EDINBURGH JOURNAL OF BOTANY 63 (1): 85–93 (2006)
doi:10.1017/S0960428606000321
Issued 9 August 2006

FOUR NEW SPECIES OF *SELAGINELLA* (PTERIDOPHYTA – *SELAGINELLACEAE*) FROM BOLIVIA

M. KESSLER[1], A. R. SMITH[2] & M. LEHNERT[1]

Four new species of *Selaginella* from Bolivia are described and illustrated: *S. alampeta*, a species from humid montane forests at 1200–1700 m that is most similar to *S. flexuosa*; *S. arroyoana*, a presumably poikilohydric species found on the walls of periodically dry stream beds and in fissures among rocks on Precambrian sandstone massifs at 750–900 m in eastern Bolivia; *S. bryophila*, an epiphytic species known only from the type collection made among mats of liverworts in humid montane rain forest, and *S. chiquitana*, from semideciduous forests at 800 m on a Precambrian sandstone massif in southeastern Bolivia.

Keywords. Bolivia, new species, pteridophytes, *Selaginella*, South America, systematics.

INTRODUCTION

The genus *Selaginella* P.Beauv. (*Selaginellaceae*) remains taxonomically fairly poorly known in tropical America. A treatment of the South American species was published by Alston *et al*. (1981) based on Alston's research before his death in 1958, but this treatment is now badly outdated. Recent monographic work has been conducted only on subgenus *Heterostachys* Baker (Valdespino, 1995) and remains unpublished. Newer floristic studies have focused on specific countries or geographical regions, such as Peru (Tryon & Stolze, 1994), Venezuelan Guayana (Smith, 1995), Mesoamerica (Moran & Riba, 1995), and Mexico (Mickel *et al*., 2004).

The pteridophyte flora of Bolivia is particularly poorly known (Smith *et al*., 1999). Alston *et al*. (1981) listed 26 species of *Selaginella* for the country, but the records of *S. lingulata* Spring and *S. sartorii* Hieron. have since been shown to be based on misidentified specimens (M. Kessler & A.R. Smith, unpubl. data). Smith *et al*. (1999) reported records of four more species for Bolivia. During work on a forthcoming field guide to the pteridophytes of Bolivia, we have obtained records of a further 10 species, bringing the total of species known from Bolivia to 38. Six of these new records correspond to unnamed species, four of which are here described; the other two species will be described by I. Valdespino (pers. comm.). Including these new taxa, seven species of *Selaginella* are now considered to be endemic to the country. The high number of new records of *Selaginella* from Bolivia in the last few years

[1] Albrecht-von-Haller-Institut für Pflanzenwissenschaften, Abteilung für Systematische Botanik, Untere Karspüle 2, 37073 Göttingen, Germany. E-mail: mkessle2@gwdg.de
[2] University Herbarium, 1001 Valley Life Sciences Bldg. #2465, University of California, Berkeley, CA 94720-2465, USA.

highlights our poor knowledge of the flora of this country and suggests that further field work will reveal even more species, both as new to science and as first country records. Indeed, eight species of *Selaginella* have been recorded in Peru within 200 km of the Bolivian border (Tryon & Stolze, 1994) and may well occur in Bolivia.

Taxonomy and discussion

Selaginella alampeta M.Kessler & A.R.Sm., **sp. nov. Figs 1A–D, 2A–D.**
A *Selaginella flexuosa* Spring foliis ciliatis (vs. denticulatis) medianis et lateralibus, foliis lateralibus superficialiter laevigatis (vs. rugosis) abstans. – Type: Bolivia, Depto. La Paz, Prov. J. Bautista Saavedra, Pauji-Yuyo, entre Apolo y Charazani, 15°02′S, 68°29′W, 1200 m, 13 vi 1997, *Kessler* 10101 (holo UC!; iso GOET!, LPB!).

Plants terrestrial, creeping; *stems* prostrate, rooting throughout, c.0.6–0.8 mm in diameter, not articulate, not flagelliform, not stoloniferous, stramineous to pale green; *rhizophores* straight, 0.2–0.5 mm in diameter; *leaves* dimorphic throughout; *lateral leaves* obliquely oblong to subovate, 2–3.5 mm long, basally rounded, apically acute, upper surface smooth, basally with broad white borders, margins basally with cilia c.0.1 mm long; *median leaves* ovate, long-aristate (aristae c.1/3 of total leaf length), 2–3 mm long including aristae, with prominent midribs and narrow white borders, exauriculate, upper surface smooth, margins basally with cilia c.0.1–0.2 mm long; *axillary leaves* ovate to lanceolate, 2.5–3.5 mm long, exauriculate, basally with cilia 0.1–0.2 mm long; *strobili* 3–7 × 1–2 mm; *sporophylls* monomorphic, spreading to ascending, symmetric, with denticulate margins; *megasporangia* in two rows; *megaspores* 200–275 μm in diameter, white, foveate and finely irregularly cristate on both faces; *microspores* 30–35 μm in diameter, light orange, verrucate-granulate on proximal face, clavate-granulate on distal face.

Distribution and ecology. Locally fairly common, saxicolous and less commonly terrestrial in humid montane forests at 1200–1700 m in the northern Bolivian Andes.

Etymology. The species epithet is derived from the Greek *alampetos* meaning dark or obscure, alluding to the dark colour of this species similar to *S. flexuosa*.

This species is most similar to *S. flexuosa* Spring (syn. *S. tarapotensis* Baker), but differs in its ciliate (vs. denticulate) lateral and median leaves, and the smooth (vs. wrinkled) upper surface of the lateral leaves (cf. Fig. 2E). *Selaginella alampeta* has darker green leaves than *S. flexuosa*. Another similar species is *S. revoluta* Baker, but that has denticulate (vs. ciliate), somewhat narrower and shorter-aristate median leaves, marginally revolute (vs. flat) lateral leaves with minute hairs on the upper surface (vs. glabrous), and generally occurs at lower elevations up to 1100 m.

Additional specimens examined. Bolivia. La Paz, Prov. Nor Yungas, Estación Biológica Tunquini, 16°11′S, 67°53′W, 1550 m, 18 viii 2000, *Eberhardt* 120 (LPB, UC); same locality, 1710 m, 24 viii 1998, *Portugal* 300 (LPB, UC), *Portugal* 317 (LPB, UC).

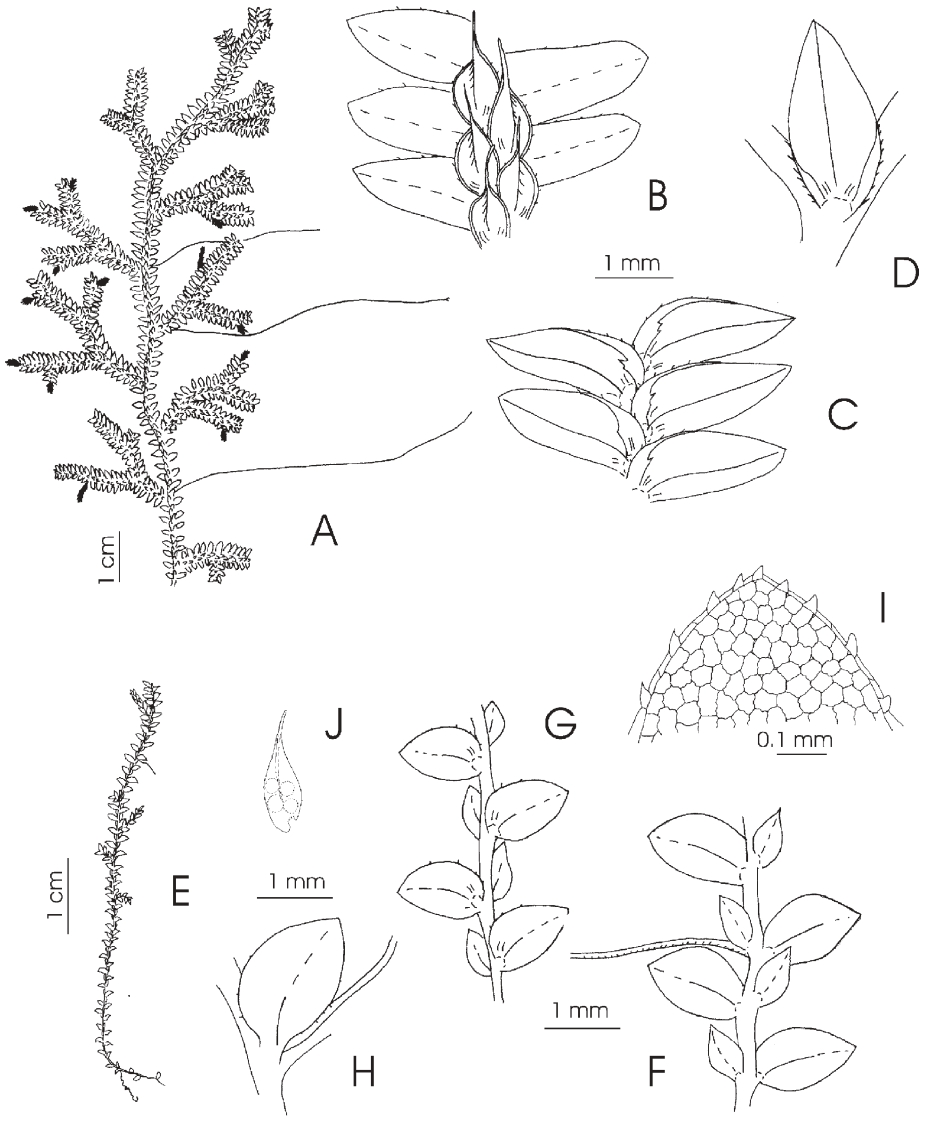

FIG. 1. *Selaginella alampeta* M.Kessler & A.R.Sm. A, habit; B, stem from above; C, stem from below; D, axillary leaf (A–D, *Kessler* 10101, GOET). *Selaginella bryophila* M.Kessler & A.R.Sm. E, habit; F, stem from above; G, stem from below; H, axillary leaf; I, detail of lateral leaf; J, megasporophyll (E–J, *Jimenez* 825, LPB).

Selaginella arroyoana M.Kessler & A.R.Sm., **sp. nov. Figs 3A–D, 4A–C.**

A *Selaginella kochii* Hieron. foliis brevioribus (lateralibus 1.5–2.5 mm vs. 3–6 mm, medianis 1.5–2 mm vs. 2–3 mm longis), foliis lateralibus ovatioribus, foliis medianis longe ciliatis (vs. denticulatis), ciliis marginem foliorum lateralium insidentibus (vs. restrictis in auriculis), foliis exsiccatis caules vaginantibus differt. – Type: Bolivia,

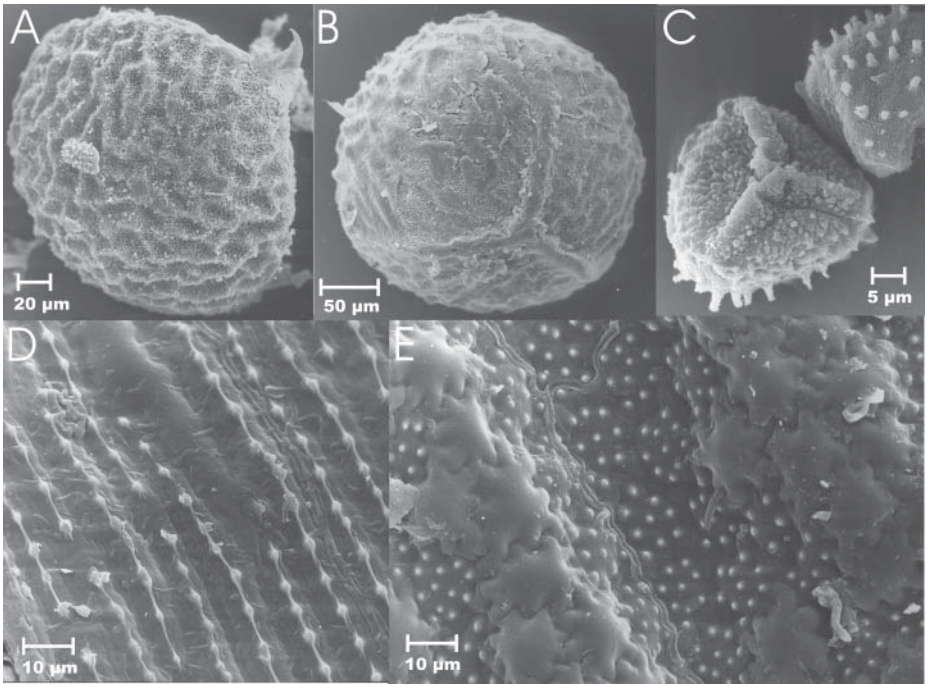

FIG. 2. *Selaginella alampeta* M.Kessler & A.R.Sm. A, megaspore, distal surface; B, megaspore, proximal surface; C, microspores; D, lateral leaf from above (A–D, *Kessler* 10101, GOET). *Selaginella flexuosa* Spring. E, lateral leaf from above (*Kessler* 9692, GOET).

Depto. Santa Cruz, Prov. Velazco, Parque Nacional Noel Kempff M., Campamento Las Gamas, 14°48′11″S, 60°23′35″W, 900 m, 1 iv 1993, *Arroyo* 202 (holo LPB!; iso MO, UC!, USZ).

Plants terrestrial, creeping; *stems* prostrate, rooting throughout, c.0.5–1 mm in diameter, not articulate, not flagelliform, not stoloniferous, stramineous to pale green; *rhizophores* straight, 0.3–0.6 mm in diameter; *leaves* dimorphic throughout, clasping the stems when dry; *lateral leaves* obliquely oblong, 1.5–2.5 mm long, apically acute, basally rounded and broadly hyaline, margins narrowly hyaline, basally with cilia 0.1–0.2 mm long, elsewhere short-ciliate (0.02–0.05 mm); *median leaves* ovate-lanceolate, 1.5–2 mm long, short-aristate (arista c.1/6 of total leaf length), exauriculate, midribs ill-defined, margins hyaline, basally with cilia 0.1–0.2 mm long, elsewhere short-ciliate; *axillary leaves* lanceolate, 1.5–2.5 mm long, exauriculate, basally with cilia to 0.25 mm long; *strobili* 3–10 × 1 mm; *sporophylls* monomorphic, spreading to ascending, symmetric, with denticulate margins; *megasporangia* in two rows; *megaspores* 200–250 µm in diameter, white, foveolate-granulate on both surfaces; *microspores* 40 µm in diameter, light orange, irregularly rugose on proximal faces, finely clavate-tuberculate on distal faces.

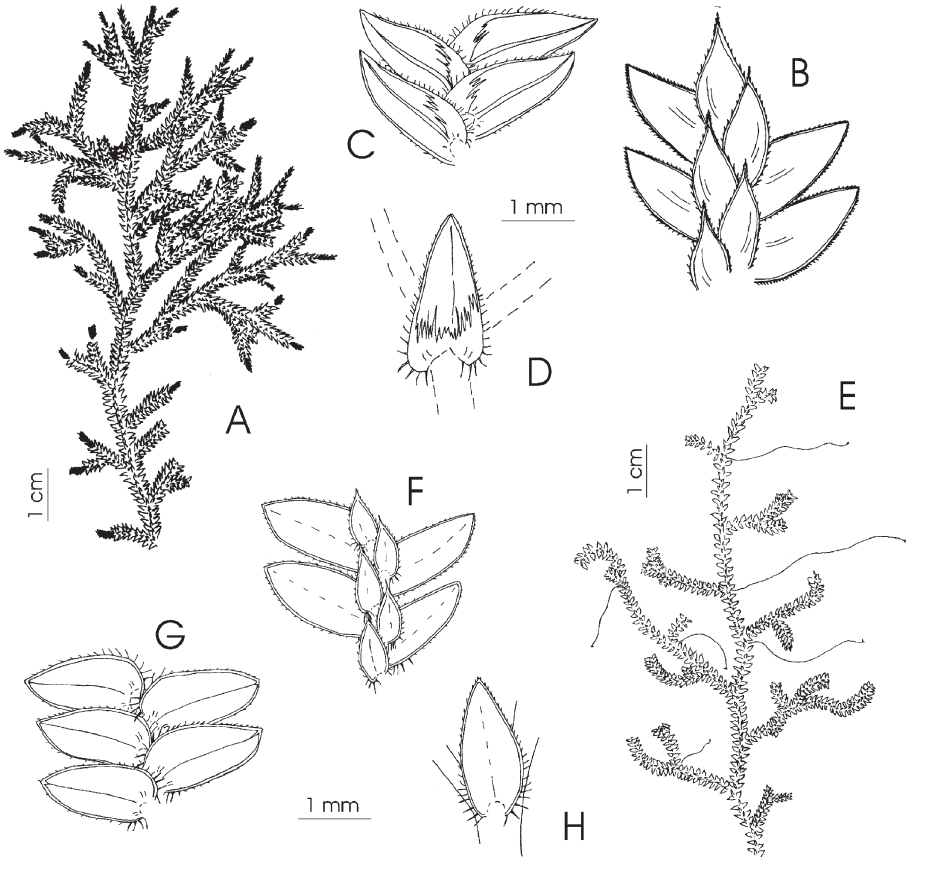

FIG. 3. *Selaginella arroyoana* M.Kessler & A.R.Sm. A, habit; B, stem from above; C, stem from below; D, axillary leaf (A–D, *Arroyo* 202, UC). *Selaginella chiquitana* M.Kessler, A.R.Sm. & M.Lehnert. E, habit; F, stem from above; G, stem from below; H, axillary leaf (E–H, *Lehnert* 642, GOET).

Distribution and ecology. *Selaginella arroyoana* is a creeping, terrestrial species found on the walls of periodically dry stream beds and in fissures among rocks on Precambrian sandstone massifs at 750–900 m in the cerrado region of easternmost Bolivia. The herbarium specimens show partly dried out branches with inrolled leaves, suggesting that this is a poikilohydric species that grows intermittently when wetted by rain or stream water.

Etymology. The name honours Luzmila "Chiqui" Arroyo who collected the type specimen of this species and many other interesting ferns in remote eastern Bolivia, greatly adding to the knowledge of the country's pteridophyte flora. The name also reflects the habitat in seasonally dry stream beds, called *arroyos* in Spanish.

Selaginella arroyoana is most closely related to *S. kochii* Hieron. and *S. xiphophylla* Baker (syn. *S. cabrerensis* Hieron.), with which it shares the prostrate habit

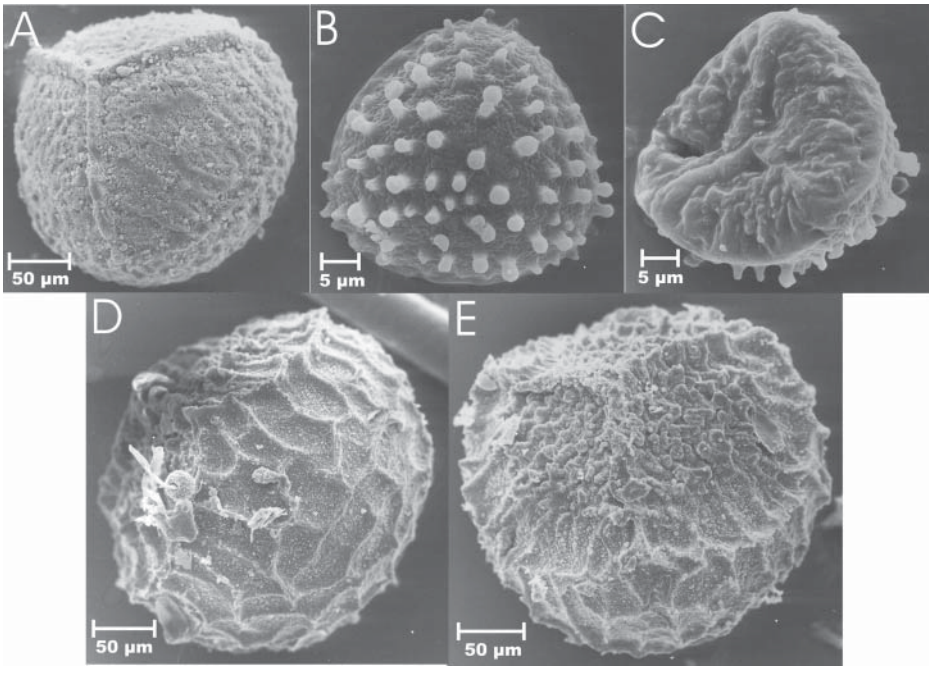

FIG. 4. *Selaginella arroyoana* M.Kessler & A.R.Sm. A, megaspore; B, microspore, distal surface; C, microspore, proximal surface (A–C, *Arroyo* 202, UC). *Selaginella bryophila* M.Kessler & A.R.Sm. D, megaspore, distal surface; E, megaspore, proximal surface (D & E, *Jimenez* 825, LPB).

with rhizophores emerging along the entire stems and on the branches, lack of flagelliform apices and stolons, elongate lateral leaves with pronounced hyaline margins, and aristate median leaves. It differs from *S. kochii* in its shorter leaves (lateral leaves 1.5–2.5 mm vs. 3–6 mm long; median leaves 1.5–2 mm vs. 2–3 mm long), relatively broader, more ovate (vs. linear) lateral leaves, long-ciliate (vs. denticulate) axillary leaves, cilia extending along the margins of the lateral leaves (vs. restricted to the auricles), and in the leaves ensheathing the stems when dry. From *S. xiphophylla* it differs in its ciliate (vs. denticulate) lateral and axillary leaves, apically more gradually reduced median leaves (vs. rather abruptly reduced to a distinct arista), relatively broader, more ovate (vs. more linear) lateral leaves, and broader sporophylls. Relative to the other two species, *S. arroyoana* has more densely imbricate leaves of a greyer colour, especially on dried branches.

Additional specimens examined. BOLIVIA. Santa Cruz, Prov. Chiquitos, Serranía de Santiago, 5 km ENE de Santiago de Chiquitos, 18°19′S, 59°35′W, 900 m, 21 xi 1989, *Daly* 6280 (LPB, UC); Serranía de Santiago, Santiago de Chiquitos, quebrada "El Banquete", 18°20′S, 59°35′W, 750 m, 22 ii 2003, *Lehnert* 631 (GOET, LPB, UC).

Selaginella bryophila M.Kessler & A.R.Sm., **sp. nov. Figs 1E–J, 4D & E.**
A *Selaginella cavifolia* A.Braun foliis latioribus lateralibus ovatioribus, sporophyllis dorsalibus majoribus acuminatioribus sine marginibus pallidis, megasporis minoribus (250–280 μm vs. 300–360 μm in diametro) paginis proximalibus granulosioribus differt. – Type: Bolivia, Depto. La Paz, Prov. Franz Tamayo, PN-ANMI Madidi, sendero Keara-Mojos, bajando por la senda de Tokuaqe a Fuertecillo, antes de llegar a Lagunillas, 14°36′S, 68°56′W, 2150 m, 11 v 2001, *Jimenez* 825 (holo LPB!).

Plants epiphytic; *stems* erect, rooting at base, 4–7 cm × 0.2–0.4 mm, not articulate, not flagelliform, not stoloniferous, pale green; *rhizophores* throughout the stems, 0.05–0.2 mm in diameter; *leaves* dimorphic throughout, membranaceous, the upper surfaces green, composed of polygonal to more or less rounded cells with sinuate walls, the lower surfaces silvery, composed of elongate cells with strongly sinuate walls; *lateral leaves* distant, broadly ovate, 1.3–1.8 mm long, apically broadly acute, basally rounded, the acroscopic bases overlapping the stems, margins not hyaline, entire to apically sparsely denticulate; *median leaves* ovate-lanceolate, 0.5–1 mm long, acute, basally asymmetric, oblique, lacking hairs, midribs well-defined, margins not hyaline; *axillary leaves* similar to lateral leaves; *strobili* terminal on branch tips, flattened, dorsiventral, c.3 × 1.5 mm; *sporophylls* dimorphic; *dorsal sporophylls* lanceolate, 1.5–2 mm long, basally rounded, apically acuminate to aristate, the margins pale green, sparsely denticulate; *ventral sporophylls* lanceolate, 1–1.5 mm, basally rounded, apically acuminate, with denticulate margins; *megasporangia* in two rows; *megaspores* 250–280 μm in diameter, pale yellow-orange, the proximal faces irregularly rugose-granulate, the distal faces reticulate; *microsporangia* unknown.

Distribution and ecology. *Selaginella bryophila* is an epiphytic species known only from the type collection made among dense mats of liverworts on the trunk and lower branches of a tree in humid montane rain forest in the northern Bolivian Andes, close to the Peruvian border.

Etymology. Named for its habitat among bryophytes.

This species is most similar to *S. cavifolia* A.Braun from which it differs by its broader, more ovate lateral leaves lacking pale borders, relatively larger, much more strongly acuminate dorsal sporophylls, and smaller megaspores (250–280 μm vs. 300–360 μm in diameter) with more granulate proximal faces. There are further slight differences in the relative length of the lateral and median leaves and in habitat (epiphytic vs. terrestrial or epipetric) but an evaluation of whether these are constant requires additional collections.

Selaginella chiquitana M.Kessler, A.R.Sm. & M.Lehnert, **sp. nov. Fig. 3E–H.**
A *Selaginella falcata* (P.Beauv.) Spring statura graciliore, foliis lateralibus axiliaribusque latioribus (2–3-plo vs. c.3–4-plo) rectioribusque, foliis medialibus latioribus cum aristis brevioribus differt. – Type: Bolivia, Depto. Santa Cruz, Prov. Chiquitos,

Serranía de Santiago, en la mesa del Arco de Piedra, 18°20′S, 59°35′W, 800 m, 23 ii 2003, *Lehnert* 642 (holo UC!; iso GOET!, LPB!).

Plants terrestrial, creeping; *stems* prostrate, rooting throughout, c.0.3–0.6 mm in diameter, not articulate, not flagelliform, not stoloniferous, stramineous to pale green; *rhizophores* straight, 0.1–0.3 mm in diameter; *leaves* dimorphic throughout; *lateral leaves* obliquely oblong, 1.5–2.2 mm long, apically acute, basally rounded, margins hyaline, basally with cilia 0.15–0.25 mm long, elsewhere short-ciliate (to 0.05 mm); *median leaves* lanceolate, 0.8–1.5 mm long, short-aristate (arista c.1/10–1/20 of total leaf length), slightly auriculate on one side, midribs ill-defined, margins hyaline, basally long-ciliate (0.1–0.2 mm), elsewhere short-ciliate; *axillary leaves* lanceolate, 1.5–2 mm long, exauriculate, basally with cilia to 0.25 mm long; *fertile organs* unknown.

Distribution and ecology. A terrestrial species known only from the sterile type collection made in disturbed semideciduous forest at 800 m on a Precambrian sandstone massif in the province of Chiquitos in southeastern Bolivia.

Etymology. Named for its location in the province of Chiquitos.

This species keys out to *S. falcata* (P.Beauv.) Spring (syn. *S. guianensis* Spring) in Alston *et al.* (1981) but that is a more robust species with narrower falcate lateral and axillary leaves c.3–4 times as long as broad (vs. 2–3 times in *S. chiquitana*), leaves with broad whitish bases, and more narrowly lanceolate median leaves with proportionately longer aristae.

Acknowledgements

We thank Viktoria Wagner for preparing the illustrations and Ivan Valdespino for valuable comments. Field work of M.K. was funded by the German Research Association, that of M.L. by the German Academic Exchange Service. We thank the Dirección Nacional para la Conservación de la Biodiversidad, the Herbario Nacional de Bolivia, Stephan G. Beck, and Iván Jimenez for enabling our work in Bolivia.

References

Alston, A. H. G., Jermy, A. C. & Rankin, J. M. (1981). The genus *Selaginella* in tropical South America. *Bull. Brit. Mus. (Nat. Hist.), Bot*. 9: 233–330.

Mickel, J. T., Smith, A. R. & Valdespino, I. A. (2004). *Selaginella*. In: Mickel, J. T. & Smith, A. R. *The Pteridophytes of Mexico*, pp. 550–602. Memoirs of the New York Botanical Garden 88.

Moran, R. C. & Riba, R. (volume eds) (1995). *Psilotaceae a Salviniaceae*. In: Davidse, G., Sousa, M. & Knapp, S. (general eds) *Flora Mesoamericana*, vol. 1, pp. 1–470. México: Universidad Nacional Autónoma de México, Ciudad Universitaria.

SMITH, A. R. (1995). Selaginellaceae. In: STEYERMARK, J. A., BERRY, P. E. & HOLST, B. K. (general eds) *Flora of the Venezuelan Guayana*, vol. 2, pp. 296–314. St Louis, MO: Missouri Botanical Garden.

SMITH, A. R., KESSLER, M. & GONZALES, J. (1999). New records of pteridophytes from Bolivia. *Amer. Fern J.* 89: 244–266.

TRYON, R. M. & STOLZE, R. G. (1994). Pteridophytes of Peru, Part VI, 22. Marsileaceae–28. Isoetaceae. *Fieldiana, Bot., n.s.* 34: 1–123.

VALDESPINO, I. A. (1995). *A monographic revision of* Selaginella *P. Beauv. subgenus* Heterostachys *Baker in Central and South America*. PhD thesis, The City University of New York.

Received 10 December 2004; accepted for publication 12 April 2006