



SELAGINELLA PECTOPUELLENSIS (SELAGINELLACEAE, LYCOPODIOPHYTA): A NEW SPECIES FROM SERRA DO PEITO-DE-MOÇA, BAHIA, BRAZIL, WITH COMMENTS ON THE TAXONOMY OF THE SPECIES REPORTED IN THE COUNTRY

SELAGINELLA PECTOPUELLENSIS (SELAGINELLACEAE, LYCOPODIOPHYTA): UNA NUEVA ESPECIE DE LA SERRA DO PEITO-DE-MOÇA, BAHÍA, BRASIL CON COMENTARIOS SOBRE LA TAXONOMÍA DE LAS ESPECIES REPORTADAS EN EL PAÍS

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VALDESPINO, I. A., C. A. LÓPEZ, J. I. CEBALLOS & J. M. PALACIOS. 2024. *Selaginella pectopuellensis* (Selaginellaceae, Lycopodiophyta): a new species from Serra do Peito-de-Moça, Bahia, Brazil, with comments on the taxonomy of the species reported in the country. *Bol. Soc. Argent. Bot.* 59: 393-403.

DOI: <https://doi.org/110.31055/1851.2372.v59.n3.44549>

Recibido: 15 Abr 2024
Aceptado: 4 Jul 2024
Publicado en línea: 30 Sep 2024
Publicado impreso: 30 Sep 2024
Editora: Olga G. Martínez 

ISSN versión impresa 0373-580X
ISSN versión on-line 1851-2372

SUMMARY

Background and aims: Our research on neotropical *Selaginella* led us to examine a collection from the Atlantic Forest of Serra do Peito-de-Moça, Bahia, Brazil, initially determined as *S. muscosa* but with unusual features, indicating it represented an undescribed species. We also reexamined the taxonomic and nomenclatural status of three *Selaginella* taxa previously described from Brazil and gathered information on introduced and naturalized species in the country.

M&M: Morphological analysis used stereomicroscopes and scanning electron microscopy to distinguish the suspected new species from its morphologically nearest ally.

Results: We confirmed that the plant material from the Atlantic Forest of Serra do Peito-de-Moça, Bahia, Brazil, is a new species that we named *Selaginella pectopuellensis* (Selaginellaceae). Additionally, we clarified the taxonomic and nomenclatural status of three *Selaginella* species previously described from Brazil and provided more information on naturalized taxa. Overall, we expanded the confirmed number of native Brazilian *Selaginella* species to 91 and confirmed six introduced and naturalized taxa in the country.

Conclusions: The description of *S. pectopuellensis* adds to our knowledge of Brazil's pteridophyte flora. We synonymized *S. kriegeriana* under *S. magnaformensis* and clarified that *S. bahiensis* subsp. *bahiensis* and *S. bahiensis* subsp. *manausensis* should not be recognized as separate taxa. We also confirmed six naturalized *Selaginella* taxa in Brazil.

KEY WORDS

Atlantic Forest, endemism, idioblasts, lycophytes, papillae.

RESUMEN

Introducción y objetivos: Nuestra investigación sobre *Selaginella* neotropical nos llevó a examinar una colección del Bosque Atlántico de Serra do Peito-de-Moça, Bahía, Brasil, inicialmente identificada como *S. muscosa*, pero con características inusuales que indicaban que representaba una especie no descrita. Además, reexaminamos la taxonomía y nomenclatura de tres taxones de *Selaginella* previamente descritos en Brasil e información sobre especies introducidas y naturalizadas en el país.

M&M: Se realizó un análisis morfológico utilizando estereomicroscopios y microscopía electrónica de barrido para distinguir la supuesta nueva especie de su aliada morfológicamente más cercana.

Resultados: Confirmamos que el material vegetal del Bosque Atlántico de Serra do Peito-de-Moça, Bahía, Brasil, es una nueva especie y la nombramos *Selaginella pectopuellensis* (Selaginellaceae). Además, clarificamos el estado taxonómico y nomenclatural de tres especies de *Selaginella* previamente descritas para Brasil y adicionamos información sobre taxones naturalizados. En general, ampliamos el número confirmado de especies nativas de *Selaginella* en Brasil a 91 y confirmamos la ocurrencia de seis taxones introducidos y naturalizados en el país.

Conclusiones: La descripción de *S. pectopuellensis* amplía nuestro conocimiento de la flora de pteridofitas de Brasil. Sinonimizamos *S. kriegeriana* bajo *S. magnaformensis* y aclaramos que *S. bahiensis* subsp. *bahiensis* y *S. bahiensis* subsp. *manausensis* no deben reconocerse como taxones separados. Igualmente, confirmamos seis taxones de *Selaginella* naturalizados en Brasil.

PALABRAS CLAVE

Bosque Atlántico, endemismo, idioblastos, licófitas, papilas.

INTRODUCTION

The Selaginellaceae of Brazil are highly diverse and species-rich (Valdespino, 2015a; Valdespino *et al.*, 2018a, b; Flora e Funga do Brasil, 2020). Alston *et al.* (1981) listed 45 native *Selaginella* species, including two subspecies for Brazil, while Valdespino (2018a, b) estimated 89–96 native species to occur in that country. Flora e Funga do Brasil (2020) indicates a total of 97 *Selaginella* species and one subspecies as occurring within Brazil, as stated in the document's summary. This number, however, is somewhat unclear since some of the listed taxa are introduced; one is a synonym of a previously described taxon, and the listed subspecies do not have taxonomic standing. Specifically, *S. kraussiana* (Kunze) A. Braun, *S. pallescens* (C. Presl) Spring, *S. plana* (Desv.) Hieron., *S. viticulosa* Klotzsch, *S. vogelii* Spring, and *S. willdenowii* (Desv.) Baker are non-native, but introduced and naturalized taxa. Likewise, *S. viticulosa* is known to naturally occur only in Costa Rica and Panama, while it has perhaps been introduced to Jamaica and Bermuda in the West Indies, and in Colombia, Venezuela, as well as in the island of Trinidad in Trinidad and Tobago (Baksh-Comeau, 2000) in South America. Specimens documenting *S. viticulosa* in Brazil, e.g., material collected in and around neighborhoods of Rio de Janeiro (i.e., Brade 16105, RB barcode RB00702089-image!; Brade s.n., RB barcode RB00691682-image!), the Botanical Garden of Rio de Janeiro (i.e., Nascimento 7, RB barcode RB01417493; Oliveira 02, RB barcode RB00316275; Simões 76, RB barcode RB00316244, 87, RB barcode RB00316245; Winter 68, RB barcode RB00533100-image!, 69, RB barcode RB00316191, 73, RB barcode RB00316187, 102, RB barcode RB00316116 – all RB images!), and the Parque Nacional da Tijuca (i.e., Mynseen 1365, RB barcode RB00726501-image!), originate from well-known areas with introduced, cultivated or naturalized flora. Additionally, *S. bahiensis* Spring subsp. *manausensis* (Bautista) Jermy & J.M. Rankin (\equiv *S. manausensis* Bautista) is conspecific with and a later heterotypic synonym of *S. palmiformis* Alston ex Crabbe & Jermy, therefore *S. bahiensis* subsp. *bahiensis* is a homotypic synonym of *S. bahiensis* (Valdespino *et al.*, 2015) and should not be listed as an independent taxon. Furthermore,

our analysis of the protologue, including SEM images, of *S. kriegeeriana* L.A. Goés, listed in Flora e Funga do Brasil (2020) as a native species, leads us to consider it conspecific with *S. magnaforensis* Valdespino & C. López, which has nomenclatural precedence. In consequence, only 90 *Selaginella* species are well-documented as native to Brazil, while six are introduced and somewhat naturalized (i.e., *S. kraussiana*, *S. pallescens*, *S. plana*, *S. viticulosa*, *S. vogelii*, and *S. willdenowii*), and another (i.e., *S. kriegeeriana*) is a recent synonym of a previously described taxon. These data serve to illustrate that our overall knowledge of *Selaginella* diversity in Brazil and, for that matter, in other South American countries such as Colombia, Venezuela, Ecuador, Peru, and Bolivia, is still far from complete (Smith & Kessler, 2018; Valdespino *et al.*, 2018a, b). Indeed, as anticipated by Valdespino *et al.* (2018a), new and undescribed species are still to be uncovered in these countries. In the case of Brazil, without a doubt, the country is proving to be a *Selaginella* treasure trove, and within it, the Bahia State has yielded recent significant findings (Valdespino 2015a, b; Valdespino *et al.*, 2015).

The state of Bahia includes an extensive territory with diverse ecosystems, among which the Atlantic Forest (Mata Atlântica) along its eastern part is a biodiversity hotspot due to the high number of endemic and threatened plant species found there (Myers *et al.*, 2000; Giulietti *et al.*, 2006; Matos *et al.*, 2010; Ostroski *et al.*, 2018; Flora e Funga do Brasil, 2020). Furthermore, Bahia is the sixth state with the highest number of lycophytes and ferns in Brazil. It harbors 18 known *Selaginella* species, which makes it the seventh in that country in terms of the number of taxa in that genus (Flora e Funga do Brasil, 2020), including four endemic *Selaginella*: *S. bahiensis* Spring (Spring, 1840), and the recently described *S. blepharodella* Valdespino, *S. crinita* Valdespino, and *S. mucugensis* Valdespino (Valdespino *et al.*, 2015). In this study, we further describe *Selaginella pectopuellensis* Valdespino & C. López as an additional new and endemic species from the Bahia State, Brazil.

MATERIALS AND METHODS

One gathering of *Selaginella pectopuellensis* was initially examined at the Herbarium of the New York

Botanical Garden (NY) using a stereomicroscope (i.e., Olympus SZ 60-ST5). Further examination of loaned material was undertaken at the University of Panama herbarium (PMA) using an Olympus SZX16 to better ascertain leaf and spore characters. Air-dried samples of stem sections, leaves, and spores were sputter coated with gold-palladium and examined with a Zeiss Model Evo 40vp Scanning Electron Microscope (SEM) at 10–15 kV at the Smithsonian Tropical Research Institute (STRI). Digitized SEM images of plant sections, leaves, and spores were taken at different magnifications, post-processed, and assembled in multipart figures using Adobe Photoshop, as explained in Valdespino (2016). Terminology and measurements used in species descriptions follow Valdespino (2019) and Valdespino & López (2019), while conservation status was determined according to the IUCN Standards and Petitions Committee (2022).

RESULTS

Selaginella pectopuellensis Valdespino & C. López, sp. nov. TYPE: BRAZIL. Bahia, Arataca, Serra do Peito-de-Moça, road joining Arataca to Una, ca. 22.4 km from Arataca, entrance to Sto. Antônio settlement, RPPN Caminho das Pedras, 15°10'25"S, 39°20'30"W, 1000 m, 13-IV-2007, F. B. Matos, S. Vieira, M. Lopes, S. Sant'Ana & L. C. Gomes 1360 (*Holotype*, NY barcode NY1686456!; *isotypes*, CEPEC-n.v., PMA!, UPCB barcode UPCB0010917-image!). Figs. 1-5.

Diagnosis. *Selaginella pectopuellensis* differs from *S. muscosa* Spring by its coriaceous (vs. chartaceous) leaves that lack elongate idioblasts on upper and lower surfaces or few scattered along acroscopic halves of lateral leaves (vs. idioblasts present on both leaf surfaces or only visible on leaf lower surfaces), broadly-ovate to ovate-orbicular (vs. ovate-lanceolate) median leaves long-ciliate throughout (vs. short-ciliate along proximal $\frac{3}{4}$, otherwise serrate to serrulate along distal $\frac{1}{4}$) margins, each cilium 0.15 or 0.2 (0.1 or less) mm long, and long-aristate apices with each arista covered by stiff, short, permanent tooth-like hair (vs. arista lacking stiff tooth-like hairs or this inconspicuous, delicate, and easily abraded) on upper surfaces.

Description. Plants terrestrial. Stems long-creeping, stramineous, 8–12 cm long, 0.8–1.0 mm diam., non-articulate, not flagelliform, non-stoloniferous, sparsely 2- or 3-branched. Rhizophores ventral, stout, borne throughout proximal $\frac{1}{3}$ – $\frac{1}{2}$ of stems, 0.2–0.5 mm diam. Leaves heteromorphic throughout, coriaceous, upper surfaces green or greenish-brown when old or due to fixing and drying processes, lower surfaces silvery green or light-brown when old or due to sample processing. Lateral leaves distant, ascending to slightly perpendicular to stems or slightly imbricate along distal portion of stem and branches, ovate, ovate-cordate to cordate, 1.8–2.5 × 1.0–1.5 mm; bases subcordate, glabrous, acroscopic bases overlapping stems, basiscopic bases free from stems; acroscopic margins on both surfaces continuously bordered by a hyaline band comprised of idioblasts, the band 3–7 cell wide, each idioblast elongate, straight-walled, and papillate, the papillae in one or two rows over each cell lumen and submarginally on upper surfaces bordered by a broad band of 5–10 round, sinuate-walled, and papillate cells along distal $\frac{1}{2}$, the papillae 5–22 on each cell lumen, basiscopic margins on upper surfaces continuously bordered by a hyaline band comprised of idioblasts, the band 1–3 cell wide, each idioblasts similar to those on acroscopic margins on upper surfaces and submarginally, continuously bordered by a band of cells similar to that found submarginally, along distal $\frac{1}{2}$ of acroscopic margins on upper surfaces, the basiscopic margins on lower surfaces, bordered by a band of papillate idioblasts, the band 2–6 cell wide, each idioblast as those in acroscopic margins and both the acroscopic and the basiscopic submarginal portion of laminae in lower surfaces without a band of rounded, sinuate-walled, and papillate cells, acroscopic margins long-ciliate along proximal $\frac{2}{3}$, otherwise short-ciliate to dentate distally, each cilium, stiff and 0.05–0.15 mm long, basiscopic margins sparsely short-ciliate to dentate throughout; apices short-acuminate, each acumen 0.05–0.2 mm long, each tipped by 1–3, short, tooth-like hairs; upper surfaces glabrous, comprising rounded, irregularly, sinuate-walled, laevigate cells, without idioblasts or stomata; lower surfaces comprising elongate, sinuate-walled cells, with few elongate and papillate idioblasts sparsely distributed along acroscopic halves of the laminae and abundantly distributed on proximal portion near the



Fig. 1. *Selaginella pectopuellensis* Valdespino & C. López. Scanned image of holotype: Matos et al. 1360 (NY). Digitized image courtesy of the herbarium of the University of Panama, Panama.

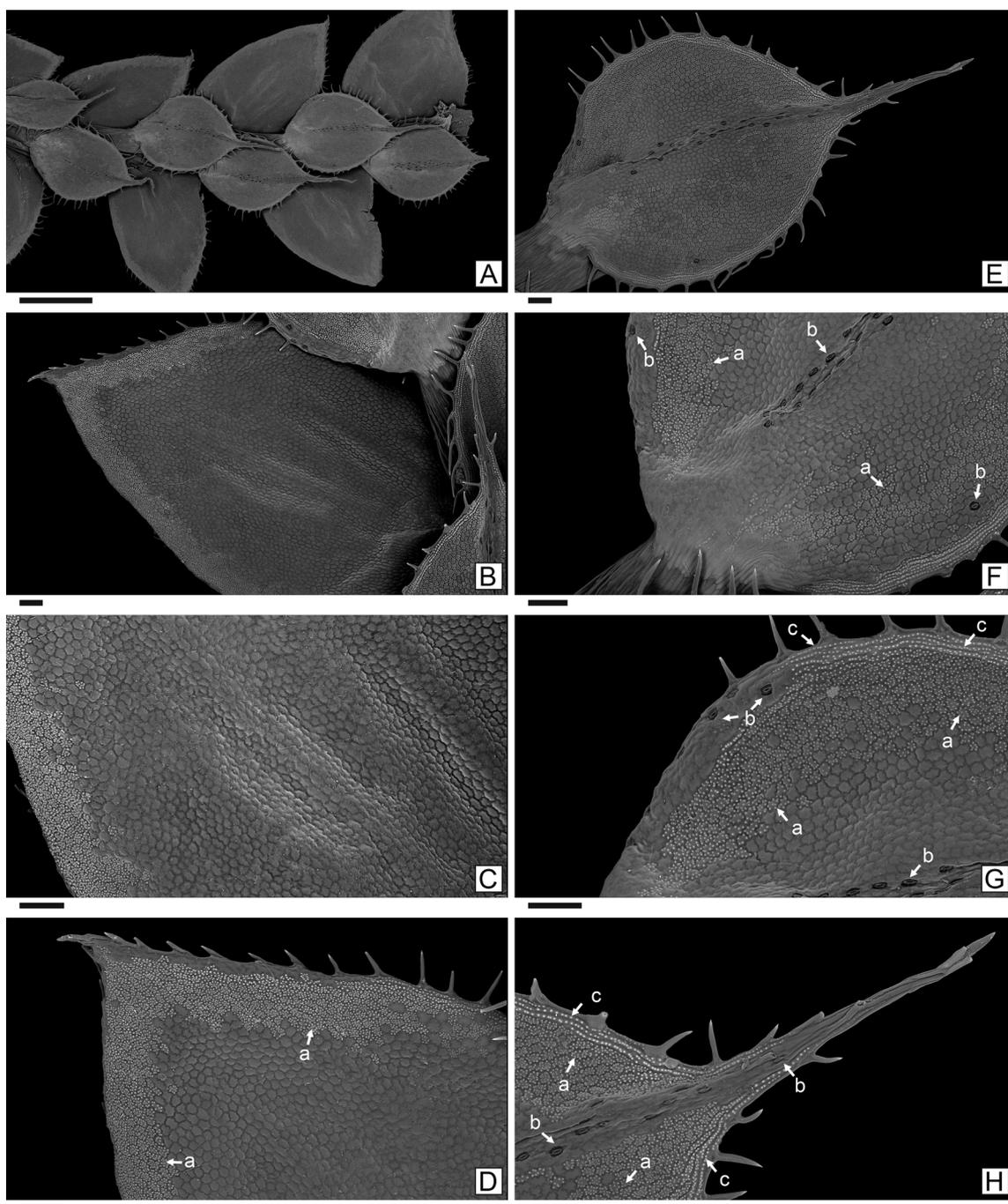


Fig. 2. *Selaginella pectopuellensis* Valdespino & C. López. **A:** Stem, upper surface. **B:** Lateral leaf, upper surface. **C:** Close-up of lateral leaf proximal section, upper surface. **D:** Close-up of lateral leaf distal section, upper surface. **E:** Median leaf, upper surface. **F:** Close-up of median leaf proximal section, inner half, upper surface. **G:** Close-up of median leaf proximal section, outer half, upper surface. **H:** Close-up of median leaf, distal section, upper surface. Abbreviations= a: round, papillate cells; b: stomata; c: elongate and papillate idioblasts. Scale bars= A: 1 mm; B–H: 100 μ m. (Matos *et al.* 1360, holotype, NY).

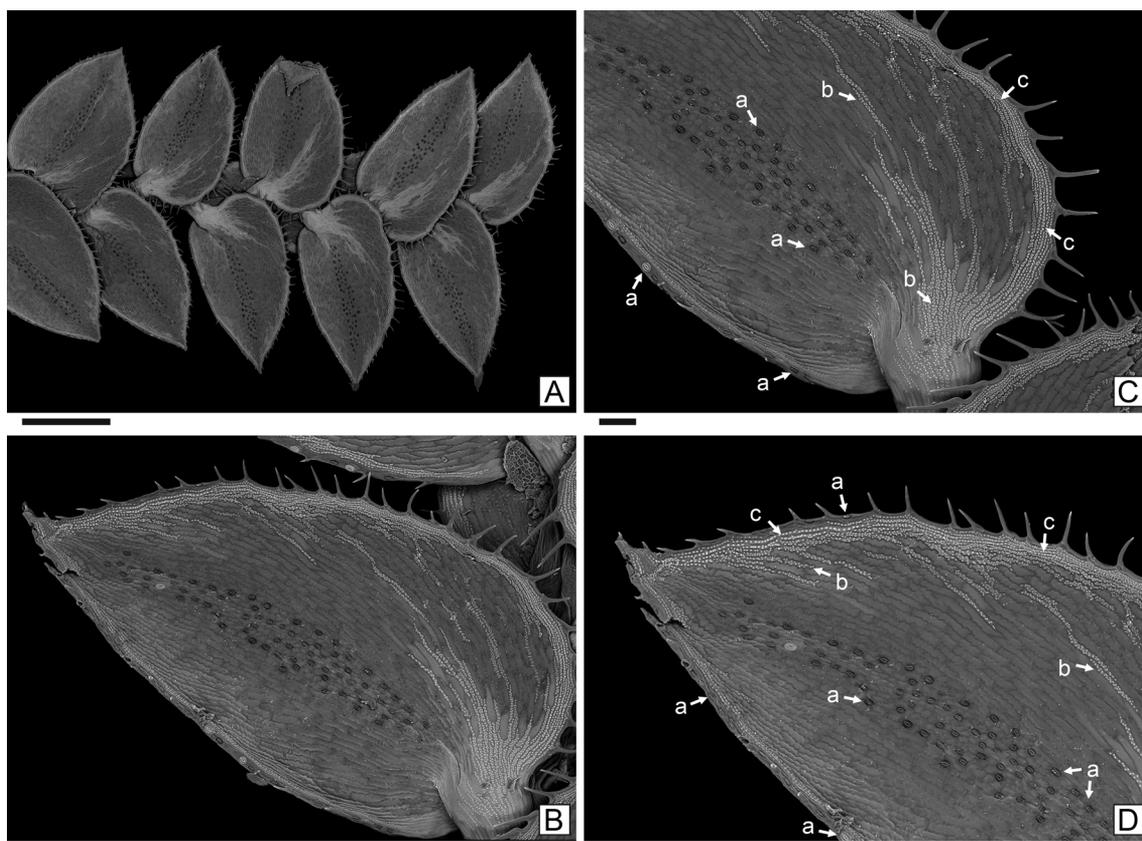


Fig. 3. *Selaginella pectopuellensis* Valdespino & C. López. **A:** Stem, lower surface. **B:** Lateral leaf, lower surface. **C:** Close-up of lateral leaf proximal section, lower surface. **D:** Close-up of lateral leaf distal section, lower surface. Abbreviations= a: stomata; b: elongate and papillate idioblasts on leaf lamina; c: submarginal and marginal, elongate and papillate idioblasts. Scale bars= A: 1 mm; B–D: 100 μ m. (Matos *et al.* 1360, holotype, NY).

bases, each idioblast lumen covered by 1 or 2 rows of papillae, with stomata in 2–5 rows along midribs and on one row along basiscopic margins. Median leaves slightly imbricate, ascending, broadly ovate to broadly ovate-elliptic or orbicular with the inner and outer halves equal in width, 1.0–1.6 \times 0.7–1.1 mm; bases glabrous, rounded to oblique on leaf near distal portions of main stems and branches, without auricles; margins continuously bordered by a broadly hyaline band comprised of idioblasts, the band 2–4 cells wide, the idioblasts, elongate, straight-walled, and papillate, the papillae on one or two rows on each cell lumen, long-ciliate throughout or entire along proximal $\frac{1}{4}$ – $\frac{1}{3}$ and long-ciliate along distal $\frac{3}{4}$ – $\frac{2}{3}$; apices keeled, long-aristate, the

arista denticulate along its margins, $\frac{1}{2}$ the length of the laminae, each 0.5–0.8 mm long, usually tipped by 1–3 teeth; upper surfaces composed of medial to submedial laevigate, rounded, sinuate-walled cells and a submedial to submarginal band of rounded, sinuate-walled, and papillate cells similar to those present in submarginal portion of the lateral leaf laminae upper surfaces, without idioblasts, with stomata in 1–3 rows along distal $\frac{3}{4}$ of midribs and one row submarginally on proximal $\frac{1}{4}$ of inner margins and 6 or 7 marginally and submarginally on proximal $\frac{1}{4}$ – $\frac{1}{3}$ of outer margins; lower surfaces similar to lower surfaces of lateral leaves, without idioblasts or stomata. Axillary leaf shape, size, bases, margins (except

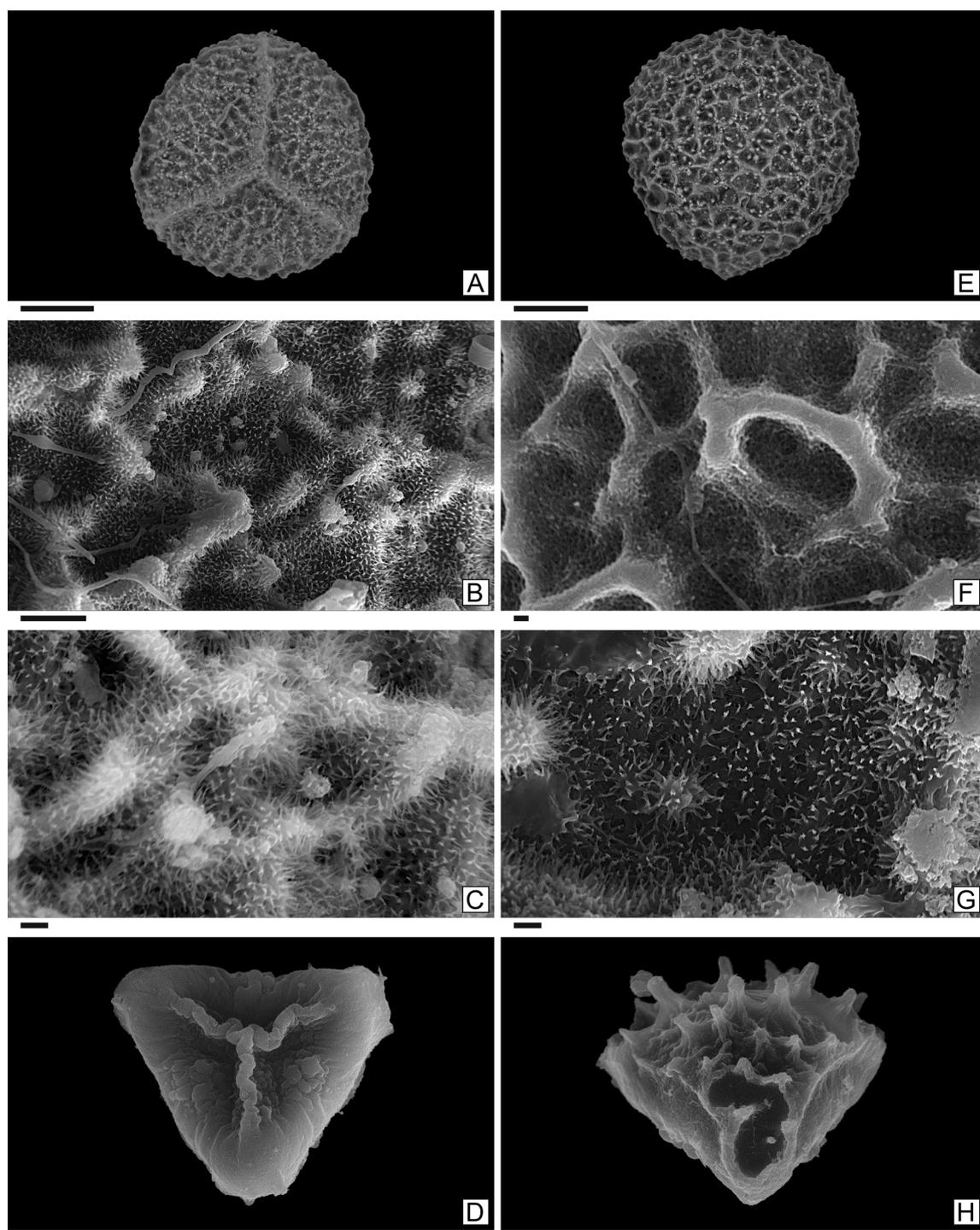


Fig. 4. *Selaginella pectopuellensis* Valdespino & C. López. **A:** Megaspore, proximal face. **B:** Close-up of megaspore, proximal face. **C:** Close-up of megaspore, proximal face. **D:** Microspore, proximal face. **E:** Megaspore, distal face. **F:** Close-up of megaspore, distal face. **G:** Close-up of megaspore, distal face. **H:** Microspore, distal face. Scale bars= A, E: 100 µm; B, D: 10 µm; C, F–H: 2 µm. (Matos *et al.* 1360, holotype, NY).



Fig. 5. Distribution map of *Selaginella pectopuellensis* Valdespino & C. López.

some with both margins as acroscopic margins of lateral leaves), apices, and leaf surfaces similar to lateral leaves. Strobili terminal, single at stem and branch tips, quadrangular to slightly dorsiventrally flattened, 3–10 mm long. Sporophylls slightly heteromorphic and spreading, ovate to ovate-lanceolate, dorsal sporophylls slightly shorter than ventral sporophylls, each with a strongly developed keel along the midrib, the keel puberulent with short teeth or hairs along distal ½, margins hyaline as in median leaves, short-ciliate to dentate throughout, apices long-aristate, aristae 0.3–0.5 mm long, each tipped by 1–4, short tooth-like projections; dorsal sporophylls 1.0–1.2 × 0.6–0.8 mm, upper surfaces green with cells as in median leaves upper surfaces, except for the halves that overlap each ventral sporophyll where the surfaces are hyaline, composed of elongate and sinuate-walled cells, similar to those of median leaves lower surfaces, lower surfaces hyaline, similar to those of the median leaves; ventral sporophylls 1.3–1.5 × 0.6–0.8 mm, upper and lower surfaces greenish-hyaline to hyaline, comprised of elongate, sinuate-walled cells. Megasporangia along two ventral rows; megaspores yellow, 330–410 µm diam., proximal faces reticulate, each reticulum small in diameter and closed, with a slightly developed equatorial flange, the microstructure echinate and perforate, distal faces reticulate, each reticulum wider than

those on proximal faces, closed, the microstructure echinate and perforate; microsporangia on two dorsal rows; microspores orange, 25–40 µm diam., proximal faces rugulate, the microstructure echinulate, distal faces rugulate with baculate to capitate projections, the microstructure echinulate.

Distribution and habitat. *Selaginella pectopuellensis* grows as a terrestrial plant among shrubby and herbaceous vegetation in montane forests with many epiphytes at 1000 m in Serra do Peito-de-Moça in southeastern Bahia, Brazil.

Etymology. The specific epithet is a free, compound word derived from the Latin, *pectus* “breast” and *puella* “maiden,” which together refer to the Portuguese name of the mountain range “Serra do Peito-de-Moça,” where this novel species occurs.

Conservation status. *Selaginella pectopuellensis* is only known from a single collection made in the Private Natural Heritage Reserve (i.e., RPPN Caminho das Pedras, Bahia). The Reserve is adjacent to and forms part of the inclusive Parque Nacional da Serra das Lontras in the Atlantic Forest (Mata Atlântica) of Brazil, which comprises significant remnants of mountain forest in the South of Bahia harboring a rich plant diversity that is highly endangered (Amorim & Matos, 2009). Based on IUCN criteria (IUCN Standards and Petitions Committee, 2022), the extent of occurrence (EOO= 0.000 km²) and the area of occupancy (AOO= 4.000 km²) suggest this species is critically endangered (CR). According to Araujo *et al.* (2009) this region severely suffers from deforestation and habitat fragmentation. This is confirmed by more recent vegetation loss analysis (Guedes *et al.*, 2021) and vegetation images (Google, 2024).

DISCUSSION

Selaginella pectopuellensis is notable by its long-creeping stems, which are sparsely 2- or 3-branched, ventral, stout rhizophores, each borne throughout proximal ⅓–½ of stems, coriaceous leaves (Fig. 1), imbricate and ascending median leaves, each broadly ovate to broadly ovate-elliptic or orbicular with the inner and outer halves equal in width and margins continuously bordered by a broadly hyaline band of

idioblasts, the band 2–4 cells wide, the idioblasts, elongate, straight-walled, and papillate, the papillae on one row on each cell lumen (Figs. 2A, E). In addition, the median leaf of *S. pectopuellensis* is long-ciliate throughout margins or entire along proximal $\frac{1}{4}$ – $\frac{1}{3}$ and long-ciliate along distal $\frac{3}{4}$ – $\frac{2}{3}$ of margins and has keeled, long-aristate apices, with aristae denticulate along margins, each arista $\frac{1}{2}$ the length of the laminae, 0.5–0.8 mm long, and usually tipped by one to three teeth (Figs. 2E–H). *Selaginella pectopuellensis* is unique by its lateral leaf upper surfaces having a distinct submedial to submarginal band of round, sinuate-walled, and papillate cells along distal $\frac{1}{2}$ on acroscopic halves of the laminae, which is also present along the laminae length on basispic halves of the laminae (Figs. 2B–D).

The type collection of *S. pectopuellensis* was initially determined as *S. muscosa*, which shows some degree of variability throughout its distribution range (Valdespino, 1995). Certainly, *S. pectopuellensis* and the latter species show certain morphological similarities, including broadly-ovate, long-aristate median leaves with hyaline margins. In addition, both species have yellow megaspores on two ventral rows of sporophylls and orange microspores on two dorsal rows of sporophylls, although *S. muscosa* might also have white megaspores. Nevertheless, *S. pectopuellensis* is easily distinguished from *S. muscosa* by the characters contrasted in the diagnosis. *Selaginella pectopuellensis* is also easily separated from the latter by its lateral leaf upper surfaces having (vs. lacking) a distinct submedial to submarginal band of round, sinuate-walled, and papillate cells along distal $\frac{1}{2}$ on acroscopic halves of the laminae, which is also present along the laminae length on basispic halves of the laminae. It is further distinct from *S. muscosa* by its lateral leaf acroscopic margins long-ciliate throughout (vs. serrate or shortly ciliate along basal $\frac{1}{4}$ and serrulate distally), each cilium stiff and 0.1 or 0.2 mm (vs. each cilium, when present, 0.5 mm) in length, with long-acuminate (vs. acute to short-acuminate) apices, each 0.1 (vs. less than 0.1) mm long.

CONCLUSIONS

This study emphasizes the rich biodiversity found in Brazil's Atlantic Forest and the importance of continued research in this area. It also highlights

the vulnerability of these species and the need for conservation efforts. The documentation of a new species like *Selaginella pectopuellensis* is significant for understanding the ecological complexity of these regions and the evolutionary relationships within the genus *Selaginella*. In this work, we recognize 91 native *Selaginella* species and 6 introduced and naturalized taxa in Brazil, while proposing *S. kriegeriana* as a conspecific with and a synonym of *S. magnaformensis*.

AUTHOR CONTRIBUTIONS

IAV: conceptualization (lead); data curation (lead); formal analysis (lead); funding acquisition (lead); investigation (lead); methodology (lead); project administration (lead); resources (lead); supervision (lead); validation (lead); visualization (lead); writing – original draft (lead); writing – review and editing (lead). CAL: data curation (equal); formal analysis (equal); investigation (supporting); methodology (supporting); writing – review and editing (equal). JIC: data curation (supporting); formal analysis (supporting); methodology (supporting); resources (supporting); visualization (supporting); writing – review and editing (supporting). JMP: data curation (supporting); formal analysis (supporting); investigation (supporting); resources (supporting); software (supporting); visualization (equal); writing – review and editing (supporting).

ACKNOWLEDGMENTS

We are thankful to Dr. Robbin Moran, Curator Emeritus of ferns and lycophytes at the New York Botanical Garden Herbarium (NY), for allowing the study of the holotype, arranging its loan, and use of fragment material for further study at the herbarium of the University of Panama (PMA). We are grateful to Dra. María de Stapf and Vielka Murillo, both at PMA, for respectively, procuring specimen loans and digitizing the holotype. The Smithsonian Tropical Research Institute (STRI) has also supported this research by allowing the use of scanning electron microscopy facilities. IAV is further indebted to the Dean of the Faculty of Natural and Exact Sciences and Technology

and the office of the Vice Chancellor for Research and Graduate Programs of the University of Panama, and the National Research System (SNI, for its initials in Spanish) of the National Secretariat for Science, Technology, and Innovation (SENACYT) of Panama for supporting his research on *Selaginella*. CAL thanks Dr. Brian E. Sedio for his constant support and advice. We also appreciate the support provided by Pedro Argudo at NovoArt in preparing composed images and Christopher Gioia and Dr. Robbin Moran for proofreading an early draft of the manuscript. Finally, we are also thankful to the reviewers and the editorial team of the Boletín de la Sociedad Argentina de Botánica for their suggestions to improve the manuscript and successfully steering the publication process.

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