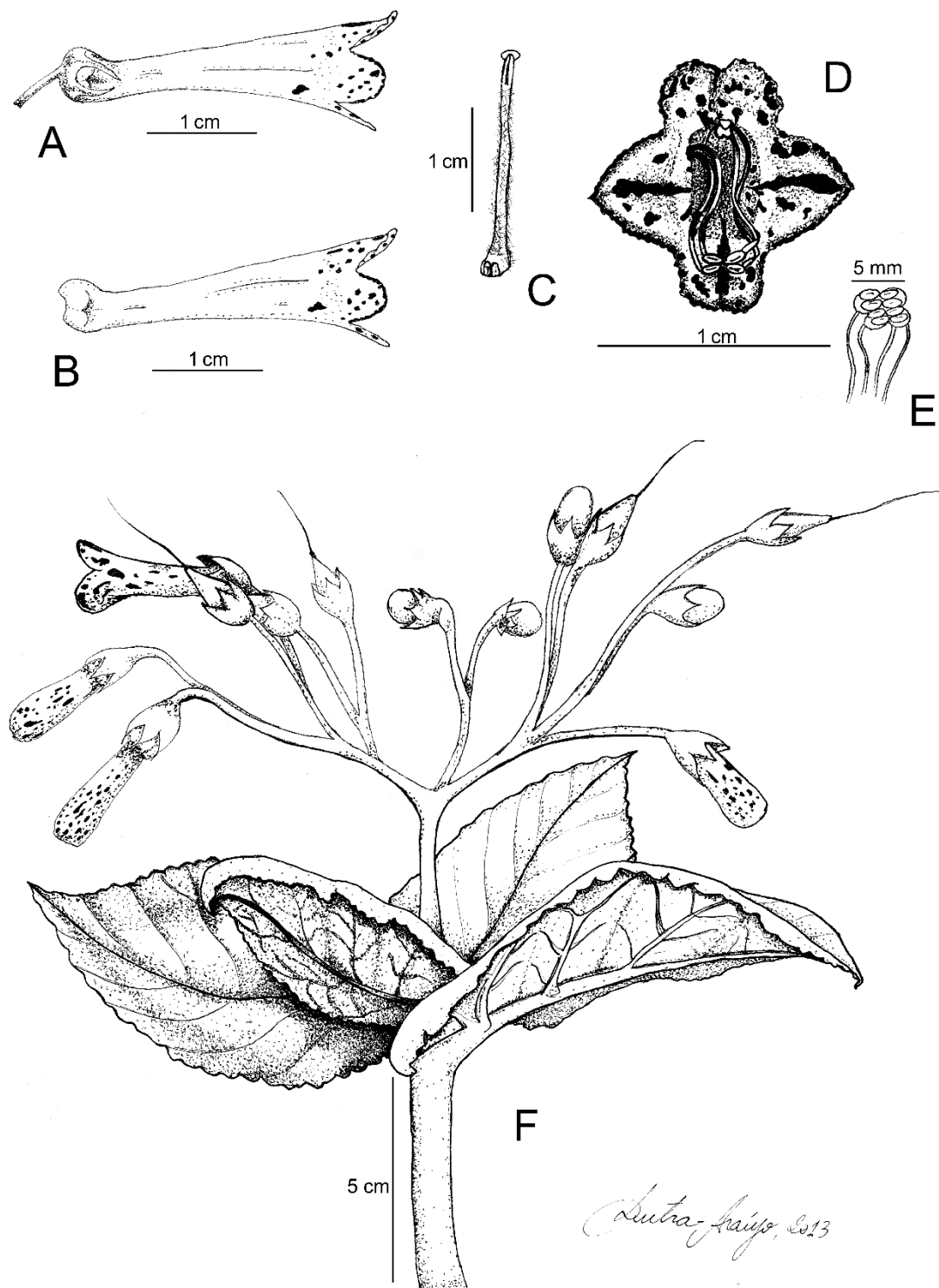


FIG. 1. *Sinningia ramboi* (from G. E. Ferreira and C. Vogel-Ely 236). A. Corolla without calyx and trichomes. B. Corolla outline in lateral view. C. Ovary and style. D. Corolla in front view. E. Anthers in front view. F. Habit.



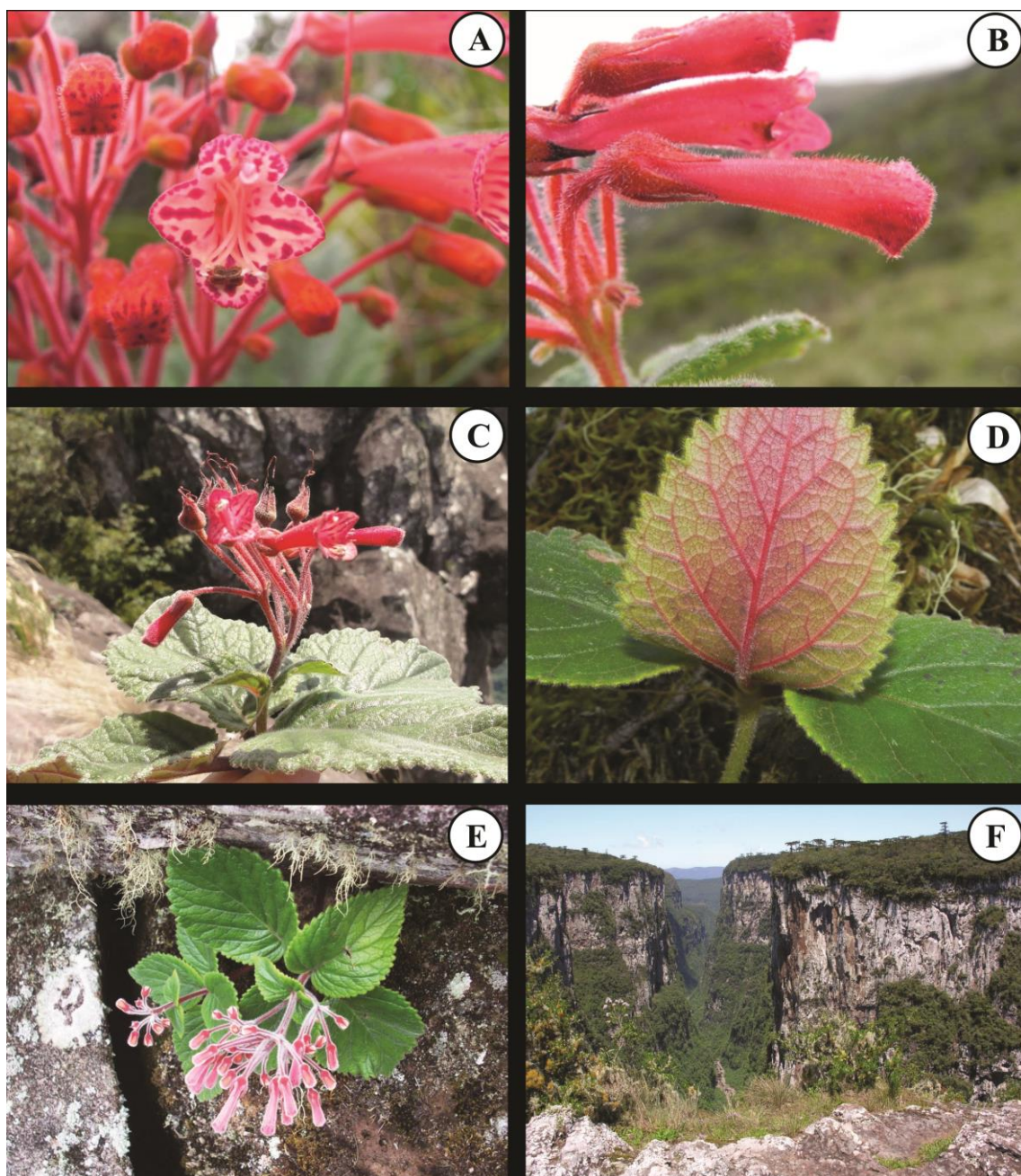


FIG. 2. *Sinningia ramboi*. A. Corolla, in frontal view. B. Corolla, calyx and pedicel in lateral view. C. Inflorescence. D. Leaf venation on the lower surface. E. Habit of a single plant. F. General view of the species habitat. (A-B-E from G. E. Ferreira and C. Vogel-Ely 236; C from M. Nervo 779).

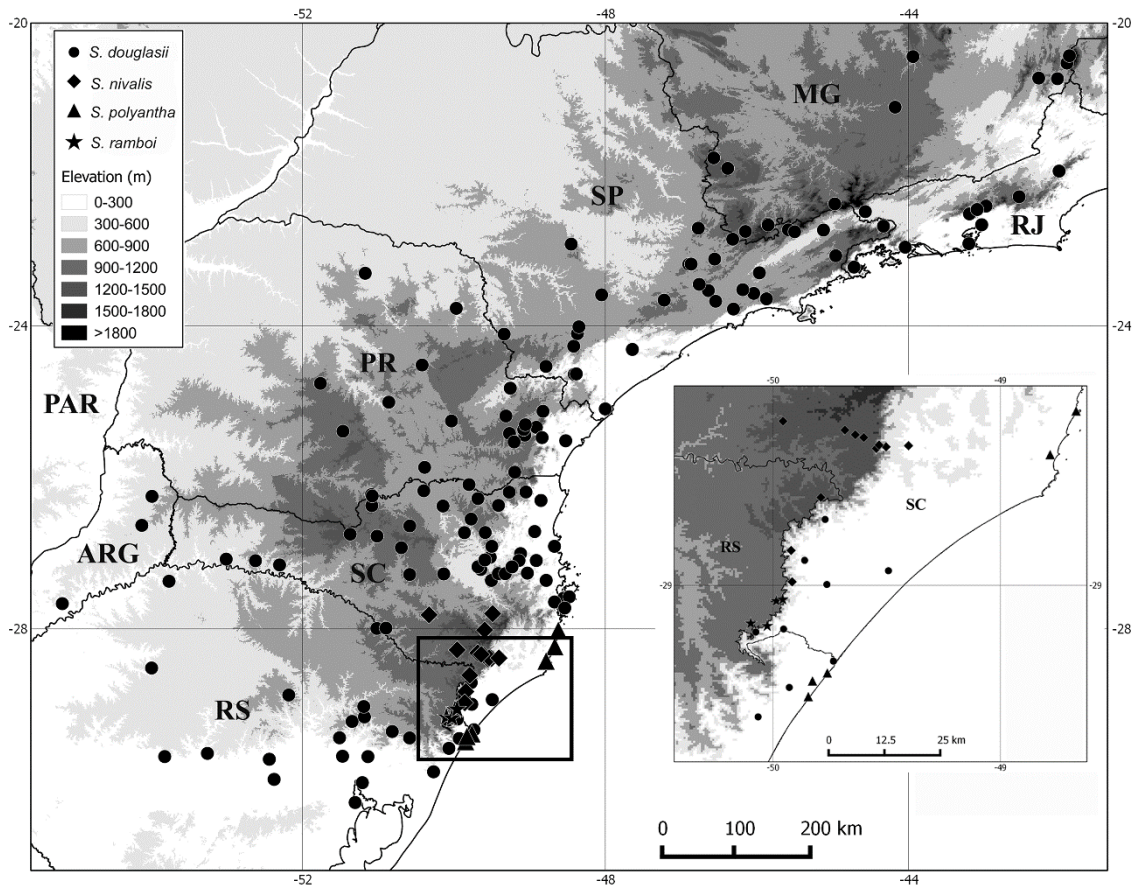


FIG. 3. Distribution of *Sinningia ramboi* and related species in South America. Close-up of the radiation zone in the steep escarpments around the canyons in southern Santa Catarina (SC) and northeastern Rio Grande do Sul (RS).

### Artigo 3

#### A new striking disjunct record of *Sinningia bullata* Chautems & M. Peixoto (Gesneriaceae) in South Brazil

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#### Abstract

*Sinningia bullata*, a narrow endemic species in Santa Catarina was found at a new site in Rio Grande do Sul, ca. 210km southwards and ca. 800msm upwards in relation to the type location. The paper includes a description, illustrations and a dichotomous key to distinguish the species from other related species occurring in the same region. Environmental data comprise a distribution map, comments on ecology and geography, and the updated conservation status of the species.

**Keywords:** geographic disjunctions, rare species, rupestral plants, subtropical endemisms, South Brazil.

#### Introduction

The neotropical genus *Sinningia* Nees (1825: 297) (Gesneriaceae, Sinningieae) is formed by ca. 70 species of tuberous herbs or subshrubs, distributed from southern Mexico to northern Argentina (Chautems *et al.* 2010). The largest number of species is found along mountain ranges within the Brazilian Atlantic rain forest, and a lower number of species occurs in areas occupied by seasonal vegetation, such as the semi-deciduous forests of the Paraná-Paraguay river basin, the cerrados of central Brazil, and the caatingas of northeastern Brazil (Chautems 2008, Perret *et al.* 2013). The diversity centre of the genus lies in southeast Brazil (Perret *et al.* 2007, Araújo & Chautems 2013).

According to Chautems *et al.* (2010) who recently described *Sinningia bullata* Chautems & M. Peixoto (2010: 242), the species was so far only known from the type locality, on Santa Catarina Island, South Brazil. In this way, the species was the geographically most confined among a small set of narrow subtropical endemism, including *S. lineata* (Hjelmquist 1937: 302) Chautems (1990: 385), *S. polyantha* (De Candolle 1839: 528) Wiehler (1981: 383), and *S. ramboi* Ferreira *et al.* (2014)(Chautems *et al.* 2010, Ferreira *et al.* 2013).

This paper presents the first record of *S. bullata* for the State of Rio Grande do Sul and provides a brief taxonomic description, comments on ecology and geographic distribution, conservation status and a dichotomous key for the identification of four related species occurring on rocky outcrops in the eastern highlands of southernmost Brazil.

## Material & Methods

Specimens of *S. bullata* were collected during field work carried out at the Canyon Fortaleza (ca. 1100msm), in Cambará do Sul, Rio Grande do Sul, Brazil, in October of 2013. Living specimens were photographed in the field using a digital camera (Nikon Coolpix P-100). All pressed material is deposited in the ICN and G herbaria. Additional collections from G, HBR and ICN were also studied. Plants in cultivation were also observed in the collection of Mauro Peixoto (sítio Primavera, Mogi das Cruzes, Brazil) and at the Conservatoire et Jardin botaniques de la Ville de Genève (Switzerland).

## Results and Discussion

The plants found in Rio Grande do Sul share the striking features of *Sinningia bullata*, *i.e.* strongly bullate leaves, dense woolly indumentum on the abaxial sides of the leaves, and corolla 3–4 cm long. However, the specimens present reduced and seasonal stems, which may be a response to the much higher elevation (and thus colder climate), and the pilosity on the pedicels and calyx is less dense than the type material. Below we present a new description based on the material collected at the new occurrence in Rio Grande do Sul.

*Sinningia bullata* Chautems & M. Peixoto, Candollea. 65: 242. Type: BRAZIL. Santa Catarina: Município de Florianópolis, Ilha de Santa Catarina, Alto Ribeirão, Testa do Macaco, ca. 315 m, 6.III.2006, A. Reis *et al.* 5040 (holotype: HBR!; isotypes: G!, HUMC, US). Fig. 1A–E.

**Rupicolous herb**, with aerial stems arising from superficially exposed tubers. **Stems** 10–15 cm long, usually unbranched, covered by a dense woolly indumentum. **Leaves** decussate, 1–2 nodes, equal in a pair, petiole 0.5–1 cm long, light green; blades elliptic to obovate, 4–6 cm × 3–4.5 cm, chartaceous, apex obtuse to rounded, base acute to cuneate, vivid green, adaxial surface bullate and glabrous, especially at young stage, abaxial surface covered with a white, dense woolly indumentum beneath at young stage, becoming looser and light brownish on older leaves, margin irregularly crenate, 5–7 pairs of veins. **Inflorescence** a frondose florescence with pair-flowered cymes with 1–8 flowers. Flowers borne on pedicels, 3–4.5 cm long, reddish. **Calyx** narrowly campanulate, fused at the base for ca. 0.3 cm, lobes 0.5 cm long, narrowly lanceolate, apex acute, base truncate, margin entire, pale green, pubescent. **Corolla** tubular, erect in the calyx, 3–4 cm long, ca. 4 mm in diam. at base, tube 2.5–3 cm long, 4–6 mm wide, orange, pubescent, limb nearly regular, lobes 8–10 × 10–12 mm, spreading and forming a right angle with the tube, the 2 dorsal ones narrower, up to 7–8 mm wide, tube inside light orange with darker lines, extending over the lateral and ventral lobes. **Stamens** 4, included, filaments ca. 2 cm long, white, glabrous, anthers coherent, all together in frontal view star-shaped, pollen cream; nectary formed by two completely separate glands. **Ovary** greenish, style ca. 2.5 cm, white, glabrous. **Fruit** not seen.

**Phenology:**—flowers from October to November, fruits from November to December.

**Distribution and habitat:**—*Sinningia bullata* occurs in South Brazil, where it is currently known from single places in the states of Santa Catarina and Rio Grande do Sul. In the former state the species occurs on granitic outcrops in a more shaded environment at 315msm. In the later state the species inhabits rhyolitic outcrops exposed to full light

and eventually strong winds at 1100msm, at the upper edges of the southeast escarpment of Fortaleza canyon (Fig. 2D).

**Conservation status:**—According to the ICN criteria, this species can be classified as Endangered (EN) B1ab, based on the extent of occurrence estimated to be less than 5,000 km<sup>2</sup> in only two locations (IUCN, 2013).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Cambará do Sul; Cânion Fortaleza, borda da escarpa sudeste do cânion, 1079 m alt., 15 October 2013, *G.E.Ferreira et al.* 238 (ICN, G); **Santa Catarina:** Florianópolis; Testa do Macaco, Alto Ribeirão, 400 m, 13 December 1972, *A.Bresolin* 661 (HBR); Testa do Macaco, Alto Ribeirão, 450 m, 12 January 1973, *A.Bresolin* 678 (HBR); Alto Ribeirão, Testa do Macaco, ca. 315 m, 6 March 2006, *A.Reis et al.* 5040 (HBR, G).

Until now, this species was recorded only from the type locality, a hill called “Testa do Macaco”, (ca. 315msm) covered with humid forest and with some rocky outcrops near the top. On this hill, the species was found at a humid and shaded place, only a few km south of the city of Florianópolis, Santa Catarina (Chautems *et al.* 2010) (Fig. 2E–F). The new record extends the area of occurrence of the species much more to the south, as the new finding place lies some 210 km far away (Fig.3). The habitat also differs strikingly from the former known occurrence, as the new population of about 15 individuals was growing on basaltic outcrops at the upper edges of the escarpment (ca. 1100msm), southeast of the Fortaleza canyon. Additionally the new occurrence extends the elevation difference in ca. 800msm. The vegetation around the rocky outcrops is formed by a mosaic of the high-altitude fields, peat-bogs, and cloud forests (Fig. 3). The particular place where *S. bullata* grows is subject to high radiation and strong winds, a xerophytic habitat shared with a cactus (*Parodia haselbergii* subsp. *graessneri* (K.Schum.) Hofacker & P.J.Braun (1998: 6) Fig. 2D). These factors may be possibly causing the reduced stems (10–15 cm long vs. 15–30 cm long) and the smaller leaves (4–6 × 3–4.5 cm vs. 7–15 × 4–10 cm) in comparison to the type description.

One possible explanation for the relatively great latitudinal and altitudinal disjunction of *Sinningia bullata* is the scarcity of plant collections along the steep slopes of the eastern highlands of Santa Catarina and Rio Grande do Sul. Although the entire region was surveyed in an early paper by Rambo (1956), and more recently included in a review by Iganci *et al.* (2011), the rupestral sites near the edges of the escarpments were possibly overlooked by many botanists more concerned with forest, peat-bog or grassland vegetation. The recent finding of *S. bullata* suggests that other interesting plants species may be found on the rocky outcrops near the Serra Geral escarpments, and that this species in particular may be found elsewhere in similar habitats.

#### **Key to distinguish *Sinningia bullata* from related species**

1. Leaves inserted along 4–7 nodes ..... *S. macrostachya*
- Leaves inserted along 1–2 nodes ..... 2
2. Leaf-blades green to purplish, veins vinaceous on the abaxial surface ..... *S. ramboi*
- Leaf-blades green, veins always green on the abaxial surface ..... 3

3. Leaves 9.5–15 × 7–14 cm, not bullate, abaxial surface pale green, tomentose ..... *S. lineata*
- Leaves 4–6 × 3–4.5 cm, bullate, abaxial surface white, dense woolly ..... *S. bullata*

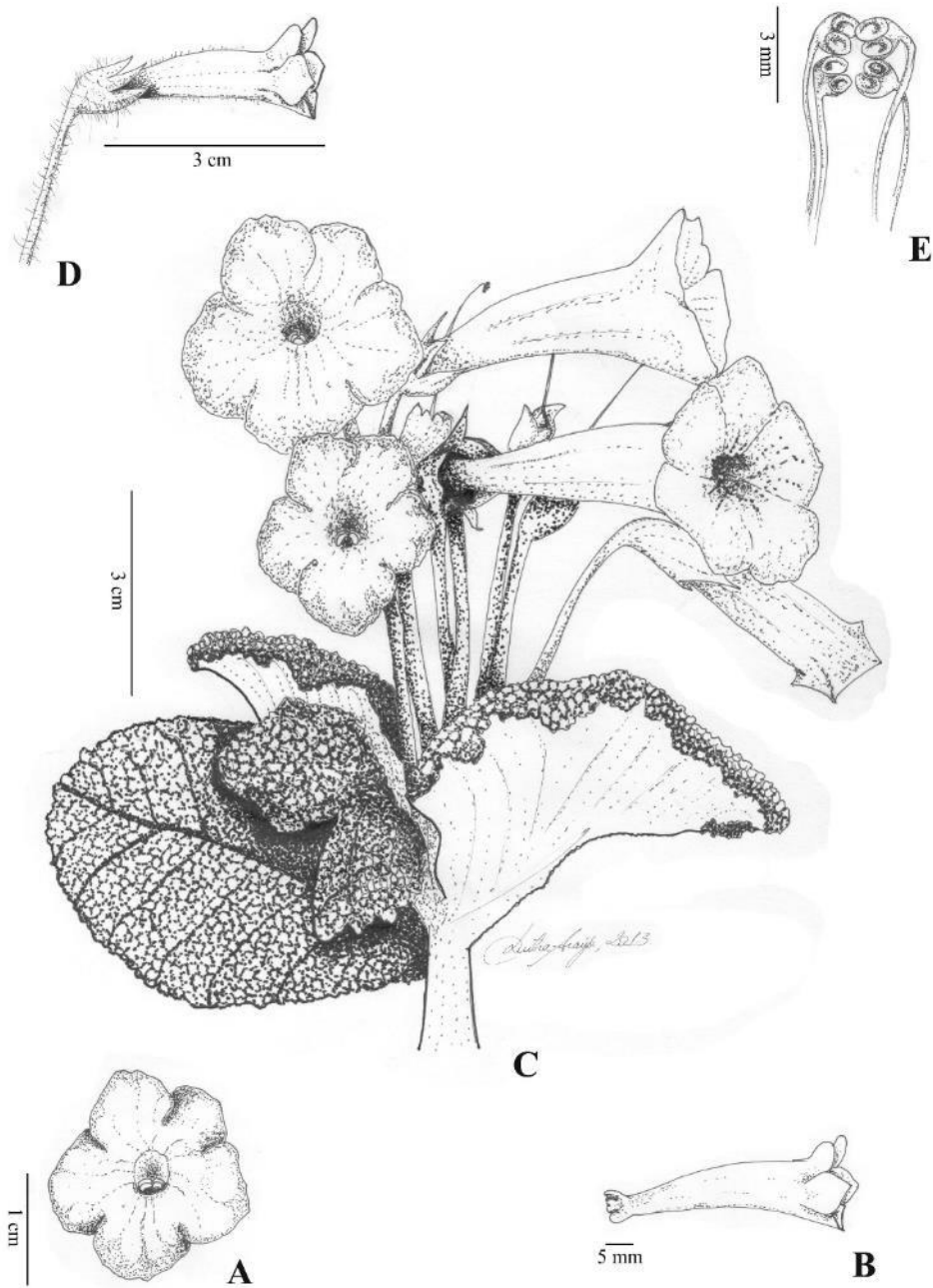
### Acknowledgements

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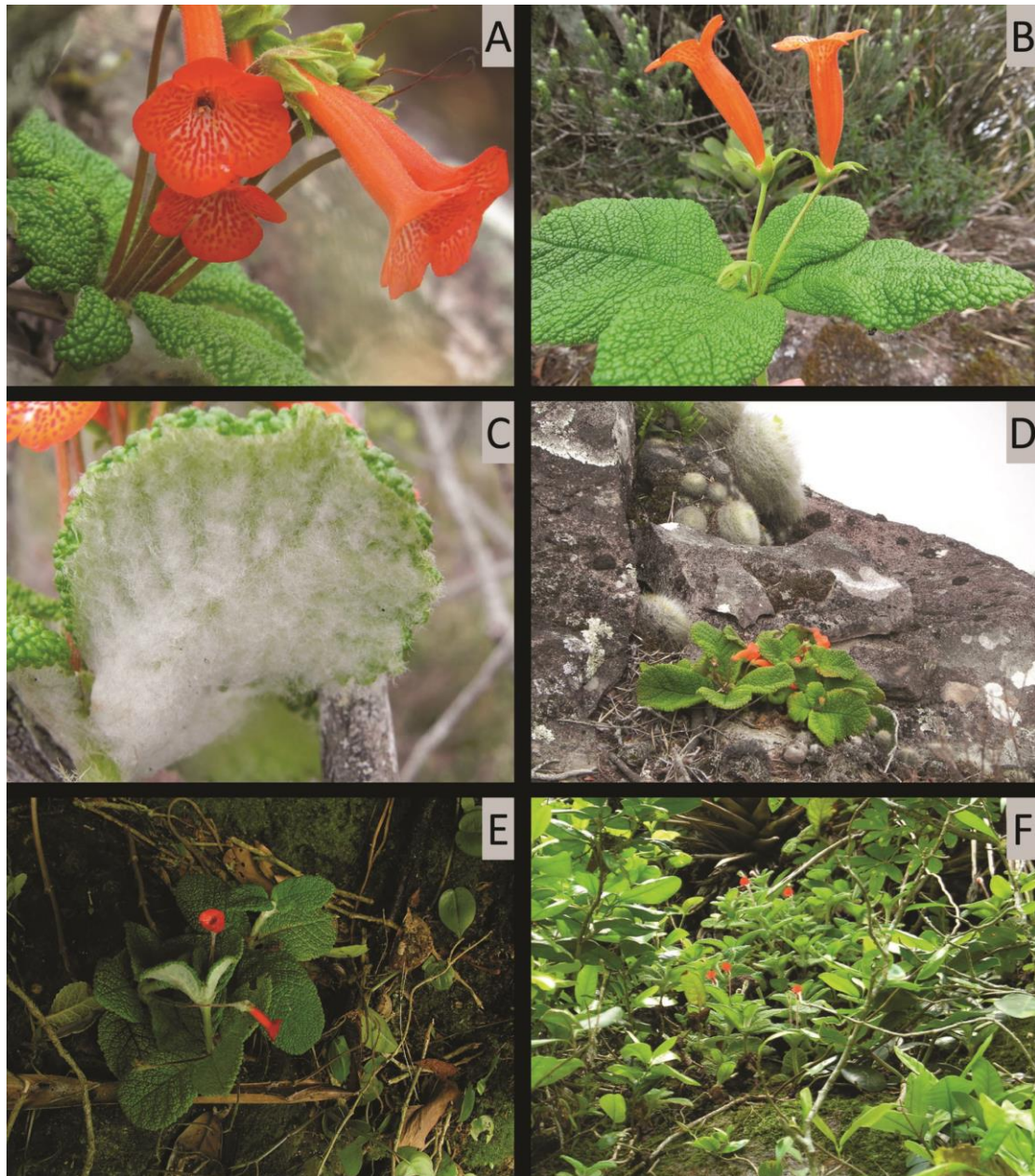
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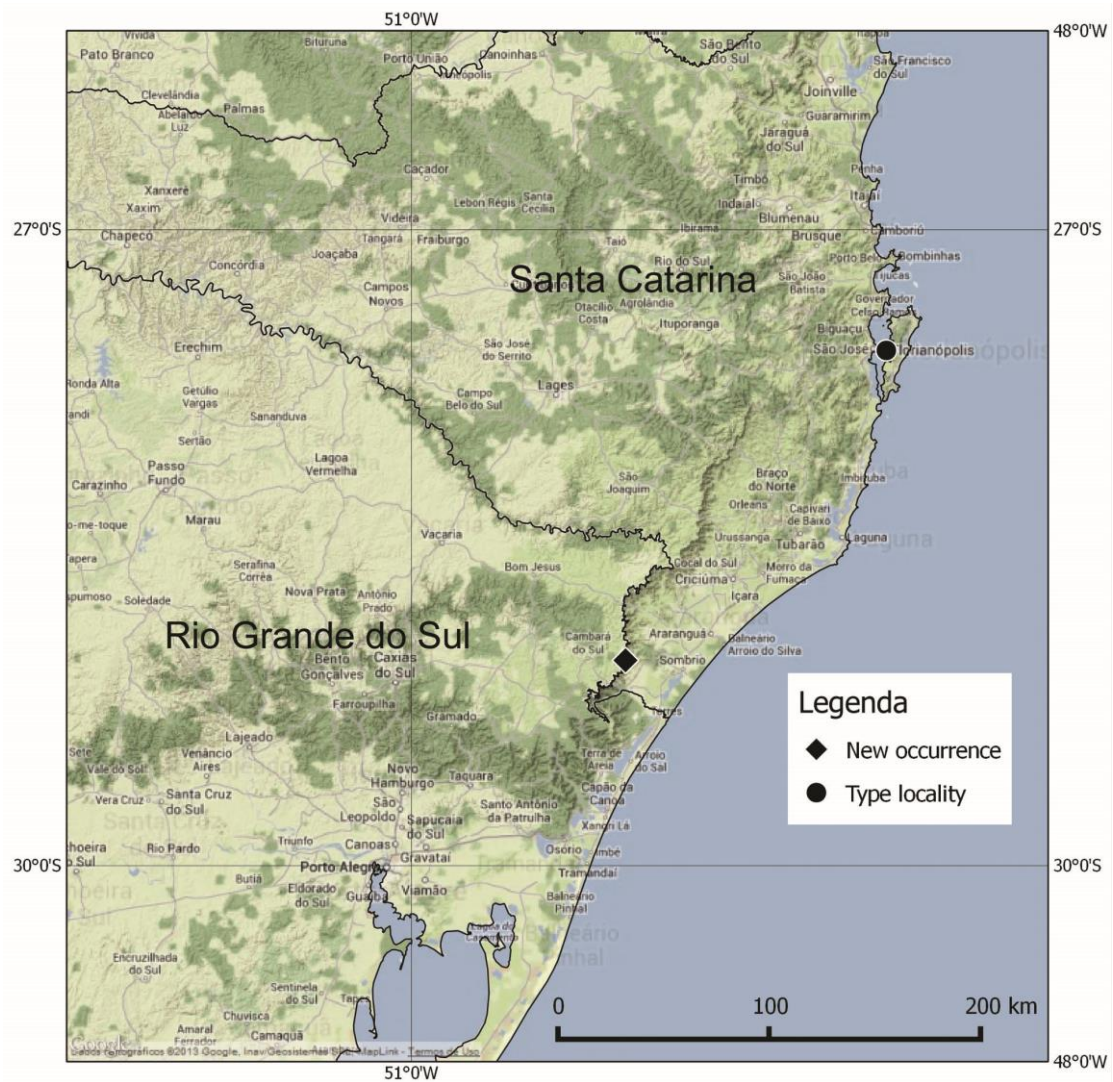


**FIGURE 1.** A–E. *Sinningia bullata*. A. Corolla in frontal view. B. Corolla outline in lateral view. C. Habit. D. Corolla, calyx and pedicels in lateral view. E. Anthers in frontal view.





**FIGURE 2.** A–F. *Sinningia bullata*. A. Flowers, in frontal view. B. Leaves and inflorescence. C. Detail of below leaf. D. General view of the species habitat. E. Habit of single plant in the type locality. F. Habitat of the species in the type locality (A–D, from G.E. Ferreira *et al.* 238 and E–F from A. Reis *et al.* 5040; photo A–B, by S.C. Pesamosca, C–D by G.E. Ferreira, and E–F, by A. Chautems).



**FIGURE 3.** Distribution of *Sinningia bullata* in Southern Brazil, showing the two presently known finding places.

## Artigo 4

### Taxonomy of *Sinningia* (Gesneriaceae) in Rio Grande do Sul, South Brazil

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#### Abstract

The genus *Sinningia* belongs to the neotropical tribe Sinningieae, presently consisting of only three genera, *Paliavana* Vandelli, *Sinningia* Nees and *Vanhouttea* Lemaire. These genera were recently separated from a larger concept of tribe Gloxinieae, based on phylogenetic studies with molecular data. *Sinningia* occurs with 12 species and one natural hybrid in Rio Grande do Sul, South Brazil. In this state the species are erect or ascending herbs or sub-shrubs arising from underground or partially exposed tubers, growing under very distinct ecological conditions, from water-saturated marshes to dry grasslands or shrublands, but mostly rupicolous or epiphytic habitats commonly associated to forest environments. In this review, we provide an identification key, morphological descriptions and illustrations, comments on taxonomic aspects, and distributional maps for all taxa. Additionally we design a lectotype for *S. allagophylla* (Martius) Wiehler and propose the recently described *S. lutea* Buzzato & Singer as a new heterotypic synonym of the highly variable *S. allagophylla*. The name of the natural hybrid *Sinningia* × *vacariensis* is validated by correcting one authority name.

#### Resumo

O gênero *Sinningia* pertence à tribo neotropical Sinningieae, atualmente composta por apenas três gêneros, *Paliavana* Vandelli, *Sinningia* Nees e *Vanhouttea* Lemaire. Esses gêneros foram recentemente segregados de um conceito mais amplo da tribo Gloxinieae, baseado em estudos filogenéticos com dados moleculares. *Sinningia* ocorre com 12 espécies e um híbrido natural no Rio Grande do Sul, sul do Brasil. No estado, as espécies são ervas eretas ou ascendentes ou subarbustos com tubérculos subterrâneos ou parcialmente expostos, crescendo em condições ecológicas muito distintas, de banhados saturados de água até campos secos, mas principalmente em habitats rupícolas ou epifíticos comumente associado a ambientes florestais. Nesta revisão, fornecer uma chave de identificação, descrições e ilustrações, comentários sobre os aspectos taxonômicos, e mapas de distribuição para todos os táxons. Além disso, designamos um lectótipo para *S. allagophylla* (Martius) Wiehler e propomos como sinônimo heterotípico a espécie recentemente descrita *S. lutea* Buzzato & Singer para *S. allagophylla*. O nome do híbrido natural *Sinningia* × *vacariensis* é validado pela correção do nome do autor.

**Keywords:** Sinningieae, Gesnerioideae, Lamiales, geophytes, lithophytes, epiphytes.

## Introduction

The genus *Sinningia* Nees (1825: 297) includes ca. 70 species of shrubs, subshrubs or tuberous herbs occurring in a great range of geographic regions and growing under very distinct ecological conditions (Skog & Boggan 2007, Chautems *et al.* 2010). The genus is presently placed in the tribe Sinningieae, composed additionally by the genera *Paliavana* Vandelli (1788: 40) and *Vanhouttea* Lemaire (1845: 346). Perret *et al.* (2003) demonstrated that *Sinningia* is in fact a paraphyletic genus, and so it should be combined with the three genera mentioned above to produce a monophyletic taxon. Based on these results a new generic circumscription will be probably proposed in a near future.

The species of *Sinningia* are widely distributed from southern Mexico to northern Argentina, nevertheless an evident centre of diversity lies within the Brazilian Atlantic Forest, where ca. 60 endemic species occur. The genera *Vanhouttea* (nine species) and *Paliavana* (six species) are also endemic to this mainly tropical formation, especially in southeast Brazil, so this region can be circumscribed as the centre of diversity for both the genus *Sinningia* and the entire tribe Sinningieae (Perret *et al.* 2007; Araujo and Chautems 2013). A relatively low number of *Sinningia* species occur in seasonal vegetation types, as the semi-deciduous forests of the Paraná-Paraguay river basin, the *cerrados* of central Brazil, and the *caatingas* of northeastern Brazil (Chautems 2008; Perret *et al.* 2013).

Most species of *Sinningia* have well-developed tubers, allowing the occurrence in relatively dry habitats, as rocky outcrops and coastal dunes. A few species contrastingly occur in permanently water-logged marshes and peat-bogs, and so the entire genus can be regarded as occupying stressful environments (Perret *et al.* 2006, Chautems 2008, Ferreira *et al.* 2014b). The flowers of *Sinningia*, like those of *Vanhouttea*, mostly display long and narrow corolla tubes which are perfectly adapted to hummingbird pollination. In the closely related genus *Paliavana* the flowers have broader and darker corolla tubes which fit into the bat pollination syndrome (Perret *et al.* 2001, SanMartin-Gajardo & Sazima 2005a,b).

There are no previous taxonomic treatments of *Sinningia* for the state of Rio Grande do Sul, neither for the family Gesneriaceae, which also includes a few epiphytic species in the genera *Codonanthe* (Martius 1829: 50) Hanstein (1854: 209) and *Nematanthus* Schrader (1821: 718). In early papers, mostly floristic surveys of particular areas or regions, the species of *Sinningia* were cited as *Corytholoma* or *Rechsteineria* (e.g. Rambo 1961). Subsequently a few publications reported new occurrences for the state (Silveira 1992, Ferreira & Chautems 2012, Ferreira *et al.* 2013a) and proposed tree new species with a restrict geographic range (Chautems 1991, Buzato & Singer 2012, Ferreira *et al.* 2014a). The first natural hybrid in the genus was also described from Rio Grande do Sul (Ferreira *et al.* 2014b).

The objective of this paper is to present a taxonomic review of the species of *Sinningia* occurring in Rio Grande do Sul, including an identification key, morphological descriptions, diagnostic illustrations and distributional maps of all native species.

## Materials and Methods

Rio Grande do Sul, with ca. 282 thousand km<sup>2</sup>, is located in the extreme south of Brazil. Elevation varies from sea level to 1,400 m, causing striking differences in climate

and vegetation. Climate, according to the Köppen-Geiger system is moist subtropical, (*Cfa*) in the lower areas, and mild temperate (*Cfb*) in the higher areas. The average temperatures vary between 15° and 18° C, with minima around -10° C and maxima around 40°C (Moreno 1961, Peel et al. 2007). The northern half is generally associated to the Atlantic biogeographic province, mostly covered with seasonal and araucaria forests, while the southern half is included in the Pampean province, mostly formed by grasslands, gallery forests and small patches of thorn savanas (Rambo 1961, Cabrera & Willink 1980, Overbeck et. al 2007).

Specimens were collected during fieldwork carried out in Rio Grande do Sul, Brazil, from September 2010 to November 2013. All pressed collected material was deposited in the ICN and G herbaria. Morphological data were gathered from living specimens in the fieldwork and from specimens on loan and/or electronic images from the following herbaria: B, G, G-DC, HAS, HBR, HPL, HUUS, ICN, K, MBM, PACA, US and R. Some flowers were preserved in 70% ethanol and used to draw floral features. Living specimens were photographed in the field using a digital camera (Nikon Coolpix P-100). Morphological nomenclature follow Harris & Harris (2001). Mapping of geographic distributions employed Quantum GIS software. Geographical coordinates are given for all collected specimens. Coordinates not available on the original labels were assigned to the middle point of the municipality of occurrence.

## Results and Discussion

The genus *Sinningia* is represented in the study area by 11 species and one natural hybrid. Among these species, six are endemic to the southern states of Brazil, circumscribing a secondary centre of diversity. Most species occur in the northeastern part of the state, especially in the northeastern highlands locally called *Campos de Cima da Serra* (montane grasslands), and in the northernmost part of the coastal lowlands around the southern limit of the Atlantic rain forest. Local radiations seem to have occurred especially around the steep escarpments of the canyons in southern Santa Catarina and northeastern Rio Grande do Sul.

### Key to the species of *Sinningia* in Rio Grande do Sul

- 1. Leaves opposite ..... 2
- Leaves whorled ..... 5
- 2. Leaves inserted along 4–7 nodes ..... *S. macrostachya*
- Leaves inserted along 1–2 nodes ..... 3
- 3. Leaf-blades green to purplish, veins vinaceous on the abaxial surface ..... *S. ramboi*
- Leaf-blades green, veins always green on the abaxial surface ..... 4
- 4. Leaves 9.5–15 × 7–14 cm, not bullate, abaxial surface pale green, tomentose  
..... *S. lineata*
- Leaves 4–6 × 3–4.5 cm, bullate, abaxial surface white, dense woolly  
..... *S. bullata*
- 5. Inflorescence a raceme or spike ..... 6
- Inflorescence a pseudo-umbrella, composed of pair-flowered cymes ..... 10
- 6. Flowers distinctly pedicellate ..... 7
- Flowers apparently sessile or shortly pedicellate ..... 9
- 7. Corolla with two erect upper lobes, distinctly larger than the lower ones ..... *S. elatior*
- Corolla without two erect upper lobes, all lobes approximately with the same size  
..... 8

8. Flowers pendulous, sepals green, stamens with exserted anthers ..... *S. sellovii*  
 - Flowers horizontal, sepals reddish, stamens with included anthers ..... *S. warmingii*  
 9. Stems 40–200 cm long; petiole 8–30 mm long; corolla 0.7–1 cm, magenta  
 ..... *S. curtiflora*  
 - Stems 40–80 cm long; petiole 1–2 mm long; corolla 0.9–1.5 cm, yellow to orange  
 ..... *S. allagophylla*  
 10. Leaves arranged along 3–4 nodes, clearly separated along the erect stems; plants  
 mostly terrestrial in coastal sand dunes ..... *S. polyantha*  
 - Leaves arranged along 2 nodes, closely grouped at the apex of the erect stems; plants  
 mostly rupicolous or epiphytic in forests ..... 11  
 11. Calyx lobes 5–7 mm long; pedicels tomentose; petioles 0.3–2.5 cm long  
 ..... *S. nivalis*  
 - Calyx lobes 2–3 mm long; pedicels puberulent; petioles 2.5–6 cm long  
 ..... *S. douglasii*

**1. *Sinningia allagophylla*** (Martius) Wiehler (1975: 32). *Gesnera allagophylla* Martius (1829: 36). Lectotype designated here:—BRAZIL. [Minas Gerais]: C.F. von Martius 1056 (lectotype P ID P00587370-image!, isoelectotypes P-image!, K-image!, NY-image! BM-image!, syntype HAL-image!). Fig. 1A–B.

*Sinningia lutea* Buzzato & Singer (2012: 109) Type:—BRAZIL. Rio Grande do Sul: Porto Alegre, Morro Tapera, [30°08'11"S, 51°11'15" W], 15 December 2009, C.R. Buzatto 588 (holotype ICN!, isotypes PACA!, RSPF).

**Terrestrial herbs** with erect stems arising from tubers. **Stems** 40–80 cm long, villous, unbranched, green to reddish. **Leaves** 3-whorled, rarely opposite or 4-whorled, inserted along 4–7 nodes, sessile or with petiole to 0.1–0.2 cm long, tomentose; blade lanceolate to elliptic or rarely obovate, 3.2–12.7 × 1.5–4.3 cm, acute or rounded at the apex, cordiform to rounded or attenuate at the base, margin crenate, adaxial surface green, pubescent, abaxial surface green to reddish-brown, pubescent between the veins and in the veins densely tomentose, with trichomes capitate. **Inflorescences** terminal, raceme, with 16–50 flowers, 3 flowers per node, borne in whorls along the inflorescence axis; flowers subsessile or pedicel until 0.2 cm long., yellow-greenish to orange, pubescent. **Calyx** subcampanulate, tube 2–5 mm long, puberulent, lobes lanceolate, 4–8 mm long, acuminate, margin entire, green to orange, puberulent. **Corolla** erect in calyx, tubular, 0.9–1.5 cm long, yellow to orange-reddish, pubescent, base with 2 dorsal gibbositities somewhat united covering the calyx lobes, tube constricted above base, 3–5 mm wide, then expanding gradually to 4–6 mm at throat, limb spreading, lobes 5, yellow to orange, unequal, 2–3 × 2 mm. **Stamens** 4, included, filaments 0.6–0.8 cm long, glabrous, anthers coherent, rectangular, pollen white, nectary consisting of five glands, two connate, two separate lateral and one isolated gland. **Ovary** 3 mm long, 1 mm wide, hispid, style 0.6–0.9 cm long, green, pubescent. Fruit a dry two-valved capsule, 0.5–0.9 × 0.4–0.5 cm, acuminate, reddish brown, pubescent.

**Phenology:**—Flowers from September to April, fruits from November to March.

**Distribution and habitat:**—The species occurs in fields and stony fields with high solar irradiation in Brazil, from Goiás to Rio Grande do Sul, Paraguay, Argentina and Uruguay (Chautems 2008). In Rio Grande do Sul, it occurs in all regions of the state (Fig. 2A).

**Conservation status:**—Least concern (IUCN, 2013).

**Notes:**—*S. allagophylla* is here treated as a variable species that occurs from central Brazil to northern Argentina. We do not recognize the opinion of Buzzato & Singer (2012) who described *S. lutea* based on a difference in size and colour of the corolla and restricted this species to a narrow area of the Rio Grande do Sul state. In addition, they claim that there is geographic isolation between *S. lutea* and *S. allagophylla*. Our field observations do not confirm any isolation, as in several localities we observed individuals bearing corollas varying in size and colour within the same population, with all kind of intermediate between the two morphologies. A rather broad introgression zone seems to occur between the two kinds of morphologies at the contact zone of the Pampa and Atlantic Forest Domain:

Short and yellow corollas occur mostly in the southern and western part of the Rio Grande do Sul as well as in northern Argentina, eastern Paraguay, and Uruguay.

Longer and orange corollas occur mostly in the northeastern Rio Grande do Sul and Santa Catarina on the higher plateau relief. A detailed study of all the morphological variants presented so far under *S. allagophylla* involving floral biology and population genetics is underway in order to better define the kind of radiation that took place in southern Brazil and to assign a taxonomic rank to these different morphologies.

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Alegrete, BR 290, solo alagadiço, December 1994, *A.Nilson 386* (HAS); a 8 km de Manoel Viana, Arroio Lageado, na rodovia Alegrete-São Francisco de Assis, fl. amarelas, December 1982, *J.Mattos & N.Mattos 23965* (HAS); Augusto Pestana, p. Ijuí, Rosário, fl. vermelho, February 1955, *Pivetta 818* (PACA); Barracão, na rodovia para Lagoa Vermelha, fl. alaranjadas, beira de estrada, February 1988, *N. Silveira & D. Faria-Filho 5423* (HAS); Bom Jesus, 2 km para Oswaldo Kroeff, terrícola, junto à pedras, January 1990, *Nunes et al. 551* (HAS); cerro na estrada Tainhas/Bom Jesus, em campo pedregoso, flores laranja claro, 13 November 2012, *G.E. Ferreira & C. Vogel-Ely s.n.* (ICN); 4° distrito, Fazenda Potreirinhos, fl. alaranjadas, campo sujo, encosta, November 1977, *O.R. Camargo 5478* (HAS); Aparados da Rocinha, in rupibus subtufosis, January 1950, *B.Rambo 45424*, (G, US); no campo, fl. alaranjadas, February 1985, *N.Silveira et al., 1948* (HAS); perto de Vargem, divisa com SC, no campo, fl. vermelhas vistosas, November 1977, *J.Mattos & N.Mattos 17736* (HAS); p. São José dos Ausentes, fl. alaranjadas, no barranco, February 1987, *N.Silveira 3962* (HAS); Serra da Rocinha, campo declivoso, 1000 m alt., 19 January 1950, *A.Sehnem 4294* (B, HBR, INPA, MBM, PACA), Silveira, campo, fl. vermelhas, February 1985, *N.Silveira et al. 1925* (HAS); Vargem, fl. alaranjadas, no morro, November 1977, *J.Mattos & N.Mattos 17857* (HAS); Fazenda do Cilho, em campo rupestre, 12 February 2007, *R.Setubal et al. 308* (ICN); Caçapava do Sul, 25 km de Capaçava do Sul na BR-153, km 34, December 1978, *A.Krapovickas & C.L.Cristobal 34176* (MBM); encosta leste da Serra de Santa Barbara, flores laranjas, 30 November 2012, *G.E. Ferreira & C. Vogel-Ely sn.* (ICN); perto do Aeroporto, fl. alaranjadas, November 1983, *J.Mattos & N.Silveira 24867* (HAS); Cambará do Sul, próximo de Cambará, em campo, inflorescência vermelha, 20 December 1969, *A.Ferreira & B. Irgang s.n.* (ICN); as margens da rodovia, antes do pórtico de Cambará, em campo rochoso, flores laranja, 14 November 2012, *G.E. Ferreira & C. Vogel-Ely s.n.* (ICN); às margens do arroio do Camisas, campo, fl. alaranjadas, February 1985, *N.Silveira et al. 1866* (HAS); Itaimbézinho, campo, bordas do Canyon, fl. alaranjadas, December 1978, *J.Mattos et al. 19990* (HAS); Itaimbézinho, campo, bordas do Canyon, fl. alaranjadas,

December 1978, *J.Mattos et al. 19992* (HAS); margem Arroio do Camisa, rod. S. Francisco Paula-Cambará do Sul, fl. alaranjadas, barranco do campo, January 1983, *N.Mattos & N.Silveira 23541* (HAS); PN Aparados da Serra, fl. laranjas, February 1987, *N.Silveira 3908* (HAS); Faxinal, 01 January 1985, *M.Sobral 3637* (ICN); Faxinal, January 1985, *M.Sobral & K.Esposito 3637* (ICN, MBM); Itaimbézinho, 11 February 1957, *A.Schultz 2894* (ICN); Itaimbézinho, no começo do itaimbé ou canion, matinho, na margem aberta do perao; flor laranja, 03 December 1971, *J.C.Lindeman et al. s.n.* (ICN); Itaimbézinho, a beira do precipicio, 29 December 1963, *A. Schultz 3404* (ICN); Canela, 13 km de Canela, Rod. S. Francisco-Canela, no campo limpo, December 1986, *J.Mattos & N.Silveira 30583* (HAS); Caracol, p. Canela, February 1948, *K.Emrich 37219* (PACA); Canguçu, no interior do município, campo aberto, January 1995, *Haussen & Nilson 17* (HAS); Canoas, 15 km norte, 29 December 1966, *J.Lindeman & H.Haas 3912* (MBM); Carazinho, 27 January 1951, *Irmão Januario s.n.* (ICN) Caxias do Sul, de Criúva pega-se estrada de terra para Mulada, após 2,6 km há uma bifurcação - dobra-se à esquerda, após mais 2,5 km chega-se a um camping, dirija-se até a margem do rio e siga uma trilha à esquerda que margeia o rio seguindo na mesma direção da correnteza, após 1 km chega-se em uma grande cachoeira em um cânion no rio, com afloramentos e paredes, afloramentos de granito ao sul da estrada, 158 m alt., 10 December 2005, *M.Machado & L.Y.S.Aona 733*, (G);, Inflorescência ereta avermelhada, beira estrada, February 1981, *O.Bueno 2969* (HAS); Cruz Alta, 16 km S of Cruz Alta, elev 435m, *Aristida* grassland on red day soil, December 1986, *G.L.Webster 25939* (ICN); along Ibiruba-Cruz Alta road, ca. 13 km E of Cruz Alta, campos and scrub on red clay soil, common, fls. pale yellow, 400m alt. December 1986, *G.L.Webster 25870* (ICN, UEC); Guaíba, Fazenda São Maximiano, no campo, 20 November 1977, *V.Citadini & S.Miotto 283* (ICN); Ipiranga do sul, BR-153, no campo, 730m alt., 27 December 1993, *R.Wasum s.n.* (HUCS, M, MO); Jarí, Boa Vista da Serra, January 1942, *B.Rambo 9507* (PACA); Júlio de Castilhos, no campo, em terreno pedregoso, flores rosadas, January 1978, *J.Mattos & N.Mattos 18144* (HAS); Lagoa Vermelha, entre Água Santa e Cruz Altinha, 06 January 1978, *M.Fleig 936* (ICN); Manuel Viana, Cerro do Tigre, em topo de cerro pedregoso, em campo sujo; flores amarelas, 23 April 2011, *E.Pasini 892* (ICN); Montenegro, L. campestre, in dumento, 22 November 1950, *A.Sehnem 5036* (PACA); Est. Exp. Zootecnia, campo sujo, flores amarelas, November 1978, *J.Mattos 20205* (HAS); Nova Prata, fl. alaranjadas, campo sujo, December 1983, *J.Mattos 25429* (HAS); Panambi, Condor-Esquina Becher, próximo a mancha estéril no lageado Morimotimã, campo de "barba-de-bode" pedregoso; flores róseas, 30 January 1973, *B.Irgang & J.Valls s.n.* (ICN); Granja L.I.Dothe, invasora de lavoura de soja; corola amarela com bordas vermelha, 1. April 1972, *B.E.Irgang s.n.* (ICN); Pelotas, Estação Experimental, campo sujo. fl. amarelas, December 1983, *J.Mattos & N.Silveira 24978* (HAS); Est. Exp. do IBDF, no campo sujo; flores amarelas, 10 January 1981, *J.Mattos et al. 22247* (HAS); Pinheiro Machado, no km 13 da rodovia para Pelotas, fl. amarelas, campo sujo, December 1983, *J.Mattos & N.Silveira 25343* (HAS); Porto Alegre, Morro da Gloria, November 1945, *B.Rambo 29391* (ICN); Morro Santana, campo pedregoso, January 1983, *P.Brack 74* (HAS); Vila Manresa, January 1981, *O.Bueno 2918* (HAS); Morro do Osso, erva, campo pedregoso, 17 January 1996, *R.S.Rodrigues 52* (ICN); Morro São Pedro, fl. vermelhas, sobre pedras, December 1995, *L.Tavares & L.S.Kern 5* (HAS); Morro Santana, Campus do Vale UFRGS, erva terrícola, 0,70 m de altura, corola amarela e pilosa, cálice verde com lacíneos vermelhos, caules pilosos, pêlos esbranquiçados; flores visitadas por abelha sem ferrão; campo aberto, beira da trilha central próximo a borda da mata, 03 December 2002, *V.F.Kinupp & P.Brack 2530* (ICN); Morro Santana, orla de mata, terrícola ou saxícola, com tubérculo flores amareladas, February 1990, *V.F.Nunes 570* (HAS); [Rio Grande], Taím, próx ao posto,



31 December 1983, *Paiva et al. s.n.* (ICN); Rio Pardo, Estação João Rodrigues, 60 m alt. January 1925, *C.Jürgens 107* (B, HBR, INPA, MBM, PACA); Santa Margarida do Sul, BR-290, 36,7 km a leste de São Gabriel em direção a Vila Nova do Sul, 31,2 km após o entroncamento da BR-290 com a RS-473, afloramentos de granito ao sul da estrada, 158 m alt., 3 December 2005, *M. Machado & L.Y.S.Aona 671* (G); Santa Maria, na estrada para São Pedro do Sul BR-453, fl. alaranjadas, num campinho, November 1988, *N.Silveira 6049* (HAS); Res. Biológica Ibicuí Mirim, no campo, vermelha, November 1988, *N.Silveira 5912* (HAS); Res. Biológica Ibicuí Mirim, fl. laranja, no campo sobre pedras, November 1990, *N.Silveira 7969* (HAS); Res. Biológica Ibicuí Mirim, fl. laranja, lobo mais desenvolvido que 7969, November 1990, *N.Silveira 7971* (HAS); Res. Biológica Ibicuí Mirim, campo limpo, fl. vermelha, December 1987, *O.Bueno 5423* (HAS); Res. Biológica Ibicuí Mirim, a margem direita da barragem Saturnino de Brito, brácteas rosadas, April 1985, *M.Neves 504* (HAS); Res. Biológica Ibicuí Mirim, campo dos Barcelos, December 1987, *O.Bueno 5187* (HAS); Res. Biológica Ibicuí Mirim, campo dos Barcelos, a direita da barragem, fl. alaranjadas, November 1988, *M.L.Abruzzi de Oliveira 1646* (HAS); flor laranja, 02 December 1999, *E.R.Salviani 744* (HPL); Santana do Livramento, Cerro do Armour, encosta do cerro, fl. amarelas, February 1980, *J.Mattos & N.Model 20948* (HAS); Santo Ângelo, campo próx estrada, não muito distante das ruínas de St. Ângelo, 15 November 1977, *J.Waechter 664* (ICN); São Borja, arroio Ivaí, herbácea, flor amarela, campo limpo seco, 13 November 2009, *E.Barbosa et al. 2590* (MBM); São Francisco de Paula, RS 110, Rio Santa Cruz, 15 January 2009, *C.R.Buzatto 473* (ICN); estrada prox. FLONA, 10 November 2009, *C.R.Buzatto & R.B.Singer 584* (ICN); Várzea do Cedro, 830m alt., November 2000, *R.Wasum 837* (G, MO, MBM); no campo sujo, sine die, *J.Mattos & N.Mattos 18876* (HAS); São José dos Ausentes, Serra da Rocinha, sobre barrancos, em beira de estrada, 1400m alt., 22 November 1997, *R. Wasum et al. s.n.* (MBM); São Leopoldo, p. Portão, November 1934, *B.Rambo 594* (PACA); p. Sapucaia, November 1948, *B.Rambo 38616* (PACA); April 1935, *B.Rambo 2040* (PACA); São Lourenço do Sul, a 5 km da divisa com Camaquã na rod. P. Alegre-Pelotas, fl. amarelas, campo sujo, November 1978, *J.Mattos et al. s.n.* (HAS); São Pedro do Sul, 7 km W of S. Pedro do Sul, Swampy grassy; common herb; fls. Orange-yellow, 175m alt., 6 December 1986, *G.L.Webster et al. 25979* (ICN); BR-453, flor amarela, rara, December 1981, *O.Bueno 3423* (HAS); São Tomé, 15 km após S. Frco. de Assis, afloramento de arenito, flores amarelas, 10 December 1976, *S.Miotto et al. 348* (ICN); Sarandí, ca. 5Km de Sarandí, Rod. Carazinho-Sarandí, campo sujo, em terreno rochoso. fl. amarelas, December 1986, *J.Mattos & N.Silveira 30223* (HAS); a 8 km de Sarandí, km 141 da rodovia Passo Fundo-Sarandí, fl. amarelas, January 1982, *J.Mattos et al. 22895* (HAS); Soledade, na rodovia para Porto Alegre, fl. alaranjadas, no campo, November 1987, *M.Bassan 1059* (HAS); Tapes, Cerro Pelado, erva, na encosta do cerro, fl. amarelas, 05 December 1988, *J.A.Jarenkow 1078* (MBM); Torres, Butiazal, 12 November 1965, *A.Schultz 3968* (ICN); dunas na praia Itapeva, flores alaranjadas-vermelha, September 1985, *N.Silveira, R.Frosi & N.Model 3428* (HAS); 14 November 1965, *A.Schultz 3989* (ICN); estrada para Itapeva, no campo, fl. alaranjadas, 23 December 1979, *J.Mattos & O.R.Camargo 19483* (HAS); Itapeva, fl. alaranjadas, January 1985, *N.Silveira 1717* (HAS); Itapeva, em areial, em butiazal, November 1989, *N.Silveira 7975* (HAS); Itapeva, em barranco no butiazal, fl. laranjas, February 1986, *N.Silveira & K.Hagelung 3228* (HAS); butiazal, 22 November 1969, *E.Vianna s.n.* (ICN); prox. ao posto da Corlac, na rod. BR-101, areial, fl. vermelhas, September 1985, *N.Silveira et al. 3554* (HAS); proximo ao posto Corlac, BR 101, September 1985, *R.Frosi et al. 539* (HAS); ca 5 km W de Torres, butiazal E da estrada, flor laranja, 19 November 1971, *J.C.Lindeman et al. s.n.* (ICN); Faxinal, em campo alterado, com solo negro, úmido, flores vermelhas, 07

February 1989, *J.Waechter 744* (ICN); estrada Itapeva, Faxinal, 4 December 1976, *L.R.M.Baptista et al. s.n.* (ICN); estrada Federal, butiazal, 4 November 1958, *A.Schultz 1935* (ICN); São Bras, flores cor de tijolo, 9 November 1972, *I.Brenner s.n.* (ICN); Parque Estadual de Itapuã, morro do Araçá, campo rupestre, 04 October 2002, *M.Pinheiro 501* (ICN); Vacaria, 33 km em direção a Lagoa Vermelha, November 1986, *Neves 807* (HAS); flor alaranjadas, 21 January 1999, *E.R.Salviani & H.Lorenzi 509* (HPL); Parque das Cachoeiras, erva, flores amarelas, proximo ao arroio, 21 November 2012, *G.E. Ferreira & C. Vogel-Ely* (ICN).

**2. *Sinningia bullata*** Chautems & M. Peixoto (2010: 242) Type:—BRAZIL. Santa Catarina: Município de Florianópolis, Ilha de Santa Catarina, Alto Ribeirão, Testa do Macaco, ca 315 m, 6.III.2006, *A. Reis et al. 5040* (holotype: HBR!; isotypes: G!, HUMC, US). Fig. 1C–E.

**Rupicolous herbs**, arising from tubers; **Stems** 10–15 cm long, usually unbranched, covered by a dense woolly indumentum. **Leaves** decussate, inserted along 2 nodes closely grouped at the apex of the erect stems, equal in a pair, petiole 0.5–1 cm long, light green; blade elliptic to obovate, 4–6 × 3–4.5 cm, chartaceous, apex obtuse to rounded, base acute to cuneate, vivid green, adaxial surface bullate and glabrous, specially at young stage, abaxial surface white, covered by a dense woolly indumentum beneath at young stage, becoming looser and light brownish on older leaves, margin irregularly crenate, 5–7 pairs of veins. **Inflorescence** a frondose florescence with pair-flowered cymes with 1–8 flowers. Flowers borne on pedicels, 3–4.5 cm long, reddish, woolly. **Calyx** narrowly campanulate, fused at base for ca. 0.3 cm, lobes 0.5 cm long, narrowly lanceolate, apex acute, base truncate, margin entire, pale green, pubescent. **Corolla** tubular, erect in the calyx, 3–4 cm long, ca. 4 mm in diam. at base, tube 2.5–3 cm long, 4–6 mm wide, orange, pubescent, base with 5 gibbositities between the calyx lobes, lobes 8–10 × 10–12 mm, spreading and forming a right angle with the tube, the 2 dorsal ones narrower, up to 7–8 mm wide, tube inside light orange with darker lines, extending over the lateral and ventral lobes. **Stamens** 4, included, filaments ca. 2 cm, white, glabrous, anthers coherent, star-shaped, pollen cream; nectary formed by two completely separate glands. **Ovary** greenish, style ca. 2.5 cm, white, glabrous. Fruit not seen.

**Phenology:**—Flowers from October to November, fruits from November to December.

**Distribution and habitat:**—The species occurs in South Brazil, in the states of Santa Catarina (Araújo & Chautems 2013) and Rio Grande do Sul (Fig. 2B). In this state the populations inhabit rocky outcrops (probably rhyolites and rhyodacites) at the edges of the escarpment southeast of the Fortaleza canyon.

**Conservation status:**—Endangered (EN) B1ab, according to the IUCN criteria, based on the extent of occurrence estimated to be less than 5,000 km<sup>2</sup> in only two locations (IUCN, 2013).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Cambará do Sul; Cânion Fortaleza, borda da escarpa sudeste do cânion, 1,079 m alt., 15 October 2013, *G.E.Ferreira et al. 238* (ICN, G).

**3. *Sinningia curtiflora*** (Malme) Chautems (1990: 382). *Corytholoma curtiflorum* Malme (1937: 5). Type:—BRAZIL. Paraná: Jacarehy, locis arenosis graminosis, 19 March 1916, *P.K.H.Dusén 18096* (holotype S-image!, isotypes F-image!, GH). Fig. 1F–G.

**Terrestrial herbs** with erect stems arising from tubers. **Stems** 40–200 cm, unbranched, green whit streaks reddish, villous to woolly. **Leaves** 3-whorled, inserted along 4–7 nodes, petiole to 0.8–3.0 cm long; blade elliptic-lanceolate 5.2–12.5 × 3.0–6.5 cm, acute at the apex, obtuse to attenuated at the base, margin irregularly crenate, adaxial surface green, pubescent, abaxial surface light green, pubescent. **Inflorescence** terminal, spiciform, with 30–70 flowers, one flower for bract, bract liner; flowers subsessile or pedicel until 0.2 cm long, green, pubescent. **Calyx** subcampanulate, tube 2–3 mm long, puberulent, lobes triangular, 4–5 mm long, acuminate, margin entire, green to reddish, puberulent. **Corolla** erect in calyx, tubular, 0.7–1.0 cm long, magenta to red, pubescent, base with 2 dorsal gibbositities some what united covering the calyx lobes, tube constricted above base, 2–3 mm wide, then expanding gradually to 4–5 mm at throat, lobes 5, magenta, equal, ca. 1 × 1.5 mm. **Stamens** 4, included, filaments 0.5–0.7 cm long, glabrous, anthers coherent, rectangular, pollen white, nectary consisting of two dorsal glands, connate. **Ovary** 1 mm long, hispid, style 0.6–0.9 cm long, beige, pubescent. Fruit a dry two-valved capsule.

**Phenology:**—Flowers from November to March, fruits from December to July.

**Distribution and habitat:**—The species occurs in Brazil, in the states of São Paulo, Paraná, Santa Catarina (Araújo & Chautems 2013) and Rio Grande do Sul (Fig. 2B), growing in marshes and wet grasslands near coastal plain.

**Conservation status:**—Endangered (EN) B1ab, according to the IUCN criteria, based on the extent of occurrence estimated to be less than 5,000 km<sup>2</sup> so far only in 4–5 localities or municipalities where the species is threatened by habitat drainage and urban development along the beaches (IUCN, 2013).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Arroio do Sal, Rondinha Nova, na costa da Lagoa Itapeva, erva em vegetação arbustiva, indivíduos com até 2,5 m de altura, flores vermelhas, 19 January 2002, *C.Mondin s.n.* (ICN); Torres, em Itapeva, prox. Aeroporto, na beira da mata paludosa, fl. vermelhas, restinga, 19 January 1990, *N.Silveira 9127* (HAS); estrada de terra entre a Praia de Torres e o Parque Estadual das Guaritas, restinga degradada, erva ca. de 1 m, cálice creme, corola vermelha, 22 January 2005, *V.C.Souza & V. F.Knupp 30550* (HPL); Faxinal, em campo alterado, com solo negro, úmido, flores vermelhas, 07 November 1978, *J.L.Waechter 744* (ICN); Itapeva, na capoeira e beira de mato, local úmido, inflorescência vermelha, pré-floração amarela, 17 February 1989, *N.Silveira 8107* (HAS); próximo e antes de Itapeva, banhado, mata de restinga, fl. vermelhas, February 1991, *N.Silveira 10619* (HAS).

**4. *Sinningia douglasii*** (Lindley) Chautems (1990: 381). *Gesneria douglasii* Lindley (1826: 62). Type:—Cult. Hort. Soc. (holotype CGE, not seen). Fig. 2A–B.

**Epiphytic or rarely rupicolous herbs** with erect stems arising from tubers. **Stems** 20–60 cm long, pilose, green to reddish. **Leaves** 3-whorled, arranged in 1–2 nodes closely grouped at the apex of the erect stems, subequal, petiole 2.5–6 cm long, tomentose, concolorous; blade ovate to elliptic, 4–14 × 2.5–10.5 cm, acute at the apex, obtuse or slightly cordate or unequal at the base, margin irregularly serrate, 7–8 pairs of veins,

adaxial surface green and puberulent, abaxial surface green to pinkish and pubescent, with midrib and major veins green to pinkish. **Inflorescences** terminal, pseudo-umbellate, composed of pair-flowered cymes, arranged in 1–2 whorled; borne on an erect axis of 10–30 cm long peduncles 0.3–2 cm long, green with reddish streaks, puberulent; pedicels ascending 2–5 cm long, green to vinaceous, puberulent. **Calyx** subcampanulate, tube 1–2 mm long, hoary-tomentose, lobes linear, 2–3 mm long, acuminate, margin entire, green, glabrescent. **Corolla** erect in calyx, tubular, 3.5–5 cm long, pink, lanulose, base with 5 gibbosities between the calyx lobes, tube constricted above base, 2–4 mm wide, then expanding gradually to 5–8 mm wide at throat, limb spreading, lobes 5, with many dark red dots, unequal, ca. 6–7 mm long. **Stamens** 4, included, filaments 3.3–4.5 cm long, glabrous, anthers coherent, star-shaped, pollen white, nectary consisting of two separate dorsal glands. **Ovary** 6–8 mm long, 3 mm wide, hispid, style 4 cm long, reddish, pubescent. **Fruit** a dry two-valved capsule, 1.3–1.7 cm long, 0.5–0.7 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, 0.7–0.9 long, brown.

**Phenology:**—Flowers from September to November, fruits from October to January.

**Distribution and habitat:**—The species occurs in Argentina (Misiones), Paraguay and Brazil (Chautems 2008), from Minas Gerais to Rio Grande do Sul (Araújo & Chautems 2013). In the state, the species is distributed mostly in the northern forested areas, where it grows epiphytically on several species of phorophytes (Fig. 2C).

**Local names:**—batata-de-árvore.

**Conservation status:**—Least concern (IUCN, 2013).

**Specimens examined:**—Brazil. **Rio Grande do Sul:** Augusto Pestana, Pestana p. Ijuí, October 1955, *Pivetta* 816 (PACA); Barra do Ribeiro, Fazenda Cerrito Maneador, October 1991, *N.Silveira* 9669 (HAS); Bom Jesus, Rio dos Touros com Rio Pelotas, epífita, erva ereta, 40 cm, flores rosa claro com maculas escuras, 13 October 2013, *G.E. Ferreira et al.* 246 (ICN); Canela, Parque da Ferradura, epifítica sobre *Cupania vernalis* na borda do mato, erva epifítica de 30 cm, flores rosas com estrias vermelho-escuro, 5 October 2012, *G.E. Ferreira* 222 (ICN); 8 km N de Canela, parque estadual; epifita sobre canela, 27 December 1972, *J.C.Lindeman et al.*, s.n. (ICN); no Parque do Caracol, na mata sobre troncos, October 1977, *J.Mattos & N.Mattos* 17664 (HAS); para Caracol, November 1987, *J.Meyer et al.* 80 (HAS); Villa Suzana, October 1974, *J.W.Thomé* s.n. (HAS); Caxias do Sul, Vila Oliva, araucarieto, January 1946, *B.Rambo* 33200 (PACA); Farroupilha, silva ad arbores, 22 November 1957, *Camargo* 2606 (B, PACA); Montenegro, Kappesberg, ad arbores, September 1949, *B.Rambo* 43377 (PACA); S. Salvador, epiphytium, 600 m alt., 11 October 1950, *A.Senhem* 4989 (B, PACA, MBM); Maquiné, distr. Barra do Ouro, Cachoeira do Garapiá, epifítica as margens do arroio, erva epifítica de 40 cm, flores rosa-escuro com estrias vermelho-escuro, 31 October 2012, *G.E. Ferreira* 226 (ICN); distr. Barra do Ouro, Cachoeira da Forqueta, rupícola sobre bloco de basalto no interior da mata, flores rosas com estrias vermelho-escuro, 31 October 2012, *G.E. Ferreira* 227 (ICN); Mampituba, Cachoeira do Borges, rupícola sobre bloco de basalto embaixo de *Phytolacca dioica*, erva de 30 cm, flores rosas com estrias vermelho-escuro, 2 November 2012, *G.E. Ferreira* 233 (ICN); Morrinhos do Sul, Morro do Forno, erva com bulbo epígeo em borda de Mata Atlântica de encosta, flores com cálice verde; corola rósea com manchas longitudinais vinosas, 19 October 1997, *J.A.Jarenkow* 3207 (MBM); Novo Hamburgo, Shwabenscheis, ad arbores in silva primaria, sterilis, May 1949, *B.Rambo* 41728 (PACA); Osório, Paredão, sobre pedras, November 1989,

*N.Silveira* 8553 (HAS); Salvador do Sul, São Salvador, October 1946, *A.Senheim* 2205 (PACA, MBM); Santa Maria, Reserva Biol. do Ibicuí-Mirim, November 1988, *N.Silveira* 5889 (HAS); Reserva Biol. do Ibicuí-Mirim, na mata, November 1988, *N.Silveira* 5844 (HAS); Reserva Biol. do Ibicuí-Mirim, December 1987, *O.Bueno* 5219 (HAS); São Francisco de Paula, Aratinga, 4 November 1995, *J.Larocca & R.Balbuena* 95049 (ICN); Rincão dos Kröeff, numa taipa velha no mato, XI.1985, *J.Mattos & M.H.Bassan* 29422 (HAS); Tenente Portela, Parque estadual do Turvo, estrada para o Porto Garcia, October 1989, *N.Silveira* 7304 (HAS); Parque Florestal do Turvo, Epífita sobre árvore caída, c/ tubérculo, October 1979, *J.Waechter* 1377 (ICN); Terra de Areia, Arroio Bonito, sobre figueira, 10 October 1999, *C.N.Gonçalves & C.F.A.Gonçalves s.n.* (ICN); Torres, Colônia SP., epíf. em "Baguaçú" November 1989, *N.Silveira* 8666 (HAS); Torres, Morro Azul, September 1978, *J.Waechter* 988 (ICN); Três Cachoeiras, November 1981, *J.Waechter* 1793 (HAS, ICN); Rio da Terra, Beira rio, epífita, September 1986, *N.Silveira* 9211 (HAS); Vale do Sol, September 1980, *J.Waechter* 1771 (ICN).

**5. *Sinningia elatior* (Kunth) Chautems (1990: 383), *Gesneria elatior* Kunth (1818: 393).** Type:—[VENEZUELA]. Tumiriquiri, Cocollar [Crescit locis umbrosis, temperatis montis Tumiriquiri (Nova Andalusia)], s.d., *A.J.A.Bonpland & F.W.H.A.von Humboldt* 191 (holotype P-image!). Fig. 2C–D.

**Terrestrial herbs** with erect stems arising from tubers. **Stems** 40–100 cm long, tomentose, green to brow. **Leaves** 3-whorled, inserted along 4–9 nodes, subequal, sessile or petiole 0.2 cm long, tomentose, green-brownish; blade lanceolate to elliptic, 4–7 × 1.1–2.6 cm, acute at the apex, acute to obtuse at the base, margin crenate, 5–9 pairs of veins, adaxial surface green, pubescent, abaxial surface green to brow, tomentose with tector trichomes. **Inflorescences** terminal, raceme, three flowers by whorl; peduncles absent; pedicels ascending 0.8–2.3 cm long, green, tomentose. **Calyx** campanulate, tube 4–6 mm long, tomentulose, lobes triangular to lanceolate, 8–10 mm long, acuminate, margin entire, green, tomentose. **Corolla** erect in calyx, tubular, 3.5–4.3 cm long, orange to red, pilose, base with 2 dorsal gibbositities some what united covering the calyx lobes, tube constricted above base, 3–5 mm wide, then expanding gradually to 8–10 mm wide at throat, lobes 5, red, unequal, the two dorsal ca. 4–6 mm long, others 2–3 mm long; **Stamens** 4, exserted, filaments 3.5–3.7 cm long, glabrous, anthers coherent, globose, pollen white, nectary consisting of 5 glands, two comnte glands larger than the others, two separate lateral glands and one isolated; **Ovary** 10–12 mm long, 4 mm wide, hispid, style 3–3.3 cm long, green, pubescent. Fruit a dry two-valved capsule, 1.5–1.9 cm long, and 0.6–0.7 cm wide, acuminate, reddish brown, pubescent; seeds brown.

**Phenology:**—Flowers from January to March, fruits from February to July.

**Distribution and habitat:**—The species is widespread in South America, occurring in Argentina, Bolivia, Brazil, Colombia, Paraguay, Peru, Uruguay and Venezuela (Skog & Boggan 2007). In Brazil, it occurs in all regions (Araújo & Chautems 2013). In Rio Grande do Sul, this species is easily observed in wetlands, from coastal marshes to montane peat-bogs (Fig. 2D).

**Conservation status:**—Least concern (IUCN, 2013).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Alegrete, Est. Uruguaiana para Alegrete, BR-290, solo úmido, December 1994, *A.Nilson* 387 (HAS); Augusto Pestana, Pestana para Ijuí, September 1958, *Pivetta* 1127 (PACA); Butiá, Alencastro, campo úmido, próx. açude vazio, fl. vermelhas, January 1989, *P.Brack* 347 (HAS); no km 105 da rod. para Santa Maria, campo, March 1982, *J.Mattos & N.Mattos* 23178 (HAS); Cachoeira do Sul, beira de estrada, December 1986, *M.Sobral et al.* 5370 (ICN); Cambará do Sul, in rupestribus graminosis humidis, 03 February 1948, *B.Rambo* 36504 (ICN); Itaimbézinho, February 1941, *B.Rambo* 4383 (PACA); Canguçu, próx. Rio Camaquã, beira estrada, flores vermelhas, January 1995, *Haussen & Nilson* 14 (HAS); Caxias do Sul, Vila Oliva, January 1946, *B.Rambo* 30922 (PACA); Vila Oliva p. Caxias, in paludosis alte dumetosis, 8 February 1955, *B.Rambo* 56662 (B, HBR, PACA); Cruz Alta, Faz. Duerr., in campo paludoso, 23 January 1964, *A.Sehnem* 8305 (PACA); Esmeralda, Aracuri, Est. Ecol., January 1983, *J.Waechter* 1977 (ICN); Guaíba, Faz. São Maximiano, lugar úmido, 21 December 1989, *N.I.Matzenbacher s.n.* (ICN); Montenegro, L. Campestre, ad rupem, 17 November 1949, *A.Sehnem* 4072 (PACA); Linha Julio de Catilhos, super rupem, 15 November 1948, *A.Sehnem* 3631 (PACA, MBM); Nonoai, Nonoai ad fl. Uruguay sup., March 1945, *B.Rambo* 28483 (PACA); Osório, Emboaba, Sol sabloneux, bord de chemin; tubercule souterrain, calice vert, corolle rouge pâle, boutons jaune verdâtre, capsules mûres, peu fréquent, 23 February 1989, *A.Chautems & J.Waechter* 331 (G, ICN); Emboaba, February 1983, *J.Waechter* 1997 (ICN); Parque Mal. Osório, January 1974, *A.Allen s.n.* (ICN); Pareci, Montenegro, Bananal, herba in humo, 19 September 1945, *A.Sehnem* 1528 (PACA); Passinhos, Lagoa dos Barros, beira de um capão alagadiço, December 1945, *A.Schultz* 459 (ICN); Pelotas, a 3 km da encruzilhada de Pelotas-Piratini, em um banhadinho, erva com flores vermelhas ornamentais, January 1981, *J.Mattos et al.* 22012 (HAS); Rosário do Sul, BR-290, km 464 em dir. São Gabriel, erva ereta de 80 cm com flores alaranjadas, pouco numerosas e dispersas, coletada em baixadas úmidas, 8 December 1986, *O.Bueno* 4751 (HAS); Santa Maria, Est. Silvíc., January 1956, *Camargo* 67 (PACA); na estrada para São Pedro do Sul, BR-453, flores vermelhas, November 1988, *N.Silveira* 6047 (HAS); Santana do Livramento, Proj. Assentamento 31 de março, em banhado, erva de 1 m com flores vermelho-claras, 15 January 2007, *M.Grings* 446 (ICN); São Francisco de Paula, Cambará, February 1948, *B.Rambo* 36505 (PACA); próx. a Tainhas, em lugar úmido, flores laranjas, February 1987, *N.Silveira* 3847 (HAS); São Lorenzo do Sul, Faz. Crisanto Soares, herba in paludoso campo, 10 December 1965, *A.Sehnem* 8354 (PACA); Tupanciretã, January 1942, *B.Rambo* 9863 (PACA); January 1942, *B.Rambo* 9892 (PACA); Xangri-lá, Bal. Atlântida, flores vermelhas, no solo, 29 November 1991, *R.Záchia* 543 (HAS).

**6. *Sinningia lineata*** (Hjelmquist) Chautems (1990: 385), *Rechsteineria lineata* Hjelmquist (1937: 302). Type:—BRAZIL. Paraná: from cult. *A.Hässer s.n.* (holotype not seen, photo reproduced in diagnosis). Fig. 2E–G.

**Rupicolous herbs** with erect stems arising from tubers. **Stems** 30–60 cm, pilose, green with reddish streaks. **Leaves** decussate, inserted along 2 nodes, rarely 3, closely grouped at the apex of the erect stems, petiole to 3–4 mm long, subequal, tomentose; blade elliptic to ovate, 9.5–15 × 7–14 cm, obtuse at the apex, cordate or sometimes unequal at the base, margin crenate, 4–8 pairs of veins, adaxial surface green, pubescent, abaxial surface pale green, tomentose. **Inflorescence** a frondose florescence with pair-flowered cymes with 2–18 flowers by peduncle; peduncles erect, 7–15 cm long, green with reddish streaks,

pilose. **Calyx** subcampanulate, tube 1–2 mm long, green-tomentose, lobes triangular to lanceolate, 4–6 mm long, acuminate, margin entire, green, pilose. **Corolla** erect in calyx, tubular, 2.8–3.5 cm, orange to reddish, pilose, base with 5 gibbosities between the calyx lobes, tube constricted above base, 5–6 mm wide, then expanding gradually to 10–12 mm at throat, limb spreading, lobes 5, orange to red, unequal, ca.  $3 \times 10$  mm, all the lobes with vinose dots. **Stamens** 4, included, filaments 2.5–3.2 cm long, glabrous, anthers coherent, rectangular, pollen white, nectary consisting of two separate dorsal glands. **Ovary** 7 mm long, 2 mm wide, hispid, style 2 cm long, green, pubescent. Fruit a dry two-valved capsule, 0.9–1.1 cm long, 0.4–0.6 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, brown.

**Phenology:**—Flowers from September to March, fruits from October to April.

**Distribution and habitat:**—The species occurs in South Brazil, in Santa Catarina and Rio Grande do Sul (Araújo & Chautems 2013). It has a restricted distribution, occurring in shaded rocky outcrops in the forests along steep slopes of the Pelotas, Canoas, and Uruguay rivers in these States (Fig. 2E).

**Conservation status:**—Endangered (EN) B1ab, according to the IUCN criteria, based on the extent of occurrence estimated to be less than 5,000 km<sup>2</sup> with only 4–5 locations. The species is presently threatened by the construction of hydroelectric dams (IUCN, 2013).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Barracão, 10 km da cidade, na estrada para o Rio Pelotas, sobre pedras, October 1988, *N.Silveira & C.J.Manson 6071* (HAS); 11 km da cidade, na estrada para o Rio Pelotas, October 1989, *N.Silveira & C.J.Manson 6075* (HAS); encosta do Rio Marmeleiro, 09 June 2000, *J.Spanholi* (MBM); Pinhal da Serra, divisa dos dois municípios, Rio Bernardo José, margem rochosa, planta rupícola, roseo-avermelhadas com pintas vermelhas, 17 March 2005, *C.M.Barroso s.n.* (ICN); Vacaria, Rod. BR-116, descida ao Rio Pelotas, paredão rochoso, tuberosa, flor vermelha, 750 m alt., 21 October 2004, *G.G.Hatschbach et al. 78338* (G, MBM).

**7. *Sinningia macrostachya*** (Lindley) Chautems (1990: 386), *Gesneria macrostachya* Lindley (1828: 1202). Type:—Cult. Hort. Soc. (holotype CGE, not seen). Fig. 3A–B.

**Rupicolous herbs** with erect stems arising from tubers. **Stems** 30–100 cm, pilose, green. **Leaves** decussate, inserted along 4–7 nodes, petiole 2.5 cm long, subequal, tomentose; blade ovate to elliptic, 8–15 × 5–9.5 cm, acute to obtuse at the apex, cordate or sometimes unequal at the base, margin crenate, 4–7 pairs of veins, adaxial surface green, pubescent, abaxial surface pale green to whitish, tomentose. **Inflorescence** terminal, racemiform, composed of pair-flowered cymes; peduncles up 1 cm long, green with reddish streaks, hirsute; pedicels ascending 0.5–2 cm long, green, hirsute. **Calyx** subcampanulate, tube 2–3 mm long, hoary-tomentose, lobes linear-lanceolate, 4–6 mm long, acuminate, margin entire, green, pilose. **Corolla** erect in calyx, tubular, 2.8–3 cm long, orange to red, puberulent, base with 5 gibbosities between the calyx lobes, tube constricted above base, 2–3 mm wide, then expanding gradually to 5–6 mm at throat, limb spreading, lobes 5, with few vinose dots mostly on ventral and lateral lobes, unequal, ca.  $2 \times 3$  mm. **Stamens** 4, included, filaments 2.6 cm long, glabrous, anthers coherent, rectangular, pollen white, nectary consisting of two separate dorsal glands. **Ovary** 4 mm long, 1 mm wide, hispid,

style 2 cm long, green, pubescent. Fruit a dry two-valved capsule, 0.8–1.0 cm long, 0.3–0.6 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, brown.

**Phenology:**—Flowers from September to December, fruits from October to March.

**Distribution and habitat:**—The species is almost endemic to Rio Grande do Sul, extending into small neighbouring areas in southern Santa Catarina and northern Uruguay (Grela & Brussa 2005). In the state it has a rather wide distribution in the Atlantic (eastern) half (Fig. 2F), where it occurs mostly in sunny but also in shadowy rocky outcrops, from sea level up to 1000 msl.

**Conservation status:**—Least concern (IUCN, 2013).

**Notes:**—The tubers of the species may reach more than 1 m in diameter.

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Aratinga, descida para Três Forquilhas, tuberosa, flor vermelha, paredões rochosos, 25 November 1994, *G.G.Hatschbah et al. 61365* (MBM); Bagé, February 1989, *I.Fernandes 683* (ICN); Bom Jesus, Cachoeira de Passo do Meio, herbácea, 50 cm, flores vermelhas, sobre matacão sombreado às margens do rio das Antas, 8 October 2003, *C.T.Blum 101* (MBM); Rio dos Touros, afloramento rochoso de basalto proximo ao rio, erva rupícola ca. 35 cm, folhas opostas, flores laranjas, 13 October 2013, *G.E. Ferreira et al. 245* (ICN); Caçapava do Sul, estrada velha Porto Alegre, 15 October 1979, *J.Mattos et al. 19411* (HAS); Canela, Caracol, rochas da cascata, 30 March 1982, *J.Mattos & N.Silveira 23358* (HAS); Parque da Ferradura, rupícola sobre bloco de basalto na descida do vale do Rio Caí, erva de 40 cm, flores laranjas, 5 October 2012, *G.E. Ferreira 223* (ICN); Caxias do Sul, Santa Lucia do Piaí, 10 November 1987, *J.Meyer et al. 63* (HAS); Santa Lucia do Piaí, 10 November 1987, *J.Meyer et al. 70*, (HAS), Dois Irmãos, Morro Reuter., fl. laranja por fora e vermelha por dentro, em pedras, November 1989, *N.Silveira 10554* (HAS); Dois Irmãos, Morro Reuter, sobre pedras, November 1989, *N.Silveira 10558* (HAS); Farroupilha, povoado de Buza, na rocha, October 1957, *Camargo 1913* (PACA); Guaíba, Faz. São Maximiliano, 17 September 2006, *C.R.Buzatto 163* (ICN); Jaquirana, rupícola, 10 November 2009, *C.R.Buzatto & R.B.Singer 580* (ICN); Maquiné, distr. Barra do Ouro, Serra do Umbu, rupícola em um barranco sombreado, erva 40 cm, flores alaranjadas, 31 October 2012, *G.E. Ferreira 230* (ICN); Mampituba, Serra Pedras Brancas, rupícola em um afloramento rochoso a pleno sol, erva de 25 cm, flores magenta em uma umbela terminal, 2 November 2012, *G.E. Ferreira 234* (ICN); Montenegro, Fortaleza p. Montenegro, silvula ad rupes, 15 December 1952, *B.Rambo 52906* (B, HBR); Linha Julio de Castilhos, super rupem, 450m, 15 September 1948, *A.Senhem 3630* (B, MBM); Morro do Cabrito, 255m alt., March 1986, *I.Fernandes 88* (ICN); Morro do Cabrito, flores cor coral, 255m alt., October 1989, *I.Fernandes 558* (ICN); Morro São João, mata, lugar pedregoso, September 1957, *Camargo 1745* (PACA); Montenegro, September 1957, *Camargo 1763* (PACA); Osório, Barra do Ouro, mata, sobre árvores, 20 December 1984, *J.Mattos & N.Model 26437* (HAS); Pantano Grande, em afloramento rochoso, proximo ao marco do exercito, raiz tuberosa de aprox. 30 cm de D, flores alaranjadas, 3 November 2008, *T.C.L.Silveira & R.T.Mattos s.n.* (PACA, ICN); Pelotas, 14 km de Pinheiro Machado, rodovia para Pelotas, 1 October 1983, *J.Mattos & N.Silveira 25507* (HAS); Pelotas, Pedreira de Santa Luzia, April 1959, *J.Costa-Sacco 1226* (F, HAS, HBR, IAN, R); Pelotas, 9 March 2008, *R.Tsuji 2495* (HPL); Piratini, ca. 2 km da cidade, em direção BR 293, erva bulbosa epipétrica, sobre matações de granito em formação campestre, flores com calixe verde e corola vermelha, 22 October 1997, *J.A.Jarenkow 3589* (MBM);



Porto Alegre, Morro das Abertas, August 1979, *O.Bueno & Soares 1655* (HAS); morro São Pedro, em campo rupestre no topo de morro, flores vermelhas, 25 August 2008, *R.Setubal & P.Ferreira 655* (ICN); morro São Pedro, Econsciencia, sobre matacão de granito, em floresta de encosta superior, erva com engrossamento basal, flores vermelhas, 02 October 2011, *M.Grings & R.Setubal 1494* (ICN); Morro Teresópolis, erva no afloramento rochoso, flores vermelhas, 15 October 2001, *C.Mondin e A.Job 2360* (PACA); parte alta morro Santana, sobre pedras, July 1992, *N.Silveira 11539* (HAS); Morro da Polícia, October 1939, *Irmão Augusto s.n.* (ICN); Santa Maria, Res. Biol. Ibicuí-Mirim, 3 October 1989, *N.Silveira 6869* (HAS); São Leopoldo, montem Sapucaia, September 1944, *B.Rambo 11718* (PACA); São Marcos, no km 138, rodovia Porto Alegre-Vacaria, 13 November 1978, *J.Mattos 20340* (HAS); Sapucaia do Sul, Morro Sapucaia, no topo, October 1955, *B.Rambo 57449* (HBR); Morro Sapucaia, 23. April 1979, *O.Bueno 1323* (HAS); Morro Sapucaia, casa de pedra, paredão, 300 m alt., February 1986, *I.Fernandes 60* (ICN); Morro Sapucaia, 290 m alt., May 1986, *I.Fernandes 122* (ICN); Taquari, c/ tubérc muito desenvolvidos, terrícola ou saxícola, November 1989, *Nunes & Silva 500* (HAS); Terra de Areia, Serra do Pinto, sobre pedras, November 1988, *N.Silveira 8093* (HAS); Serra do Pinto, sobre pedras, November 1988, *N.Silveira 8095* (HAS); Serra do Pinto, sobre pedras, November 1988, *N.Silveira 8097* (HAS); Torres, 8 km SW, lagoa Itapeva, capoeira, encosta barranco natural, 19 November 1971, *J.C.Lindeman et al. s.n.* (ICN); coletada na Praia de Torres nas falésias, flores vermelhas, ca. 50 cm altura, 5 November 1999, *E.R.Salviani & H.Lorenzi 578* (HPL); Itapeva, 26 July 1988, *N.Silveria & C.Mondin 6259* (HAS); Lagoa Itapeva, January 1973, *G.G.Hatschbah & Guimarães 31182* (MBM); parque de Torres, Pedra Itapeva, July 1972, *B.Irgang & A.Girardi s.n.* (ICN); Parque Estadual da Guarita, nos paredões, 31 December 1987, *N.Silveira 5075* (HAS); Parque estadual de Guarita, morros na beira da praia, Torre sul, 10-40 m, nas fendas da rocha (basalto), corola vermelho vivo, branca na base do tubo, pólen branco, estilete rosado, February 1989, *A.Chautems et J.Waechter 330* (G, ICN, US); Parque Guarita, 13 March 1981, *J.Mattos s.n.* (HAS); Parque Guarita, fl. avermelhadas, March 1981, *J.Mattos s.n.* (HAS); Perdida, epipétrica, sobre afloram basáltico de potreiro, cálice verde, corola vermelha c/ pintas vermelhas na fauce, February 1991, *J.Waechter 2454* (ICN); Porto Fagundes, 26 August 1987, *N.Silveira 4707* (HAS); Porto Fagundes, 14 July 1984, *N.Silveira et al. 1351* (HAS); próximo a Lagoa Jacaré, 24 September 1985, *R.Frosi et al. 522* (HAS); October 1971, *G.G.Hatschbah & Koczicki 27222* (BH, MBM, UC); 3 September 1979, *J.Mattos & N.Mattos 20853* (HAS); paredão basáltico, September 1984, *J.Waechter 2034* (ICN); Vacaria, Faz. do Cedro, ad rupes in declivo, 13 April 1975, *A.Sehnem 14635* (PACA); Próx. São Bernardo, beira estrada, no barranco, numerosa, October 1985, *M.Neves 555* (HAS); Vale do Rio das Antas, na mata, em paredão, November 1983, *J.Mattos & N.Mattos 25357* (HAS); Veranópolis, próx. Rio Jaboticaba, 30 October 1987, *N.Silveira 4858* (HAS); Viamão, Ilha dos Juncos, October 1981, *Nilson 25* (HAS); Itapuã, campo sujo em afloramento rochoso, 200 m alt., October 1979, *O.Bueno 1830* (HAS); Morro da Grota, Juny 1980, *O.Bueno 2591* (HAS); Morro da Grota, no mato, em pedras, June 1980, *Aguiar & Martau 488* (HAS); Morro Itapuã, rupícola, March 1996, *C.C.Waldemar s.n.* (ICN); Parque Itapoã, Morro da Grota, entre matações, January 1975, *M.L.Porto et al. s.n.* (HAS); Itapoã, 28 October 1967, *C.O.Diefenbach s.n.* (ICN).

**8. *Sinningia nivalis*** Chautems (1991: 418). Type:—BRAZIL. Santa Catarina: Bom Jardim da Serra, topo das Serra dos Aparados, próximo ao monumento rodoviário,

28°23'S/49°32'W, 1450 m alt., 2 December 1989, A. Chautems & R. Reitz 354 (holotype HBR!, isotypes G-image!, US). Fig. 3C–D.

**Rupicolous or rarely epiphytic herbs** with erect stems arising from tubers. **Stems** 10–15 cm, pilose, green to reddish. **Leaves** 3–whorled, inserted along 2 nodes closely grouped at the apex of the erect stems, subequal, petiole 0.3–2.5 cm, tomentose, pinkish below; blade elliptic to ovate, 6–15 × 3.5–7 cm wide, obtuse at the apex, cordate or sometimes unequal at the base, margin irregularly crenate to serrate, 7–9 pairs of veins, adaxial surface green, strigillose, abaxial surface whitish-tomentose with midrib and veins pinkish. **Inflorescences** terminal, pseudo-umbellate, composed of pair-flowered cymes, borne on an erect axis of 7–17 cm long, reddish green, hirsute; peduncles 0.1–1 cm long, reddish, hirsute; pedicels ascending 1.5–4 cm long, reddish, tomentose; a second inflorescence rarely develops above the first. **Calyx** campanulate, tube 2–3 mm long, hoary-tomentose, lobes linear-lanceolate, 5–7 mm long, acuminate, margin entire, reddish, pilose. **Corolla** erect in calyx, tubular, 2.5–3 cm long, pink to dark-pink with dark red striations and dots toward the upper half, pilose, base with 5 gibbositities between the calyx lobes, tube constricted above base, 4 mm wide, then expanding gradually to 6–9 mm at throat, limb spreading, lobes 5, unequal, the two dorsal partially connate, 6 × 8 mm wide, others subequal, ca. 6 × 6 mm. **Stamens** 4, included, filaments 2.7–3 cm long, glabrous, anthers coherent, star-shaped, pollen white, nectary consisting of two separate dorsal glands; **Ovary** 8 mm long, 3 mm wide, hispid, style 2 cm long, reddish, pubescent. **Fruit** a dry two-valved capsule, 1.3–1.7 cm long, 0.5–0.7 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, 0.7–0.9 long, brown.

**Phenology:**—Flowers from September to December, fruits from November to March.

**Distribution and habitat:**—The species occurs in Brazil, in Santa Catarina and Rio Grande do Sul (Araújo & Chautems 2013). In the latter state it occurs only in a restricted area in the northeastern highlands (Fig. 3A). This species inhabits the abrupt escarpments and the edges of the canyons. It can also occur epiphytically in the forests near the canyons.

**Conservation status:**—Critically Endangered (CR) B1ab, according to the IUCN criteria, based on the extent of occurrence estimated to be less than 100 km<sup>2</sup> with two location known (IUCN, 2013).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Jaquirana, Cachoeira dos Venâncio, afloramento rochoso de basalto proximo ao rio, 14 November 2013, G.E.Ferreira et al. 240 (G, ICN, RB, PACA); São José dos Ausentes, Cãnion Monte Negro, afloramento rochoso próximo a escarpa do cãnion, 12 November 2013, G.E.Ferreira et al. 241 (G, ICN).

**9. *Sinningia polyantha*** (A.P. de Candolle) Wiehler (1981: 383). *Gesneria polyantha* A.P. de Candolle (1839: 528). Type:—BRAZIL. Santa Catarina, 1932, C.Gaudichaud 182 (holotype G-DC-image!, isotypes G-image!, P-image!). Fig. 3E–F.

**Terrestrial or more rarely rupicolous and epiphytic herbs** with erect stems arising from tubers; **Stems** 30–80 cm long, unbranched, villous, reddish. **Leaves** 3–whorled, inserted along 3–4 nodes, equal in a whorl, petiole 0.2–3 cm long, villous, green; blade ovate, 5–14 × 3–8 cm, acute at the apex, obtuse to truncate or slightly cordiform at the base, adaxial surface green, sericeous, abaxial surface pale green to canescent, tomentose,

margin irregularly serrate to serrulate, 5–6 pairs of veins. **Inflorescence** terminal, pseudo-umbellate, in one or two whorls in the upper stem, peduncle 1–5 mm, bracts 5–15 × 3–5 mm, pedicels 1.5–3 cm long, densely pubescent. **Calyx** campanulate, fused at base for 2–3 mm, lobes linear-lanceolate, 3–4 mm long, apex acute, margin entire, green to reddish, pubescent. **Corolla** erect in the calyx, tubular, 3.1–3.4 cm long, tube constricted above base 3–4 mm wide, then expanding gradually to 5–7 mm wide at throat, limb spreading, base with 5 gibbosities between the calyx lobes, bright pink with wine red streaks in the upper half, pubescent, lobes 5, unequal, the two dorsal ones 3–4 × 3–4 mm, the ventral and lateral lobes 3–4 × 4–5 mm, overlapping at the apex, erect to slightly spreading, throat pink with wine red streaks extending on the inner lobes. **Stamens** 4, included, filaments white, anthers coherent forming a rectangle, pollen white; nectary consisting of two dorsal glands, ca 3 mm long, separate, only 12 touching in their basal portion; **Ovary** reddish, style ca. 2.5 cm, pink. **Fruit** held on erect pedicel, capsules ovoid, apex acute, 12–15 × 4–6 mm; seeds narrowly ellipsoid, ca. 1 mm long.

**Phenology:**—Flowers from October to December, fruits from November to January.

**Distribution and habitat:**—The species occurs in South Brazil, in the States of Santa Catarina and Rio Grande do Sul. In Rio Grande do Sul it only occurs in the northeastern lowlands, growing on coastal dunes or *restingas* (Fig. 3B). Occasionally the species also grows on rocks and trees in the transition zone between beach vegetation and coastal forest. This is also the only species in the genus growing on sandy substrate, with tubers that can be totally buried in sand (Chautems 2010).

**Conservation status:**—Critically Endangered (CR) B1ab, according to the IUCN criteria, based on the extent of occurrence estimated to be less than 100 km<sup>2</sup> in a strongly fragmented habitat, due to urban expansion along coastal beaches (IUCN, 2013).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Arroio do Sal, Baln. Rondinha Velha, erva, 11 November 1990, *M.G.Rossoni* 570 (ICN); Baln. Rondinha Velha, erva, 11 November 1990, *M.G.Rossoni* 571 (ICN); Parque Tupancy, 2 m., mata de restinga, interior e beira de mata, algumas vezes crescendo em areia; epífita ou erva terrestre, flores rosé-avermelhadas, 16 October 2004, *L.F.P.Lima* 28 (ICN); Rondinha Velha, num capão distante ca. 400 m do mar, beira de mata, flores vermelhas com rajados escuros, October 1987, *C.Mondin & V.Manfro* 243 (HAS); Praia de Rondinha, sobre a duna ao sol, epifítica, frutos passados, March 1991, *N.Silveira* 8824 (G, HAS); September 1985, *N.Silveira et al.* 3531 (HAS); Torres, Praia Paraíso, terrícola na duna fixa, em local sombreado, cercada de bromeliaceae, erva de 40 cm, flores rosas com estrias vermelho-escuro, indivíduos epifíticos sem flores, 1 November 2012, *G.E.Ferreira* 231 (ICN); Itapeva, epífita em mata de dunas, sobre *Vitex megapotamica*; cálice verde com lobos avermelhados, corola rósea com traços vináceos, com tubérculos, cápsulas abertas, December 1987, *J.Waechter* 2282 (ICN).

**10. *Sinningia ramboi*** G.E.Ferreira, Waechter & Chautems. (2014). Type:—BRAZIL. Rio Grande do Sul: Cambará do Sul, Cânion Fortaleza, afloramento rochoso próximo a escarpa do cânion, 29°3'45.42"S, 49°57'23.53"W, 14 November 2012, *G.E. Ferreira and C. Vogel-Ely* 236 (holotype ICN!; isotypes G!) Fig. 4A–B.

**Rupicolous or rarely epiphytic herbs** with erect stems arising from tubers. **Stems** 7–20 cm long, pilose, green to reddish. **Leaves** decussate, inserted along 2 nodes closely grouped at the apex of the erect stems, subequal, petiole 1.5–3 cm long, pilose, vinaceous; blade ovate–elliptic, 6–11 × 4–8 cm wide, acute at the apex, obtuse or slightly cordate or unequal at the base, margin irregularly serrate, 6–7 pairs of veins, adaxial surface green and puberulent, abaxial surface green to purplish and puberulent, with midrib and major veins vinaceous. **Inflorescences** terminal, cymose, with a short main axis 3–6 cm, ramified in 3–5 peduncles bearing pair-flowered cymes; peduncles 1–3 cm long, reddish, pilose; pedicels ascending 1–3 cm long, reddish, pilose. **Calyx** campanulate, tube 2–4 mm long, lobes 6–8 mm long, truncate at base, subulate at the apex, margin entire, reddish to vinaceous, pilose. **Corolla** erect in calyx, tubular, 2.2–2.8 cm long, dark pink to crimson with vinaceous streaks and dots toward the upper half, puberulent to pilose, pubescent, 2–3 mm wide at base, base with 5 gibbosities between the calyx lobes, the two dorsal ones larger than the three other ones that are barely marked, tube constricted above base, then expanding gradually to 4–6 mm wide at throat, limb spreading, lobes 5, unequal, the two dorsal ones 2–3 × 4 mm, ventral and lateral lobes 3–4 × 4 mm, overlapping slightly. **Stamens** 4, included, filaments 2–2.5 cm long, glabrous, anthers coherent, rectangle, pollen white, nectary consisting of two separate dorsal glands, ca. 2 mm long, whitish. **Ovary** 8 mm long, 3 mm wide, hispid, style 2.1–2.6 cm long, reddish, puberulent. **Fruit** a dry two-valved capsule, 1.1–1.5 cm long, 0.5–0.7 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, 0.5–0.6 mm long, brown.

**Phenology:**—Flowers from September to December, fruits from November to March.

**Distribution and habitat:**—*Sinningia ramboi* is known only from Cambará do Sul, a municipality in the northeastern highlands of Rio Grande do Sul (Fig. 3C). The dominant vegetation types in this region are araucaria forests and montane grasslands of the Atlantic Forest Domain. *Sinningia ramboi* occurs predominantly on rocky outcrops near the abrupt escarpments of the canyons, at around 1000msm, but can also grow epiphytically in the nearby montane forests. The species has a relatively large population around the upper edges of Fortaleza canyon.

**Conservation status:**—Endangered (EN) B1ab, according to the IUCN criteria, based on the extent of occurrence estimated to be less than 5,000 km<sup>2</sup> in only two locations (IUCN, 2013).

**Specimens examined:**— BRAZIL. **Rio Grande do Sul:** Cambará do Sul, Cânion Fortaleza, afloramento rochoso próximo a escarpa do cânion, 29°3'45.42"S, 49°57'23.53"W, 14 November 2012, *G.E.Ferreira and C.Vogel-Ely* 236 (G, ICN); Cânion Itaimbézinho, in araucarieto, ad arbores, 18 December 1950, *B.Rambo* 49387 (B); Cânion Itaimbézinho, in araucarieto, epiphyta, 3 November 1954, *B.Rambo* 56197 (B, HBR); Cânion Itaimbézinho, afloramento rochoso próximo a escarpa do cânion, 18 November 2012, *G.E.Ferreira & C.Vogel-Ely* 237 (G, ICN); Cânion Fortaleza, rupícola, flor vermelha com manchas vinosas, paredão rochoso, 19 November 2008, *J.M.Silva et al.* 7379 (MBM); Cânion Fortaleza, alto do morro sobre pedras, March 1987, *J.Mattos et al.* 30993 (HAS); Cambará do Sul, Cânion Fortaleza, junto aos peraus da fortaleza, September 1981, *O.Bueno* 3062 (HAS); fundo da cascata do Rio das Antas, estrada para a S. Rocinha, September 1975, *C.R.Dillenburger s.n.* (HAS); Rupestre, Formação campestre, 06 October 2012, *M.H.Nervo*, 779 (ICN); Faxinal, erva em interior de mata, December 1983, *M.Sobral & J.R.Stehmann* 2794 (ICN); beira de peraus, nas pedras,

flores vermelhas, October 1993, *N.Silveira 11619* (HAS); na mata, 8 November 1986, *R.Wasum & alunos s.n.* (HUCS, US).

**11. *Sinningia sellovii*** (Martius) Wiehler (1978: 72), *Gesneria sellovii* Martius (1829: 36). Type:—BRAZIL. Rio Grande do Sul: [Candelária], [Cerro] Botucaraí, 1814, *Sellow s.n.* (holotype G-DC-image!; isotype K-image!; syntype HAL). Fig. 4C–D.

**Rupicolous herbs** with erect stems arising from tubers. **Stems** 30–80 cm, often branched, reddish to vinous, villous. **Leaves** 3-whorled, inserted along 4–7 nodes, petiole to 0.5–1 cm long; blade elliptic to oval-elliptic 7–12 cm × 2.5–4.0 cm, acute at the apex, obtuse or rounded at the base, margin crenulate, adaxial surface pubescent, abaxial surface green, pubescent, both two surfaces with tector trichomes. **Inflorescence** terminal, racemiform, solitary flower or pair-flowered cyme per bract axil, borne in whorls along the inflorescence axis; pedicel 0.6–2 cm long, vinaceous, pubescent. **Calyx** subcampanulate, tube 0.3 × 0.5 mm, pubescent with tector trichomes, lobes triangular, 0.5–0.8 cm long, acuminate, margin entire, green, puberulent. **Corolla** erect in calyx, tubular, 1.8–2.6 cm long, red to lilac, rarely white, lanate with tector trichomes, base glabrous, base with 2 dorsal gibbositities somewhat united covering the calyx lobes, tube constricted above base, 2–4 mm wide, then expanding gradually to 5–7 mm after contracting slightly at throat, limb spreading, lobes 5, pink, red, greenish, rarely white, equal, ca. 2–3 × 4 mm. **Stamens** 4, exserted, filaments 2–3.2 cm long, glabrous, staminode present, anthers coherent, rectangular, pollen white, nectary consisting of two connate glands. **Ovary** 4–5 mm long, 1–2 mm wide, hispid, style 2–3.3 cm long, greenish, pubescent. Fruit a dry two-valved capsule ball-shaped with a short beak, 1.0–1.1 cm long, and 0.5–0.6 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, brown.

**Phenology:**—Flowers from September to February, fruits from October to March.

**Distribution and habitat:**—The species is widespread in Argentina, Bolivia, Brazil, Paraguay, and Uruguay (Skog & Boggan 2007). In Brazil, it occurs in Mato Grosso do Sul, Paraná, Santa Catarina and Rio Grande do Sul (Araújo & Chautems 2013). In this latter state it occurs in all regions mostly in the northern forested areas, and more rarely in the southern grassland areas (Fig. 3D). The species inhabits rocky outcrops, especially in shady and humid places.

**Conservation status:**—Least concern (IUCN, 2013).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Bento Gonçalves, na descida da Serra no Vale do Rio das Antas, barranco da estrada sobre pedras, 17 October 1988, *N.Silveira & J.Mansan 6065* (HAS); Canela, Parque da Ferradura, rupícola sobre bloco de basalto na descida do vale do Rio Caí, erva 60 cm, pendentes, flores pendulas alvas, 5 October 2012, *G.E.Ferreira 224* (ICN); 8km de Canela, Caracol, Parque Estadual, 27 December 1972, *J.C.Lindeman et al. s.n.* (ICN); Caracol, January 1951, *B.Rambo s.n.* (PACA); Caracol, February 1947, *B.Rambo s.n.* (PACA); Caracol, fl. vinosas com lacínios da corola verde claros, internamente pintalgados de lilás, October 1962, *G.Pabst & E.Pereira 6388* (R); Usina da Toca, 29 October 1997, *C.Mansan 147* (HAS); Caracol, *B.Rambo 50186* (PACA); Serra do Caracol, November 1949, *A.Schultz 716* (ICN); Caxias do Sul, Santa Lucia do Piaí, flores cor creme, interior com manchas bordô, 10

November 1987, *J.Meyer et al. 61* (HAS); Santa Lucia do Piaí, flor rosada por fora, com os lobos esverdeados externamente e bordô internamente com estrias, 10 November 1988, *J.Meyer et al. 65* (HAS); subida para S. Marcos, 16 January 1975, *L.Arzivenco s.n.* (ICN); Derrubadas, Picada da Cascata, entrada em Derrubadas, junto à queda da cascata; flores rosa variegada de escuro, com lenho de mais ou menos 15 cm de diam., 22 November 1975, *M.L.Porto 1922* (ICN); Farroupilha, rivum rupestris, November 1957, *Camargo 2559* (PACA); Maquiné, Barra do Ouro, 20 December 1989, *J.Mattos & N.Silveira 26437a* (ICN); Serra do Pinto, flor roxa, November 1989, *N.Silveira 8546* (HAS); Montenegro, Campestre, December 1935, *B.Rambo 2214* (PACA); L. Campestre, ad rupes humiditas, 450 m alt., November 1949, *A.Senhem 4072* (MBM); Linha Júlio de Castilhos, super rupem, 400 m alt., 15 November 1948, *A.Senhem 3631* (ALCB, B, INPA, MBM); Parecí, humidis dumetosis, October 1945, *Henz s.n.* (PACA); Piedade, December 1940, *B.Rambo 3679* (PACA); Nova Petrópolis, Linha Araripe, sobre paredão de basalto, sub-arburto com grande xilopódio e com flores rosas, 01 December 2005, *M.Grings 632* (ICN); Nova Prata, ca 9 km de Nova Prata para a Cascata, "rainha do abismo", 17 November 1982, *J.Mattos & R.Frosi 23743* (HAS); Picada Café, Walachai, rio Loch, na beira da mata, arbusto de 0,6 m, flores rosa-lilás, 01 October 2010, *M.Grings & S.Bordignon 1134* (ICN); Santa Maria, Reserva Biol. do Ibicuí-Mirim, barragem do Saturnino, 9 November 1988, *N.Silveira 6172* (HAS); Reserva Biol. do Ibicuí-Mirim, campo dos Barcelos, December 1987, *O.Bueno 5187* (HAS); Reserva Biol. do Ibicuí-Mirim, Nonato, em um barranco, prefloração com flores brancas, 8 November 1988, *N.Silveira 6007* (HAS); October 1955, *A.Schultz 1178* (ICN); Santana do Livramento, 18 km E, Cerro Palomas, morro de arenito com chapada de basalto, margem exposta da mesa basáltica, 15 October 1971, *J.C.Lindeman et al. 15* (ICN); Cerro Paloma, morro de arenito, 14 October 1974, *M.L.Porto 998* (ICN); Estrada Livramento-D.Pedrito, Cerro Paloma, encosta pedregosa, October 1974, *Sidia 170* (HAS); no Cerro Paloma, nas escarpas íngremes do cerro, nas rochas, fl. vermelhas, 22 October 1986, *J.Mattos & N.Mattos 31636* (HAS); no Cerro Paloma, nas rochas do costão do morrinho, 18 October 1984, *J.Mattos & N.Silveira 26968* (HAS); Taquarí, via Tabaí, terricola ou rupicola crescendo entre folhas secas, luz difusa a direta, flores vermelhas, tubérculo muito desenvolvido, 2 November 1989, *V.F.Nunes & T.N.Silva 500* (HAS); Terra de Areia, Rio Três Forquilhas, ca. 300m, barranco rio, December 1989, *A.Chautems et J.Waechter 373* (G); região de mata ombrófila densa (mata atlântica), erva sobre pedras, em beira de mata, flores roxo-claras, November 1996, *M.Sobral & C.Schindwein 81173* (ICN); Vacaria, a 8 km do Rio Pelotas, na rodovia para Lajes, 2 November 1983, *J.Mattos & N.Mattos 24680* (HAS); no Vale do Rio das Antas, "rainha do abismo", 29 November 1986, *J.Mattos & N.Mattos 30387* (HAS); Veranópolis, 4a. secção, beira do mato, 26 December 1983, *N.Silveira 974* (HAS); beira do mato, December 1983, *N.Silveira 974* (HAS); no reflorestamento da Madeireira José Abruzzi & Filhos, fl. lilás, 29 October 1987, *N.Silveira & J.Mattos 5689* (HAS); no Vale do Rio das Antas, borda da mata, arbusto com fl. alaranjadas, 27 September 1985, *J.Mattos & N.H.Bassan 28573* (HAS); no Vale do Rio das Antas, barrancos rochosos, 4 November 1982, *J.Mattos & N.Mattos 31062* (HAS); no Vale do Rio das Antas, nas pedras úmidas dos paredões, 16 September 1987, *N.Silveira 7128* (HAS); no Vale do Rio das Antas, na rodovia para Veranópolis, mata, sobre rochas, fl. rosadas externamente, vermelhas internamente, 27 October 1987, *J.Mattos & N.Silveira 31212* (HAS). Vale do Sol, rupícola em barranco rochoso, margem arroio, tubérculo com ca. de 10 cm diam., com numerosas raízes superficiais, cálice verde, corola rósea com pelos brancos, 18 February 1980, *J.Waechter 1557* (ICN); August 1981, *J.Waechter 1840* (ICN);

**12. *Sinningia warmingii*** (Hiern) Chautems (1990: 386), *Gesneria warmingii* Hiern (1877: 90). Type:—BRAZIL. Minas Gerais: Lagoa Santana, 12 December 1865, *Warming s.n.* (lectotype C-image!; isolectotype K-image!) Fig. 4E–F.

**Rupicolous or terrestrial herbs** with erect stems arising from tubers; **Stems** 40–120 cm, often branched, reddish to green, villous. **Leaves** 3-whorled, inserted along 4–9 nodes, petiole to 0.5–2.0 cm long; blade elliptic or oval-elliptic 3.0–12.0 × 1.6–4.0 cm, acute at the apex, acute or obtuse at the base, margin crenate, adaxial surface pubescent, abaxial green, pubescent, both two surface with tector trichomes. **Inflorescence** terminal, raceme, 3 flowers per whorl; pedicel 0.6–2 cm long, reddish, pubescent. **Calyx** subcampanulate, tube 0.8–1.5 mm wide, pubescent with tector trichomes, lobes triangular, 0.9–1.0 cm long, acuminate, margin entire, red to red-greenish, puberulent. **Corolla** erect in calyx, horizontal, tubular, 3.3–5.0 cm long, salmon to red-yellowish, pubescent with tector trichomes, glabrous at the base, base with 2 dorsal gibbosities some what united covering the calyx lobes, tube constricted above base, 2–3 mm wide, then expanding gradually to 5–7 mm at throat, limb spreading, lobes 5, salmon to red, unequal, ca. 4 × 5–6 mm. **Stamens** 4, included, filaments 3.0–4.8 cm long, glabrous, pinkish, staminode present, anthers coherent, rectangular, pollen white, nectary consisting of five glands, two conade glands larger than the others, two separate lateral glands and one isolated. **Ovary** 8 mm long, 2 mm wide, hispid, style 2.4 cm long, green, pubescent. Fruit a dry two-valved capsule, 1.0–1.1 cm long, 0.5–0.6 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, brown.

**Phenology:**—Flowers from November to March, fruits from February to May.

**Distribution and habitat:**—The species is widespread occurring in Argentina, Bolivia, Brazil, Colombia, Paraguay, Peru, Uruguay and Venezuela (Skog & Boggan 2007). In Brazil, it occurs in all regions (Araújo & Chautems 2013). In Rio Grande do Sul, the species is more easily observed in the northeastern Atlantic rainforest (Fig. 3E). The species inhabits rocky outcrops or rocky soils, being indifferent to light intensities.

**Conservation status:**—Least concern (IUCN, 2013).

**Notes:**—*Gesneria lindleyi* Hooker (1837: 3602) is considered a synonym of *S. warmingii* by Chautems (1990) although it is an older name than *G. warmingii* Hiern. However, the epithet “*lindleyi*” is already occupied by *Sinningia lindleyi* Schauer (1834: 642), therefore the epithet “*warmingii*” has been used for this species (Chautems 1990).

**Specimens examined:**—BRAZIL. **Rio Grande do Sul:** Bom Jesus, Serra da Rocinha, January 1944, *R.Reitz 1059* (PACA); Serra da Rocinha, 12 November 1987, *J.Meyer et al. 198* (HAS); Cambará do Sul, Itaimbézinho, rupes húmidas, February 1951, *B.Rambo 50162* (PACA); Maquiné, na estrada para Barra de Ouro, 8 March 1988, *N.Silveira 6571* (HAS); na subida da Serra para Cambará do Sul, frutos maduros, 23 May 1984, *N.Silveira et al. 1156* (HAS); parte alta da Serra do Pinto, sobre pedras, flores vermelhas, March 1989, *N.Silveira 8651* (HAS); subida Serra do Pinto, 2 December 1986, *J.Mattos & N.Mattos 30320* (HAS); Osório, Serra do Ouro, February 1971, *L.R.M.Baptista s.n.* (ICN); Rolante, Riozinho, December 1979, *O.Bueno 2007* (HAS); São Francisco de Paula, Estrada Tainhas-Aratinga, descida Serra do Pinto, barranco da estrada sobre rocha; caule ramificado, folhas discolores, verde branqueada na face abaxial, cálice vermelho

pálido, corola vermelho pálido, estilete vinoso, 22 February 1989, *A. Chautems et J. Waechter* 329 (E, G, ICN, NY, US, WU); Inst. Nac. do Pinho [FLONA], in dumetoso ad rupem, 600 m alt., 14 February 1952, *A. Senhem* 5869 (PACA); Morrinhos, rupes húmidas, February 1951, *B. Rambo* 52123 (HBR, PACA, S); Serra do Umbú, nos peraus, 5 February 1986, *J. Mattos et al.* 29147 (HAS); São Francisco de Paula, March 1983, *M. Sobral* 1604 (ICN); Sapiroanga, no Morro Ferrabrás, “casa de Jacobina”, rupícola, erva de 40 cm, flores vermelho cálice esverdeado, 10 March 2013, *G.E. Ferreira* 250 (ICN); prope Hamburgo, ad montem Ferrabrás, April 1949, *B. Rambo* 41608 (HBR, PACA); Terra de Areia, Serra do Pinto. 0,80 m alt., em touceira, cálice vermelho, 28 November 1988, *N. Silveira* 8091 (HAS); Torres, Lagoa Itapeva, Porto da Colonia, paredões de arenito, January 1973, *G.G. Hatschbach & O. Guimarães* 31177 (MBM, Z); Torres, Morro Azul, December 1977, *J.L. Waechter & L.R.M. Baptista* 675 (ICN).

**13. *Sinningia* ×*vacariensis*** G.E.Ferreira, Waechter & Chautems (2013: 46). Type:—BRAZIL. Rio Grande do Sul: Vacaria, Afloramento rochoso no interior da Floresta com Araucária, próximo ao Rio Pelotas, 28°12'42"S, 50°45'35"W, 660 m, 18 November 2012, *G.E. Ferreira and C. Vogel-Ely* 235 (holotype ICN!, isotype G!). Fig. 4G–H.

**Rupicolous herbs** with erect stems arising from tubers; **Stems** 80–100 cm, pilose, green with reddish streaks. **Leaves** decussate, inserted along 3–5 nodes, subequal, petiole 1.5 cm, tomentose, concolor; blade ovate–elliptic, 8–15 × 7–12 cm, obtuse at the apex, cordate or sometimes unequal at the base, margin irregularly crenate, 4–5 pairs of veins, adaxial surface strigillose, abaxial surface whitish-tomentose. **Inflorescence** terminal, racemiform, composed of pair-flowered cymes, borne in the axils of bracts or upper leaf pairs over the ca. 30 cm long apex of the axis; peduncles 0.5–2 cm long, green with reddish streaks, hirsute; pedicels ascending 0.5–2 cm long, green with reddish streaks, hirsute. **Calyx** subcampanulate, tube 2–3 mm long, hoary-tomentose, lobes linear-lanceolate, 4–6 mm long, acuminate, margin entire, green, pilose. **Corolla** erect in calyx, tubular, 2.5–3 cm long, red, pilose, base with 5 gibbositities between the calyx lobes, tube constricted above base, 3–4 mm wide, then expanding gradually to 5–7 mm at throat, limb spreading, lobes 5, with many dark red dots, unequal, ca. 4 × 4 mm; **Stamens** 4, included, filaments 2.9–3.2 cm long, glabrous, anthers coherent, rectangular, pollen white, nectary consisting of two separate dorsal glands; **Ovary** 6 mm long, 2 mm wide, hispid, style 2 cm long, green, pubescent. Fruit a dry two-valved capsule, 0.9–1.1 cm long, and 0.4–0.6 cm wide, acuminate, reddish brown, pubescent; seeds narrowly ellipsoid, brown.

**Phenology:**—Flowers from October to December, fruits from December to February.

**Distribution and habitat:**—This hybrid occurs in the Vacaria municipality in Rio Grande do Sul, next to the Pelotas River. We located only one individual, growing on basaltic rocky outcrops within an Araucaria forest, close to streams or in shaded habitats, between 600 and 800 m in elevation (Fig. 3F).

**Conservation status:**—Not available

**Notes:**—This naturally hybrid between *S. lineata* and *S. macrostachya*, found only once on rocky outcrops inside an Araucaria forest in Rio Grande do Sul, Brazil. This name was recently published as *Sinningia* ×*vacariensis* Ferreira, Waechter & Chautems. However,



the name “Ferreira” was used before by Alejandro Rodrigues Ferreira, and so we propose a replacement to “G.E.Ferreira”.

**Specimens examined:**— BRAZIL. **Rio Grande do Sul:** Vacaria, Afloramento rochoso no interior da Floresta com Araucária, próximo ao Rio Pelotas. 28°12'42”S, 50°45'35”W, 660 m. 18 November 2012. *G.E.Ferreira & C.Vogel-Ely 235* (G, ICN).

### Acknowledgements

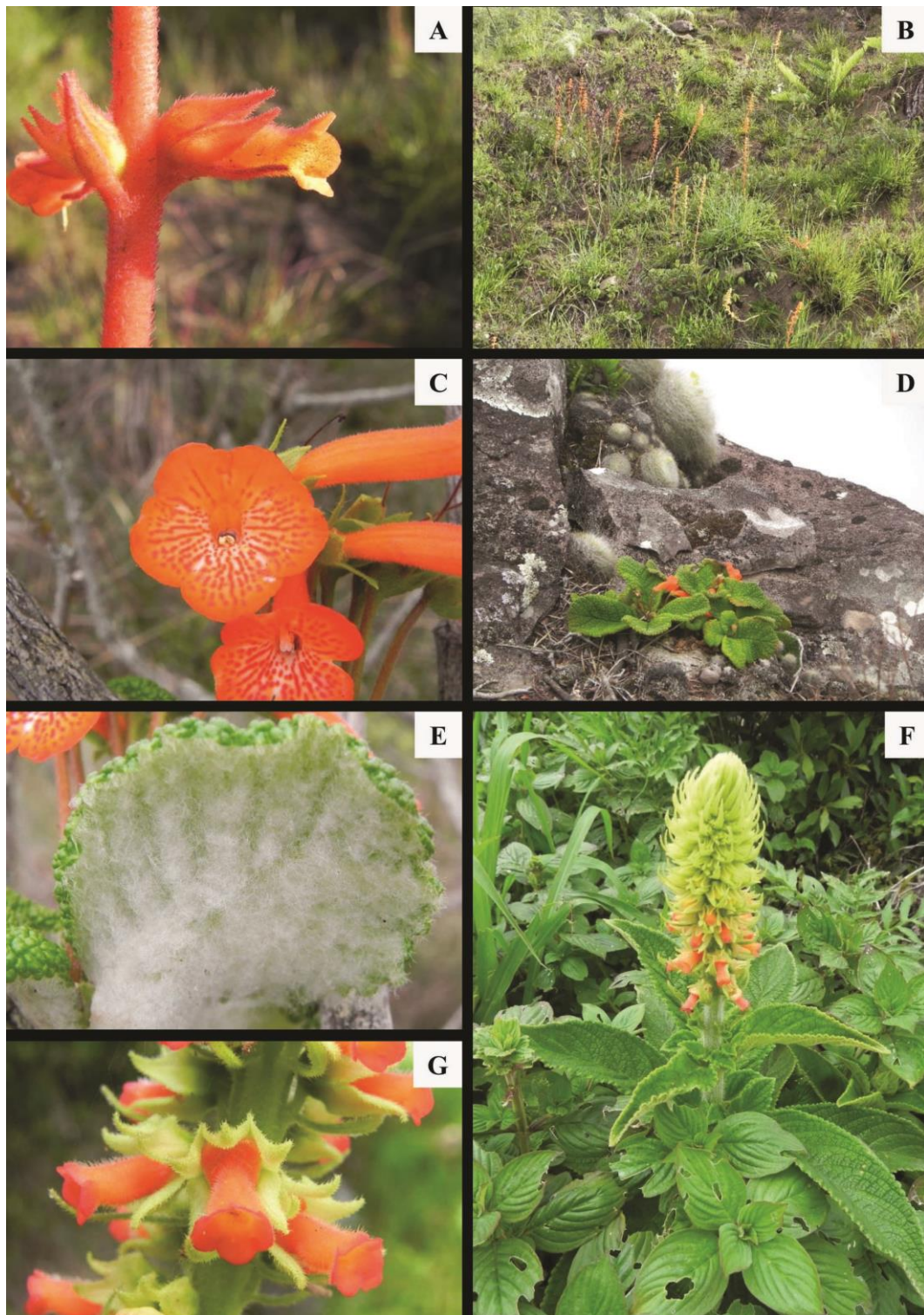
We are grateful to Capes (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for providing a scholarship to the first author and to Juliana Allgayer, Cleusa Vogel-Ely, Pedro J. Silva Filho, Silviane C. Pesamosca and Marlon Fracco for their great help during field expeditions.

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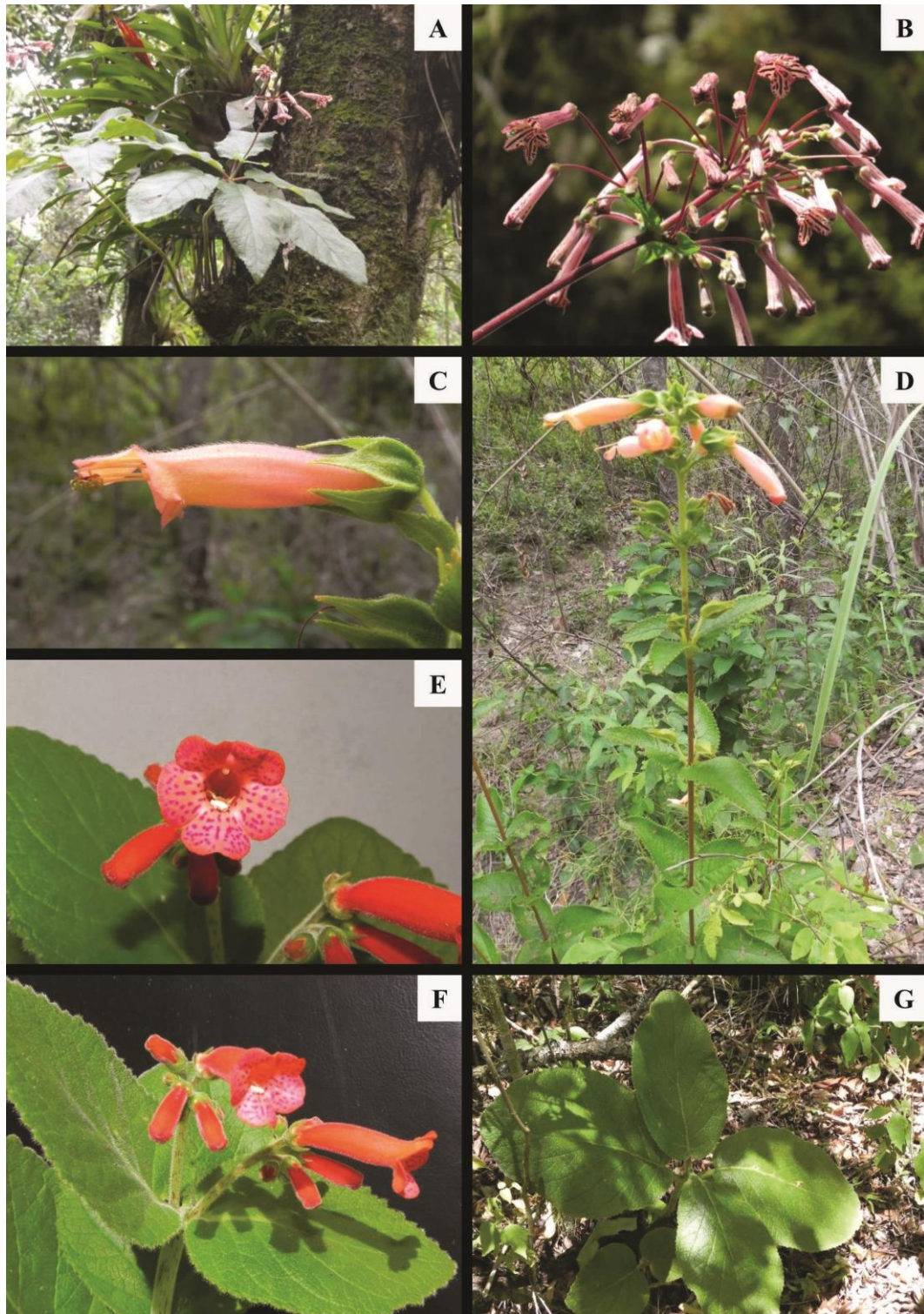
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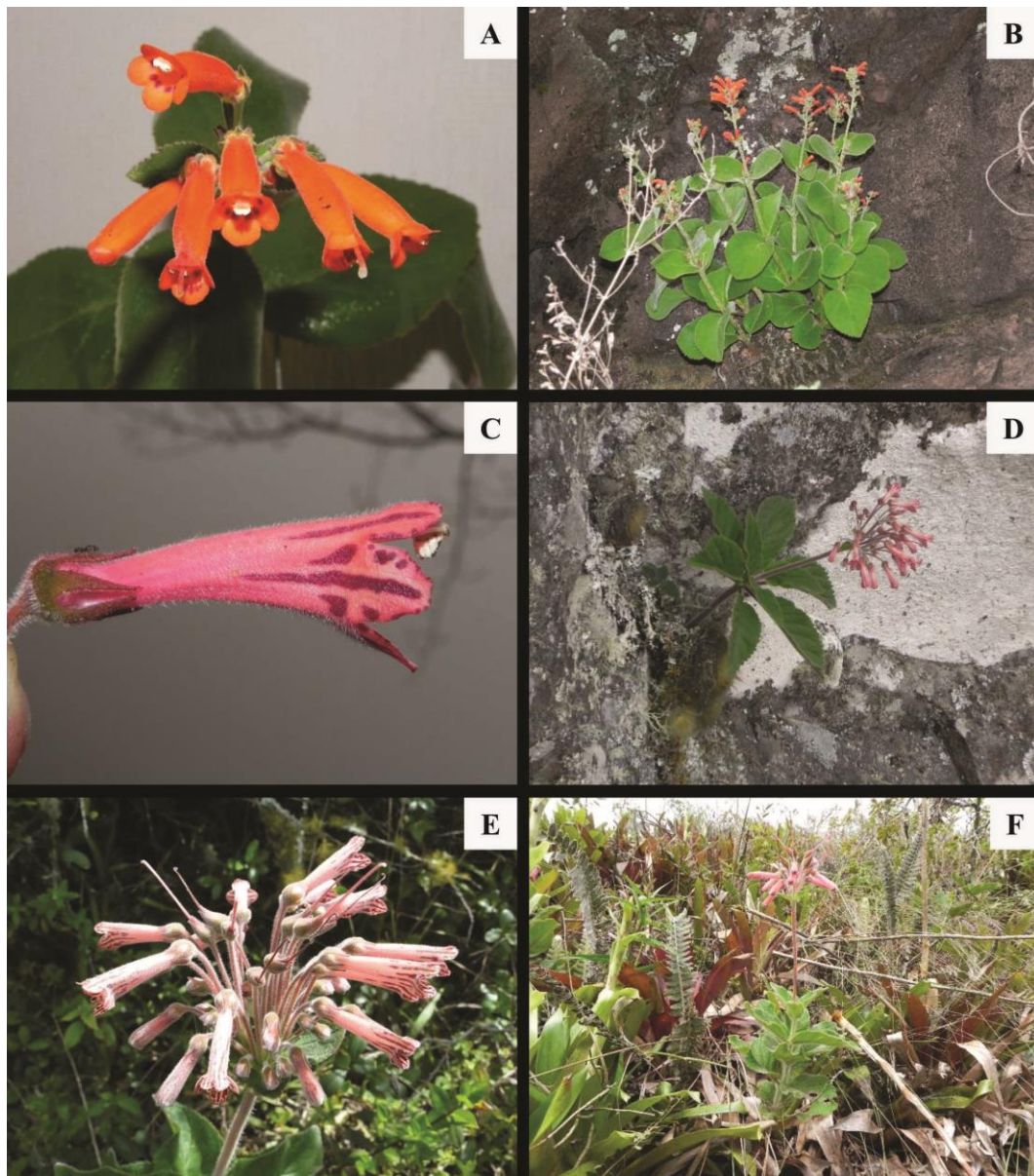
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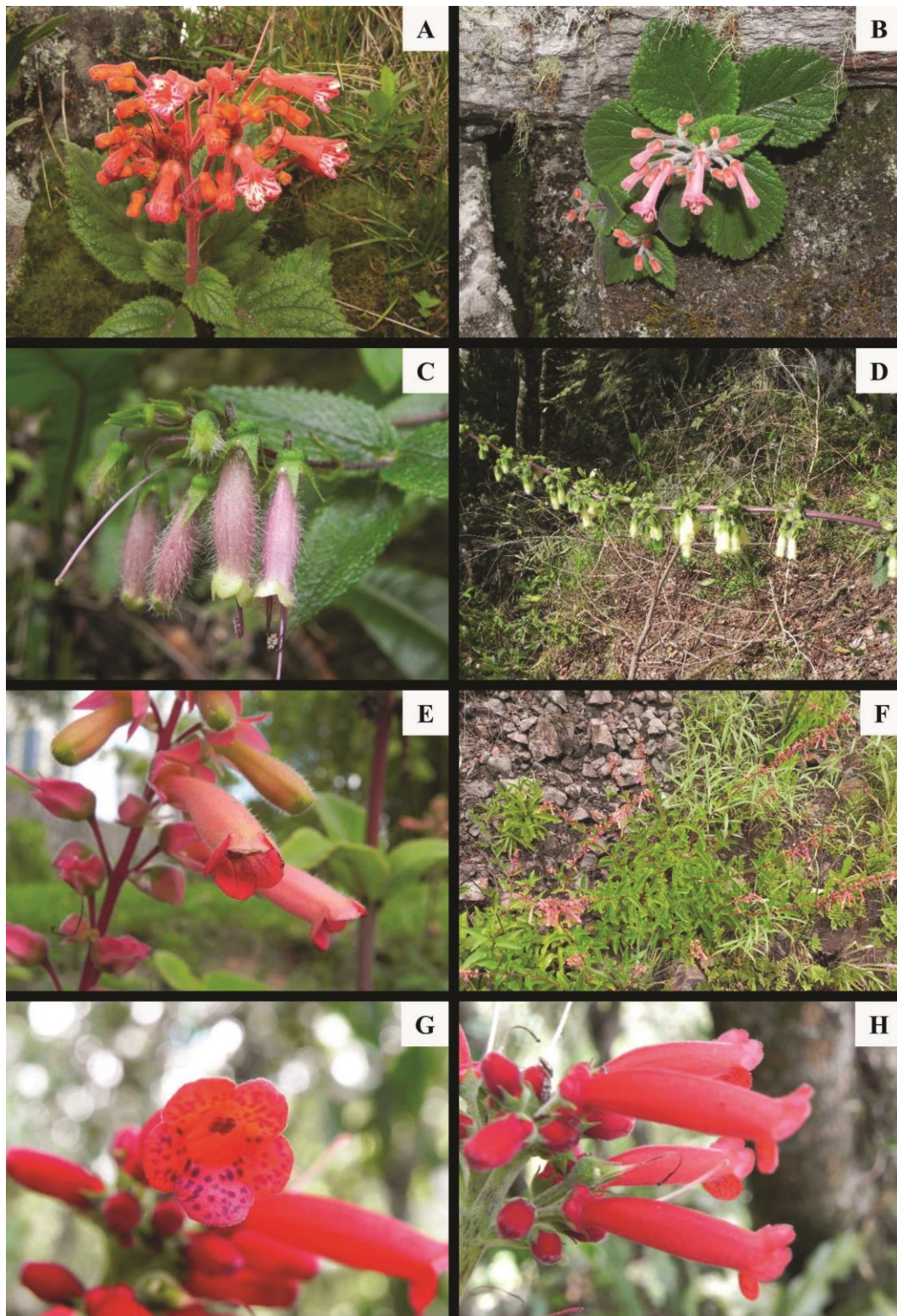
**FIGURE 1.** A–B. *Sinningia allagophylla*. A Corolla in lateral view. B. Habit. C–E. *Sinningia bullata*. C. Corolla in front view. D. General view of the species habitat. E. Detail of below leaf. F–G *Sinningia curtiflora*. F. Habit. G. Corolla in front view.



**FIGURE 2.** A–B. *Sinningia douglasii*. A. Habit. B. Inflorescence. C–D. *Sinningia elatior*. C. Corolla in lateral view. D. Habit. E–G *Sinningia lineata*. E. Corolla in front view. F. Detail of inflorescence. G. Habit.



**FIGURE 3.** A–B. *Sinningia macrostachya*. A. Detail of inflorescence. B. Habit. C–D. *Sinningia nivalis*. C. Corolla in lateral view. D. Habit. E–F *Sinningia polyantha*. E. Detail of inflorescence. F. Habit.



**FIGURE 4.** A–B. *Sinningia ramboi*. A. Inflorescente. B. Habit. C–D. *Sinningia sellovii*. C. Flowers in lateral view. D. Inflorescence. E–F. *Sinningia warmingii*. E. Corolla in frontal view. F. Habit. G–H *Sinningia* × *vacariensis*. G. Corolla in frontal view. H. Detail of inflorescence.

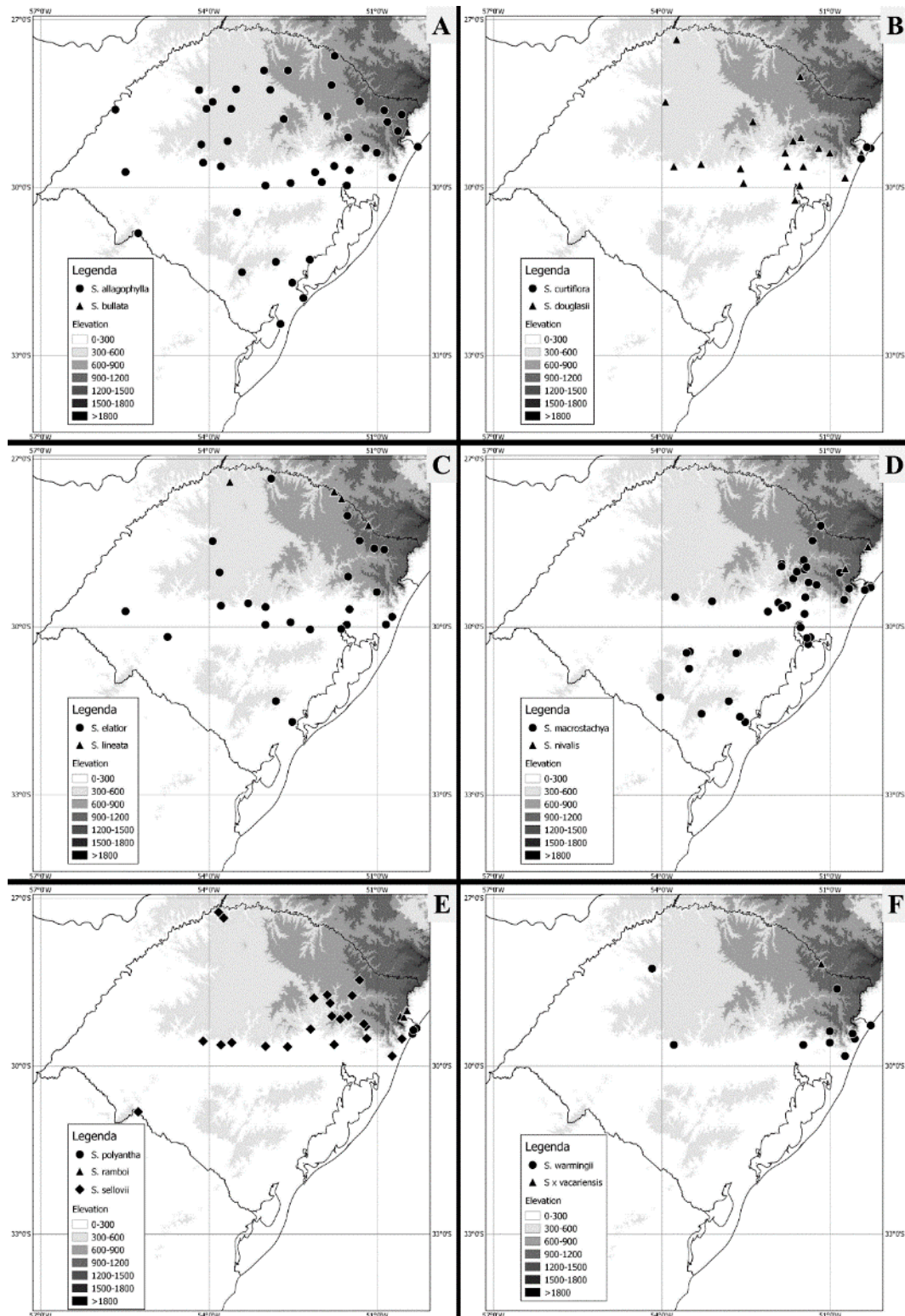


FIGURE 5. Distribution of *Sinningia* in Rio Grande do Sul.



**Capítulo 2. Biogeografia do gênero *Sinningia* (Gesneriaceae) na América do Sul  
Subtropical**

**Artigo 5**

Original Article

**Subtropical species of *Sinningia* (Gesneriaceae): distribution patterns and limiting environmental factors**

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***Sinningia* (Gesneriaceae) in subtropical South America**

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## **Abstract**

*Background and Aims* The neotropical genus *Sinningia* Nees encompasses tuberous herbs or subshrubs which occupy a wide range of environments, including climate and soil or substrate types. The genus has more than 70 species distributed from Southern Mexico to Northern Argentina, with a diversity centre in the Brazilian Atlantic Rainforest. In this formation, a large number of species occur in several particular vegetation types, occupying terrestrial to rupestral and epiphytic habitats substrates. The aims of this study were to describe the distribution patterns of subtropical *Sinningia* species and to determine possible limiting factors for their range extension.

*Methods* We summarized environmental data for 21 species. Ten geographical and ecological variables were subdivided into several regional or local conditions. The occurrence of species in each of these conditions was obtained from published material, herbarium reviews and original field expeditions. We used exploratory multivariate approaches, (cluster and ordination analyses) to assess the contribution of these data on species' ecological and geographical distributions. Comparisons between groups of species were evaluated for significance using randomization tests.

*Key Results* Two major patterns of geographic distribution were identified for subtropical *Sinningia* species: widespread and restricted. Species richness according to spatial and climatic variables showed four distinct patterns. Habitat tolerance of the species also distinguished two groups in a wider continuum context. Cluster analysis resulted in two stable groups, which coincided almost entirely with an a priori classification based on geographic range. Ordination analysis distinguished widespread and restricted species along axis 1, and a gradient of different substrate occupancy along axis 2.

*Conclusions* Patterns of ecological and geographical distribution are strongly related to the evolutionary history of the genus. The southern limit of distribution of *Sinningia* is

mainly due to vegetation changes around parallel 30°, where the northern forested Atlantic and Paranean biogeographic provinces give place to the southern non-forested Espinal and Pampean provinces.

**Keywords:** biogeography, *Corytholoma*, *Dircaea*, ecology, epiphytes, lithophytes, helophytes, psammophytes.

## INTRODUCTION

*Sinningia* Nees is a Neotropical genus of the family Gesneriaceae with more than 70 species (Perret *et al.*, 2006). The species of the genus are tuberous herbs or subshrubs, standing out for the variability of environments or substrates they occupy. Different species have specialized to occur in closed vegetation types such as pluvial, seasonal and montane forests, and more open dune forests (*restingas*), savanas, lowland and montane grasslands, marshes and peat bogs, and rocky outcrop vegetation. Regarding substrate, species can be terrestrial, epipetric, and epiphytic (Chautems *et al.*, 2000; Araújo and Chautems, 2013).

The genus *Sinningia* is presently inserted in tribe Sinningieae, along with *Paliavana* Vandelli and *Vanhouttea* Lemaire. The probable origin of *Sinningia* was a vicariant event with an ancestral taxon from the Amazon Forest that dates back around 30 Mya (Perret *et al.*, 2013). *Sinningia* is a paraphyletic genus (Perret *et al.*, 2003) however, a new generic circumscription will be probably proposed in a near future.

The genus is distributed from Southern Mexico to Northern Argentina, with a diversity centre in the Brazilian Atlantic Rainforest (Wiehler 1983; Chautems *et al.*, 2000; Perret *et al.*, 2006; Araújo and Chautems, 2013). The greatest diversity of *Sinningia* is found along mountain ranges within the Brazilian Atlantic Rain Forest. A lower number of species also occurs in areas occupied by seasonal vegetation, such as the semi-deciduous forests of the Paraná-Paraguay river basin, the cerrados of central Brazil, and the caatingas of northeastern Brazil (Chautems 2008; Perret *et al.*, 2013).

The subtropical *Sinningia* species belong to two lineages, *Dircaea* and *Corytholoma*, probably originated in the northeastern region of the Brazilian Atlantic rainforest. The *Dircaea* clade has diversified in the Paraná River basin area, while the

*Corytholoma* clade in the north of the Tropic of Capricorn within the northern Atlantic rain forest and the São Francisco River basin (Perret *et al.*, 2006). The southward migration of *Corytholoma* and the northward migration of *Dircaea* maybe have been interrupted by an ecophysiological barrier, such as an area with very low pluviocity, referred as a cause of floristic differences along the Brazilian Atlantic Rainforest (Brown, 1987; Oliveira-Filho and Fontes, 2000; Behling and Negrelle, 2001; Perret *et al.*, 2006).

In order to better understand the biogeographic history of a given taxonomic group it is convenient to integrate knowledge on phylogenetic relationships and ecological characteristics. However, few biogeographic studies have in fact addressed these two points simultaneously (Huggett, 2004; Wiens and Donoghue, 2004). The aim of this paper was basically to answer three major questions: (i) how are *Sinningia* species distributed in eastern subtropical South America? (ii) do distribution ranges of species define regional centres of endemism? (iii) which ecological and/or geographical factors are limiting the occurrence of subtropical species?

## MATERIALS AND METHODS

### *Study area*

We defined our study area as a subtropical region comprising the two southernmost states of Brazil, Santa Catarina and Rio Grande do Sul, the three northeastern provinces of Argentina, Misiones, Corrientes and Entre Rios, and Uruguay (Fig. 1). This area totalizes ca. 820,000 km<sup>2</sup> and lies roughly between 25 and 35°S, often considered as the limits for subtropical latitudes (Strahler & Strahler 1989). The western limit is naturally defined by the course of the Paraná River.

Climate types in the region, according to the Köppen-Geiger system, are basically moist subtropical (*Cfa*) in the lowlands and submontane areas and mild temperate (*Cfb*) in the higher elevations, above 800m (Peel *et al.*, 2007). Temperatures show a strong

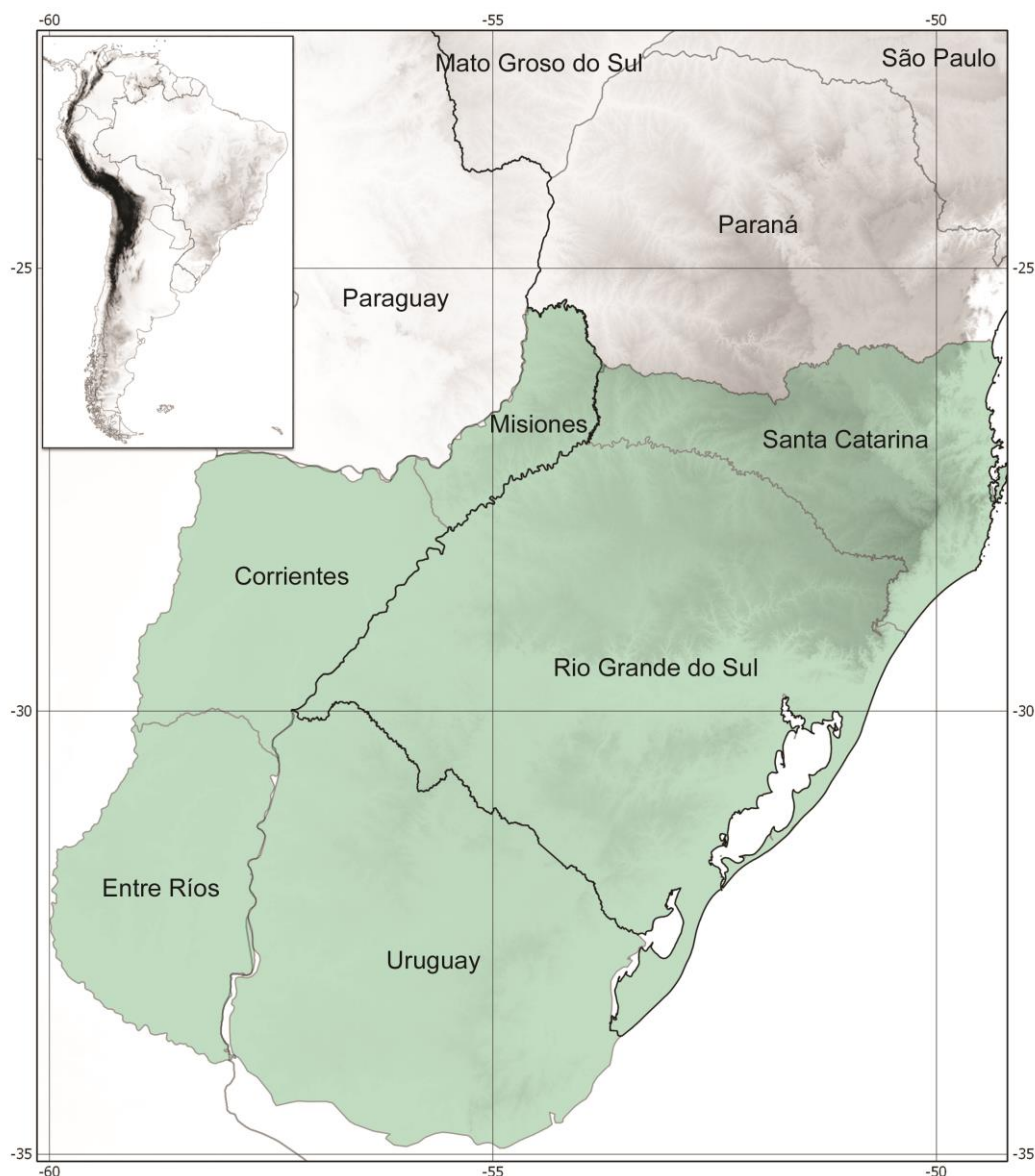
seasonal variation, from hot summers in continental plains to moderate or relatively severe winters in montane areas, where up to 30 annual frost days and occasionally snowfall may occur. Mean annual temperature varies between 15 and 18 °C, with minimum around -10 °C and maximum around 40 °C (Moreno, 1961; Nimer 1990; Hijmans *et al.*, 2005).

Vegetation types in the region may be roughly divided into grassland and forest-dominated formations. Actually, the area comprises three major formations: forests (coastal rain forests, interior seasonal forests, and montane Araucaria forests), grasslands (northern montane grasslands and southern Pampas with gallery forests) and parklands (“palmares” or palm savannahs and “espinales” or thorn savannahs).

Rain forests are essentially coastal formation influenced by orographic rainfalls along the Atlantic slopes of the Serra Geral mountain range. This formation occurs along the entire coastal region in Santa Catarina and extends to northeast Rio Grande do Sul, achieving there the southern limit of distribution (Rambo 1961). Seasonal forests are mostly interior formations, possibly submitted to greater temperature than precipitation variations along the year. Seasonality in these forests is manifested by a greater diversity and abundance of deciduous species, mainly of the legume family (Rambo 1951; 1954; Spichiger *et al.*, 2004). Araucaria forests are most typical for higher elevations of the South Brazilian Plateau and are thus characterized by a higher proportion of temperate floristic elements (both Holarctic and Antarctic), especially the conifers *Araucaria* and *Podocarpus* (Rambo 1951; Prado 2000).

South Brazilian grasslands, collectively circumscribed as South Brazilian Campos (Overbeck *et al.*, 2007), are commonly divided into two major occurrence areas, the northern montane grasslands of the Paranean biogeographic province and the southern grasslands of the Pampean biogeographic province, mostly lying at lower elevations

(Cabrera & Willink 1980). Both areas of “campos” extend beyond the limits of South Brazil, the former to the Southeast and Northeast regions (Longhi-Wagner *et al.*, 2012) and the later to Uruguay and the northeast provinces of Argentina, comprising an area sometimes circumscribed as the Rio de La Plata Grasslands (Soriano *et al.*, 1992; Bilenca and Miñarro, 2004). Parklands are mostly southern grasslands with scattered palms of the genus *Butia* or spiny legumes of the genus *Prosopis* (Cabrera & Willink 1980).



**FIG. 1.** The study area as circumscribed by six political areas in south Brazil, northeast Argentina and Uruguay.



### *Data collection*

Data regarding distribution and environment of *Sinningia* species were obtained from three information sources: 1) published material; 2) herbarium exsiccates; and 3) original field work. The bibliographical research focused mainly on floristic databases such as the Species List of the Brazilian Flora (Araujo and Chautems 2013), the Flora del Conosur (Chautems 2008) and the Global Biodiversity Information Facility - GBIF database. We consulted the following herbaria: B, G, G-DC, HAS, HBR, HPL, HUCCS, ICN, K, MBM, PACA, US and R. The ecogeographical data on herbarium labels were annotated. Additionally, field expeditions for *Sinningia* sampling were conducted from September 2010 to November 2013.

Climatic data were obtained from Worldclim (Hijmans *et al.*, 2005). Rock and soil types follow the database of Environmental Data Explorer (available at <http://geodata.grid.unep.ch/>) and DIVA-GIS (available at <http://www.diva-gis.org/Data>). Vegetation types follow commonly recognized formations in publications on Brazilian and South American biogeographic systems (e.g. Cabrera and Willink, 1980, Morrone, 2001). The occurrence of each species was plotted on maps with the aid of Quantum GIS software (QGis DT 2013), overlapping the ecogeographical data.

The occurrence of *Sinningia* species was also plotted on a matrix containing 10 potentially factorial variables. At a regional scale these variables can be divided into spatial (latitude, elevation, distance from the coast), climatic (mean annual temperature, mean annual precipitation and number of frost days), and biogeographic (vegetation types). At a local scale, we differentiated soil types for terrestrial species, rock types for epipetric or rupestral species, and bark types for epiphytic species. The number of classes or intervals considered for each of the potential factors varied from four (substrate types) to 12 (vegetation types), totalling 62 possible occurrences for each species (see

Supplementary Data, Table S1). The number of occurrences in all environmental classes was interpreted as a measure of habitat tolerance for each species.

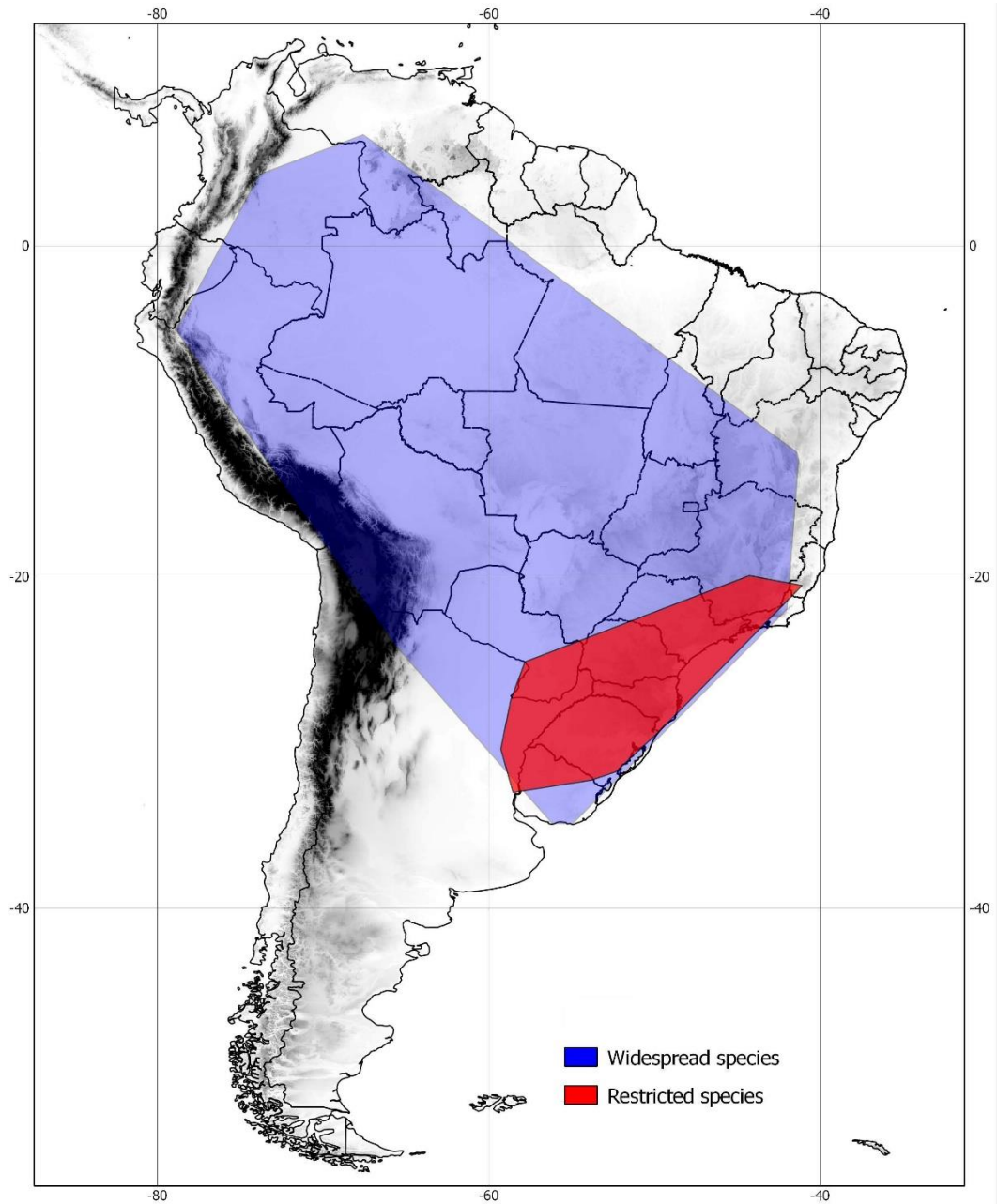
#### *Data analyses*

We used an exploratory multivariate approach to assess the contribution of the above mentioned variables on species' geographical and ecological distribution. To do so we merged continuous variables into intervals, and used minimum and maximum values for each variable, as well as the number of vegetation types in which a given species occurred and its classification as terrestrial, epipetric or rupicolous and/or epiphytic. The resulting summarized data matrix (21 species described by 16 variables) was submitted to cluster and ordination analyses (Principal Coordinate Analysis) using Gower distance as a dissimilarity measure between species and incremental sum of squares as a clustering criterion. Stability and significance of clustering groups and ordination axes were evaluated with bootstrap resampling methods (Pillar 1998; Pillar 1999a, b). The 21 species were classified *a priori* into groups according to two criteria: phylogenetic group (*Dircaea* and *Corytholoma*) and geographic range (restricted and widespread). This classification was tested using randomization tests with bootstrap resampling (Pillar and Orłóci, 1996). All randomization tests comprised 10,000 bootstrap iterations. Analyses were carried out with softwares Multiv (Pillar, 1997) and the R Platform (R Development Core Team 2013).

## RESULTS

#### *Distribution patterns*

The 21 species of *Sinningia* belong to two lineages, *Corytholoma* with seven species, and *Dircaea* with 14 species (Tab. 1).



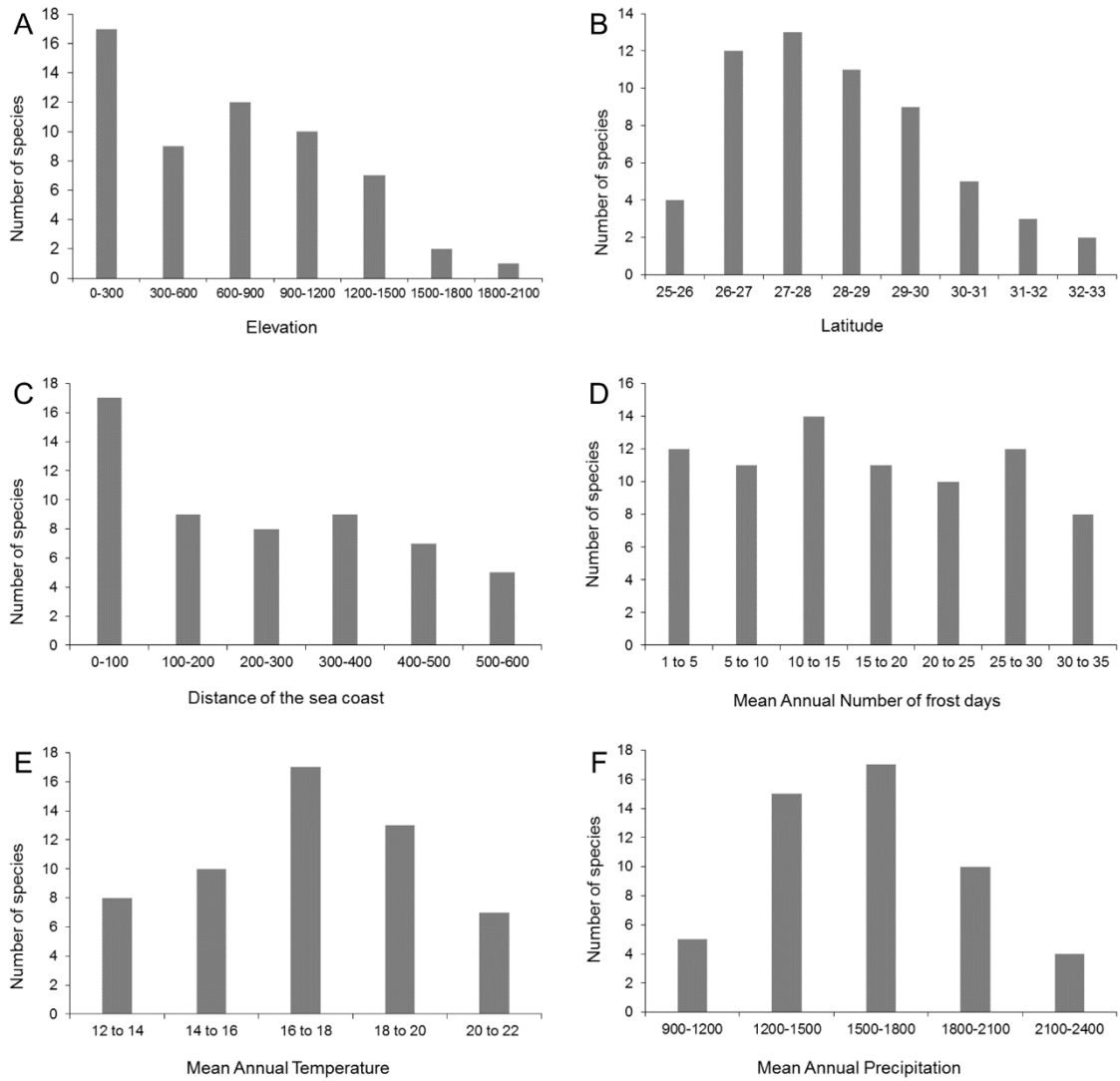
**FIG. 2.** The two major distribution areas of subtropical *Sinningia* species in South America: restricted and widespread.

**TABLE 1.** Geographic distribution and habitat of the *Sinningia* species (Gesneriaceae) occurring in the study area. Countries: ARG = Argentina, BOL = Bolivia, BRA = Brazil, COL = Colombia, ECU = Ecuador, PER = Peru, PRY = Paraguay, URY = Uruguay, VEZ = Venezuela. Habit: T = terrestrial, R = epipetric or rupicolous, E = epiphytic, H = helophytic, P = psammophytic.

<i>Sinningia</i> species	Acronym	Distribution	Habit	Distribution
<i>S. aggregata</i> (Ker Gawl.) Wiehler	aggr	BRA, PRY	R	Widespread
<i>S. allagophylla</i> (Mart.) Wiehler	alla	ARG, BRA, PRY, URY	T	Widespread
<i>S. bullata</i> Chautems and M. Peixoto	bull	BRA	R	Restricted
<i>S. conspicua</i> (Seem.) G. Nicholson	cons	BRA	T	Restricted
<i>S. cooperi</i> (Paxton) Wiehler	coop	BRA	E	Restricted
<i>S. curtiflora</i> (Malme) Chautems	curti	BRA	H	Restricted
<i>S. douglasii</i> (Lindl.) Chautems	doug	ARG, BRA	ER	Widespread
<i>S. elatior</i> (Kunth) Chautems	elati	ARG, BOL, BRA, COL, PER, PRY, URY, VEZ	H	Widespread
<i>S. hatschbachii</i> Chautems	hats	BRA	E	Restricted
<i>S. leopoldii</i> (Scheidw. ex Planch.) Chautems	leop	BRA	R	Restricted
<i>S. leucotricha</i> (Hoehne) H.E. Moore	leuc	BRA	R	Restricted
<i>S. lineata</i> (Hjelmq.) Chautems	line	BRA	R	Restricted
<i>S. macropoda</i> (Sprague) H.E. Moore	macp	BRA	R	Restricted
<i>S. macrostachya</i> (Lindl.) Chautems	macs	BRA	R	Restricted
<i>S. nivalis</i> Chautems	nival	BRA	RE	Restricted
<i>S. polyantha</i> (DC.) Wiehler	poly	BRA	P	Restricted
<i>S. ramboi</i> G.E. Ferreira <i>et al.</i>	ramb	BRA	RE	Restricted
<i>S. reitzii</i> (Hoehne) L.E. Skog	reit	BRA	R	Restricted
<i>S. sellovii</i> (Mart.) Wiehler	sell	ARG, BOL, BRA, PRY, URY	R	Widespread
<i>S. tubiflora</i> (Hook.) Fritsch	tubi	ARG, PRY, URY	T	Restricted
<i>S. warmingii</i> (Hiern) Chautems	warm	ARG, BRA, ECU, PER, PRY	R	Widespread

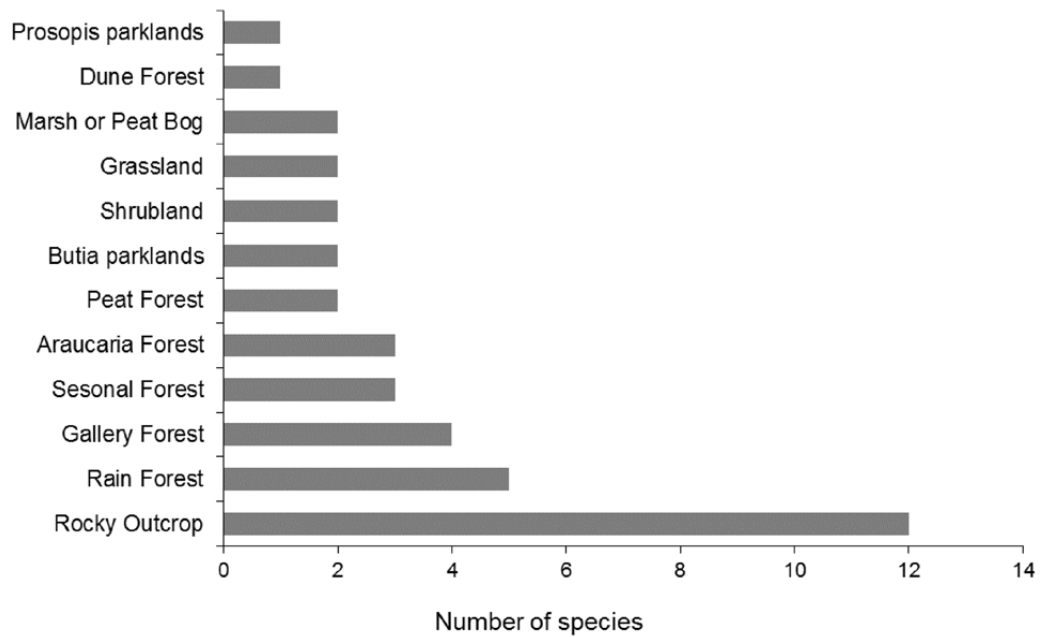
### *Ecological and geographic variables*

According to particular spatial and climatic variables the number of *Sinningia* species showed four distinct patterns (Fig. 3): 1) an overall decreasing tendency related to latitude and elevation, which are surrogates for temperature in macroscale and mesoscale, respectively; 2) an outstanding species richness (or diversity) in one extreme situation of a gradient, as shown by the higher number of species in coastal areas; 3) an almost constant or low varying richness along several environmental classes, as indicated by tolerance to the number of annual frost days; and 4) a non-monotonic hump shaped response, suggesting more favourable conditions at intermediate intervals of a broader range, as evident in the relationship between species number and both mean annual temperature and mean annual precipitation.



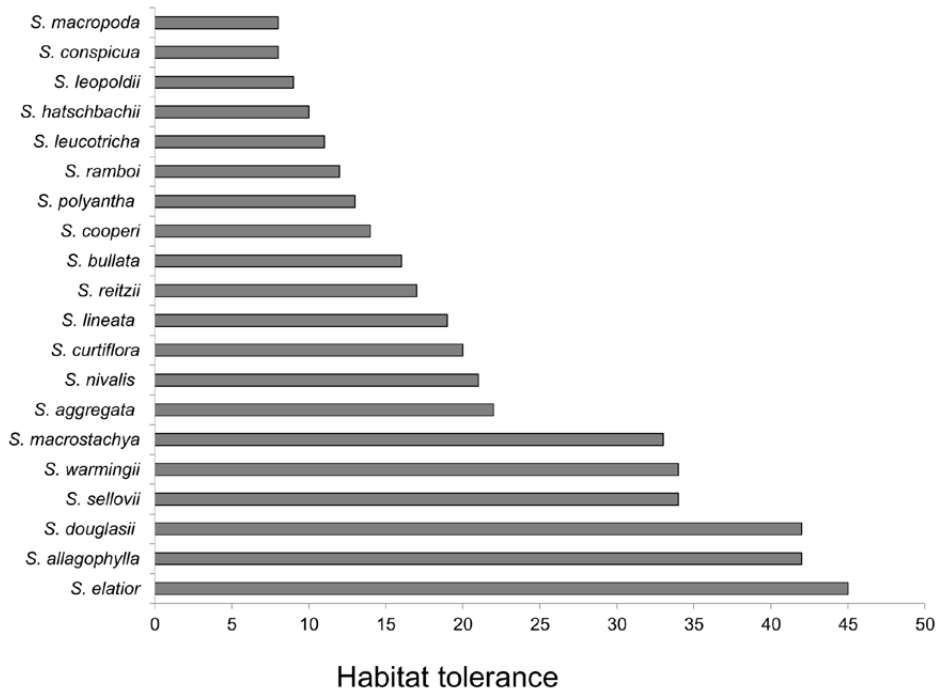
**FIG. 3.** Variation in the number of *Sinningia* species in relation to spatial and climatic variables.

The most common habitat type for subtropical *Sinningia* species are rocky outcrops, being these immersed or not in forests environments. In this habitat, the species are often associated to other xerophytic plants species, as cacti, bromeliads and orchids, so that rocky outcrops can also be regarded as vegetation types. The number of species decreases strongly towards other vegetation types (Fig. 4).



**FIG. 4.** Number of *Sinningia* species in major vegetation types in eastern subtropical South America.

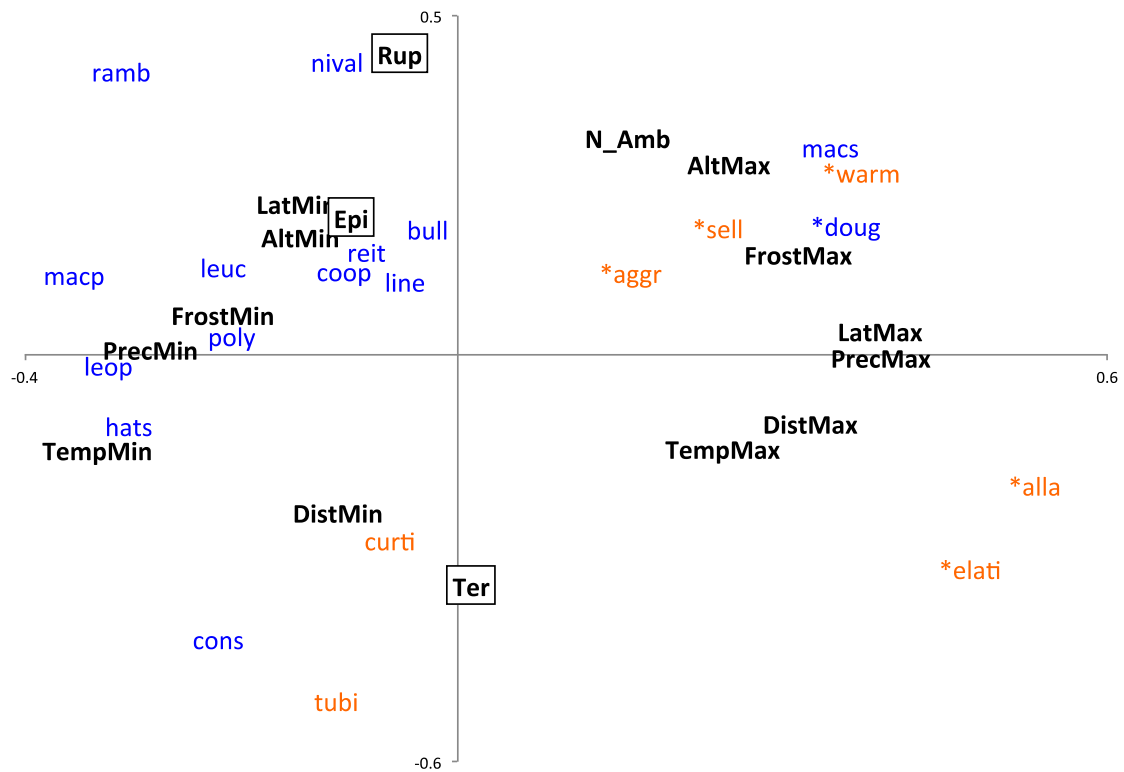
Habitat tolerance distinguished two species groups, separated by a larger discontinuity along the species rank according the number of habitat classes (Fig. 5). One group was formed by six species occurring from 36 to 45 different habitat conditions, and another formed by the remaining set of 15 species growing from nine to 24 habitat classes. The first group was formed by four species classified in the clade *Corytholoma* (*S. elatior*, *S. allagophylla*, *S. sellovii* and *S. warmingii*), and two species included in the clade *Dircaea* (*S. douglasii* and *S. macrostachya*).



**FIG. 5.** Habitat tolerance in subtropical species of *Sinningia*, an almost continuum where two major groups can be distinguished, the more restricted species (above) and the more widespread species (below). Habitat tolerance was defined as the total number of conditions in which a given species occurs (see text for detailed explanation).

Cluster analysis resulted in two stable groups ( $P > 0.20$ ), which coincided almost entirely with the *a priori* classification based on range size (with the exception of *S. cooperi*, which grouped with the remaining widespread species). Ordination analysis also showed a clear segregation between restricted and widespread species along axis 1, as well as a gradient of different habitat occupancy along axis 2 (Fig. 6). Although the distinction between species from different lineages was not significant based on our data ( $P = 0.13$ ), the ordination diagram also showed a rough separation of lineages, with a great coincidence with geographical ranges. Most species in *Dircaea* grouped on the left side of the diagram, except *S. macrostachya* and *S. douglasii*, which grouped with the species of the *Corytholoma* lineage on the right side of the diagram (Fig. 5).





**FIG. 6.** Principal coordinate analysis (PCOA) showing *Sinningia* species (see acronyms on Table 1) and environmental factors. Species in clade *Dircaea* are shown in blue while those in clade *Corytholoma* are shown in red. Axis 1 distinguishes mostly restricted (at left) from widespread (at right) species; axis 2 distinguishes mostly rupicolous and epiphytic habitats (above) from mostly terrestrial habitats (below), these including both dry and wet environments. Legend: AltMin - Minimum altitude; AltMax - Maximum altitude; LatMin - Minimum latitude; LatMax - Maximum latitude; DistMin - Minimum distance; DistMax - Maximum distance; TempMin - Minimum temperature; TempMax - Maximum temperature; FrostMin - Minimum frost day; FrostMax - Maximum frost day; PrecMin - Minimum precipitation; PrecMax - Maximum precipitation; NoAmb - Number of environments; Ter – Terrestrial; Rup – Rupestral; Epi – Epiphytic.

## DISCUSSION

The genus *Sinningia* shows a decreasing number of species according to all spatial variables analysed in this study: from northern to southern latitudes, from lowlands to highlands, and from coastal to inland regions. These general tendencies, were already identified for the tribe Sinningieae (including *Vanhouttea* and *Paliavana*) by Perret et al. (2006) and other plant groups, such as trees (Oliveira-Filho and Fontes, 2000), and bromeliads (Martinelli *et al.*, 2008). Perret *et al.* (2006) also assert that the group originated in tropical forests along the São Francisco River in northeast Brazil, and

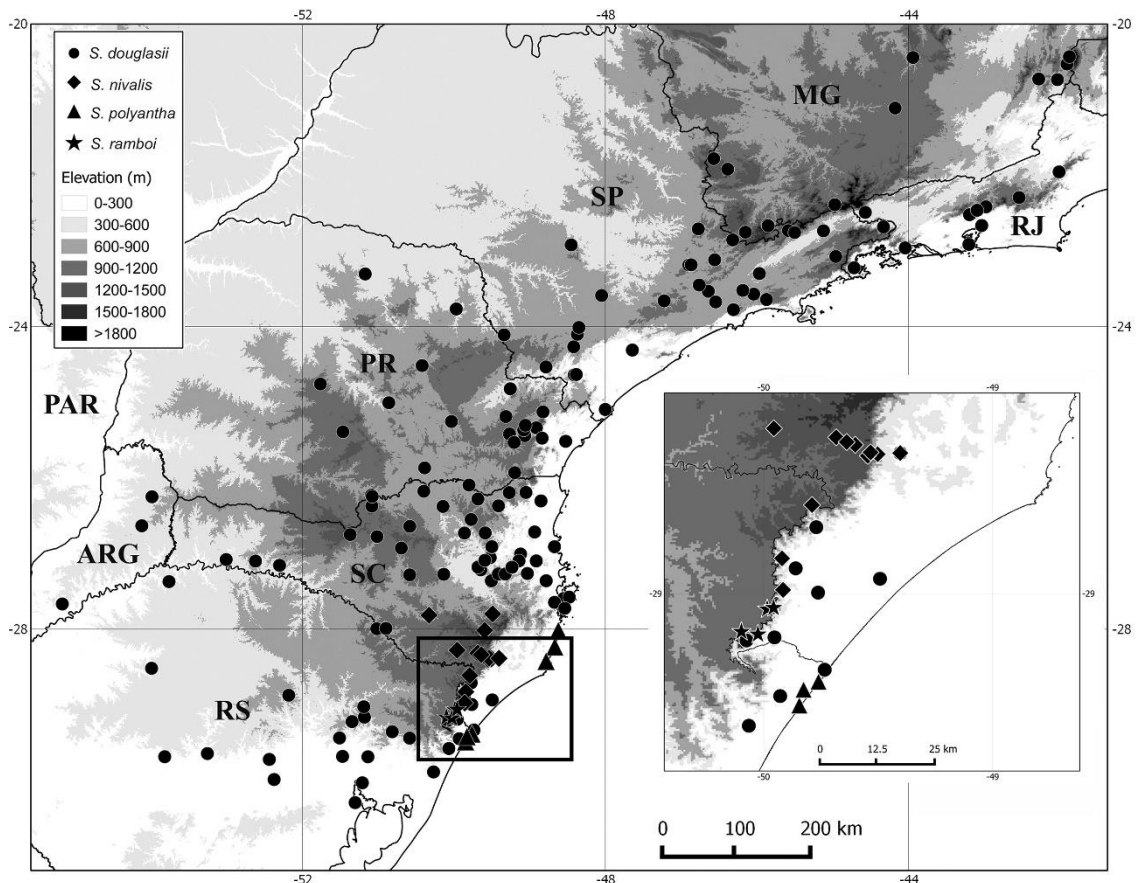
migrated southwards from this region. In southern Brazil, the increasing distance from the ocean and the displacement to southern latitudes creates striking seasonal fluctuations in temperature and below the parallel 30°S, the precipitation also diminishes gradually, which is reflected in mostly grassland ecosystems (Soriano *et al.*, 1992; Nery, 2005; Bilenca and Miñarro, 2004; Overbeck *et al.*, 2007; Gonçalves and Souza, 2013).

Most species have a more or less continuous distribution within their range, whether restricted or widespread. To the present knowledge, only *S. conspicua* and *S. reitzii* (both in the clade *Dircaea*) have a disjunct distribution. The former occurs from Minas Gerais to Santa Catarina but is absent from São Paulo. The latter occurs from São Paulo to Santa Catarina but was still not found in Paraná (Araujo and Chautems 2013). These occurrence gaps may be due to habitat destruction and replacement of natural vegetation by extensive areas with agricultural crops, but also because of a lack of sampling in areas with difficult access along the Brazilian Atlantic Rainforest. This may be particularly true for the epipetric species growing on steep rocky escarpments, which is the case of most species of *Sinningia*.

A subtropical regional centre of endemism can be defined as a relatively small area around parallel 29°S, which coincides with the border between southern Santa Catarina and northeastern Rio Grande do Sul (Fig. 7). In this area, four species of *Sinningia* show a remarkable similar vegetative and reproductive morphology, the closely related *S. douglasii*, *S. nivalis*, *S. polyantha* and *S. ramboi*. The latter three species are endemic to Santa Catarina and Rio Grande do Sul, and in fact to a very small part of the studied area. These species are probably a result of a local radiation towards increasing specialization to different habitats. While *S. douglasii* is an essentially epiphytic species in moist forests, and relatively widespread in the study area and beyond (Fig. 7), the other three species are only rarely epiphytic and otherwise specialized on coastal dunes near

the sea level (*S. polyantha*) or on rocky outcrops at high elevations of the Serra Geral mountain range (*S. nivalis* and *S. ramboi*).

The time of divergence of the four species can be estimated between 3 and 1 Mya (Perret *et al.*, 2013), suggesting that these species are derived from the most recent radiation events within the genus *Sinningia* (Ferreira *et al.*, 2014). The restricted distribution of these species may be due to their recent radiation, i.e., a relatively short time to expand their range. The ancestor of the four species was probably a taxon with a restricted distribution at the coastal region, where the proximity of the Atlantic Ocean produces a lower variation in both temperature and rainfall seasonality, the Atlantic forest refugia (Carnaval and Moritz, 2008; Carnaval *et al.*, 2009). After the climate change that resulted in Araucaria forest expansion over grasslands in the South Brazilian highlands (Behling *et al.*, 2004; Jeske-Pieruschka *et al.*, 2013), the higher elevations probably showed improved climatic conditions for the colonization of these species.



**FIG. 7.** Distribution of four closely related *Sinningia* species in South America, with a detailed map showing the radiation area of three narrow endemic species, including coastal dunes and montane scarps near the canyons of southern Santa Catarina (SC) and northeastern Rio Grande do Sul (RS).

A relatively high number of species occur in the Atlantic and Paranean biogeographic provinces, both associated to the mostly forested Amazonian domain (Cabrera and Willink 1980). The parallel 30°S represents a striking floristic and vegetational transition in South America. In the study area around this parallel the forest types of the Atlantic and Paranean provinces more or less abruptly change to grasslands and parklands of the Pampean and Espinal biogeographic provinces, both associated to the Chacoan domain (Cabrera and Willink, 1980; Waechter, 2002).

The results demonstrate a great overlap of biogeographic ranges (broad and narrow species) and phylogenetic groups (*Corytholoma* and *Dircaea* clades). The species with a widespread distribution are also those with the greatest range of habitat occupancy. The species with the widest distribution and environmental tolerance are those of the *Corytholoma* lineage, a clade that diverged prior to *Sinningia*, ca. 14 Mya. The remaining species are those of the *Dircaea* lineage, a clade that diverged later, ca. 10 Mya (Perret *et al.*, 2013). The species in *Corytholoma* have the widest geographical and ecological distribution possibly because they have had more time to expand its distribution and to colonize a larger number of environments in relation to *Dircaea*. Only two species in this clade, namely *S. douglasii* and *S. macrostachya*, have relatively wide ecological amplitude, and this may be due to an early divergence. On the other hand, *S. curtiflora* and *S. tubiflora*, both in the clade *Corytholoma*, have a relatively lower habitat tolerance, possibly, because these species diverged late in the clade.

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## Considerações finais

No decorrer de diversas expedições de coleta por todo o Rio Grande do Sul foram coletados cerca de 70 espécimes do gênero *Sinningia*. Das 12 espécies que ocorrem no estado apenas *Sinningia elatior* não foi coletada. O material proveniente das coletas encontra-se depositado no ICN e duplicatas foram enviadas aos maiores herbários de Brasil e para o herbário G, em Genebra, Suíça, que possui uma das maiores coleções de Gesneriaceae do mundo.

As principais contribuições deste trabalho foram 1) a nova ocorrência de *Sinningia bullata* para o Rio Grande do Sul, antes tida como espécie endêmica para Florianópolis, na Ilha de Santa Catarina; 2) a descrição de *Sinningia ramboi* endêmica dos Cânions Fortaleza e Itaimbézinho, como nova para a ciência; 3) a descrição de *Sinningia ×vacariensis*, o primeiro híbrido natural registrado para o gênero. O estudo taxonômico forneceu uma chave taxonômica, descrições morfológicas, imagens diagnósticas e mapas de distribuição geográfica, que deverão facilitar a identificação correta das espécies nativas no estado.

Foi realizado o primeiro estudo biogeográfico envolvendo caracteres ecológicos e evolutivos para Gesneriaceae, onde se buscou identificar os possíveis fatores ambientais que limitam a distribuição sul do gênero *Sinningia*.

A maioria das espécies demonstrou uma grande especificidade de habitat, com muitas espécies restritas a áreas geográficas bem pequenas. Este aspecto indica que ainda se pode encontrar espécies novas para a ciência e novas ocorrências para o estado, visto que durante o tempo reduzido para realização do Mestrado torna difícil uma exploração mais detalhada de todas as regiões fisiográficas do estado.