

Selaginella wuyishanensis (sect. *Tetragonostachyae*, Selaginellaceae), a new species from East China and its phylogenetic position based on molecular data

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Abstract

A new spikemoss species, *Selaginella wuyishanensis*, is described and illustrated based on materials collected from Fujian Province, East China. The new species can be distinguished from *S. lutchuensis* Koidzumi and *S. albociliata* P. S. Wang by its leaves with extremely long cilia (up to 8 mm) and distinctly white margins, ovate ventral sporophylls, and sporophyll-ptyx completely inverted on dorsal sporophylls. In the present work, a molecular phylogeny, taxonomic description, distribution information, line drawing, and photographs of this new species are presented. A morphological comparison is also given to distinguish it from morphologically similar species in *Selaginella* sect. *Tetragonostachyae* (Hook. & Grev.) Hieron. & Sadeb.

Keywords

Danxia landform, *Selaginella albociliata*, *Selaginella* subg. *Heterostachys*, species diversity

* These authors contributed equally as co-first authors.

Introduction

Selaginella P. Beauv. (Selaginellaceae) is the largest genus of seed-free vascular plants with more than 700 species worldwide (Jermy 1990; Zhou and Zhang 2015; PPG 2016; Weststrand and Korall 2016a). It is mainly distributed in tropical and subtropical regions, with a few species reaching the arctic-alpine zones in both hemispheres (Jermy 1990; Zhang et al. 2013). Members of *Selaginella* are heterosporous, and usually have rhizophores, leaves arranged in four rows, and terminal strobili. Though the subgeneric classification of *Selaginella* has been controversial (Zhou and Zhang 2015; Weststrand and Korall 2016b), integrative taxonomy based on morphological, cytological, and molecular data can effectively provide new insights into the species delimitation and discovery of new taxa (Zhou and Zhang 2015; Zhou et al. 2015a, b, 2016; Wu et al. 2017; Ye et al. 2020; Zhang et al. 2021; Wang et al. 2022).

Since 2019, we have conducted investigations into wild vascular plants in Wuyishan National Nature Reserve (**WNNR**) in Fujian Province, East China. Most of the *Selaginella* species we have encountered are common in WNNR and can be easily identified to described species. However, one species collected from Danxia regions of WNNR didn't match species listed in available checklists and monographs or those recently described species from East Asia (Zhang et al. 2013; Zhou et al. 2015a, b; Wu et al. 2017; Shalimov et al. 2019; Ye et al. 2020; Zhang et al. 2021; Wang et al. 2022). Based on morphological study of herbarium specimens and consultation of literature, we found that this species is most similar to *S. albociliata*, but this species has smooth megaspore surfaces and ovate-lanceolate ventral sporophylls. In order to infer the phylogenetic relationships of this species, we conducted a phylogenetic analysis using both plastid and nuclear loci. With evidence from morphological characters and molecular phylogeny, we propose it as a new spikemoss species, and describe and illustrate it herein.

Materials and methods

The gross morphology of the new species was observed and examined both from the fresh plants and dried herbarium specimens using SMZ1270 stereomicroscope (Nikon, Japan). For spore morphology, a scanning electron microscope (SEM) was used to observe the megaspores and microspores. Spore samples obtained from herbarium specimen were mounted on specimen tabs and then coated with platinum in a sputter coater. Observations were conducted using an ESEM-Quanta 200 (FEI, Hillsboro, Oregon, USA) with 15 Kv at Nanjing Forestry University, Nanjing, China. The quantitative characters of the new species were measured using the ImageJ software (Pérez and Pascau 2013). Voucher specimens (see Appendix 1) were deposited at NF and PYU (herbaria acronyms according to Thiers 2018).

For the phylogenetic study, a total of 84 accessions representing 50 species of the genus were included, of which four accessions representing four species were selected

as outgroups based on earlier phylogenetic analysis (Zhou et al. 2016; Weststrand and Korall 2016b). Three samples from three different populations of the new species were newly sequenced. Total genomic DNA was extracted from silica-dried leaves using a TIANGEN plant genomic DNA extraction kit (TIANGEN Biotech, Beijing, China) Mini Kits (Qiagen, Germany) following the manufacturer's protocols. One plastid gene *rbcL* and one nuclear region *ITS* were selected for the phylogenetic analysis based on Zhou et al. (2016). The PCR and sequencing protocols follow Zhou et al. (2016). The newly generated sequences were assembled and edited using Sequencher ver. 4.14 (GeneCodes Corporation, Ann Arbor, Michigan). All sequences of *rbcL* and *ITS* regions were initially aligned with MAFFT ver. 7 (Katoh and Standley 2013) and manually adjusted in BioEdit (Hall 1999). The two alignments were concatenated and the final combined dataset was analyzed with maximum likelihood (ML) and Bayesian inference (BI) methods. The ML tree searches were performed using RAxML-HPC2 on XSEDE with 1000 bootstrap replicates. The model GTR+I+G was chosen for the combined dataset using the AIC criterion with JModelTest 2 (Darriba et al. 2012). The BI was conducted using MrBayes ver. 3.2.7a (Ronquist and Huelsenbeck 2003) with temperature parameter set to 0.2, and keeping other parameters consistent with the default parameters of the software. Two independent runs of four Markov chain Monte Carlo chains, each with four chains (one cold, three heated), were conducted, each beginning with a random tree and sampling one tree every 1000 generations of 10 000 000 generations. Convergence among runs and stationarity were assessed using Tracer ver. 1.4 (Rambaut and Drummond 2007), and the first 25% was discarded as burnin. The remaining trees were used to calculate a 50% majority-rule consensus topology and posterior probabilities (PP).

Results and discussion

Based on our phylogenetic analysis, three collections from three different populations of the new species is in a polytomy with *S. lutchensis* and *S. albociliata* (Fig. 1). Three samples of this new species are not resolved as a monophyletic group. However, both *S. lutchensis* and *S. albociliata* are monophyletic and they form a strongly supported clade together (MLBS = 95% and BIPP = 0.99) (Fig. 1). Morphologically, all the three species have leaves ciliate along the margin. Based on the recent infrageneric classification of *Selaginella* proposed by Zhou and Zhang (2015), *S. wuyishanensis* should be assigned to *S.* subg. *Heterostachys* Baker sect. *Tetragonostachyae* (Hook. & Grev.) Hieron. & Sadeb.

Morphologically, *Selaginella wuyishanensis* is most similar to *S. albociliata* and *S. lutchensis* in having plants creeping (Fig. 2A), leaf margins white (Fig. 2H–L), axillary and ventral leaves ciliate along the margins (Fig. 2H–L), megaspore surfaces reticulate ornamentation with fine muri (Fig. 2M, N), and microspore surfaces verrucate (Fig. 2O, P), but *S. wuyishanensis* has long cilia on ventral leaves up to 0.6 mm long (Fig. 2H; vs. short cilia up to 0.2 mm long in *S. lutchensis*), dorsal leaves long

Taxonomic treatment

Selaginella wuyishanensis K.W.Xu, X.M.Zhou & Y.F.Duan, sp. nov.

urn:lsid:ipni.org:names:77302501-1

Figs 2, 3

Type. CHINA. Fujian: Wuyishan City, Mt. Wuyishan, alt. 200m, 27°41'12.82"N, 117°56'12.24"E, 25 Nov. 2021, *Ke-Wang Xu et al. WY21* (holotype: NF!; isotype: PYU!).

Diagnosis. The new species is most similar to *Selaginella albociliata* and *S. lutchuensis* in the habit, sterile leaves, and spores. However, *S. wuyishanensis* can be distinguished from the latter two species by its long leaf cilia (up to 0.6 mm), ovate ventral sporophylls, and the smooth perispore surface of the megaspores (Figs. 2, 3).

Description. *Plants* epilithic, evergreen, creeping, without erect or ascending stems. *Rhizophores* present at intervals throughout the length of creeping stem and branches, born on ventral side in the axil of main branches, slender, glabrous, 2–5 cm long, 0.1–0.2 mm in diameter; roots usually forked at the apex. *Stem* 5–12 cm long, rarely longer than 12 cm, 3–4 mm in width, irregularly and slightly dichotomously branched. *Leaves* arranged in four ranks (two dorsal and two ventral). *Axillary leaves* present at branching points, oblong-ovate, base slightly cuneate, apex acuminate, 0.8–1.2 × 2.2–2.5 mm, long ciliate along the margin from base to 2/3 of the axillary leaves, cilia up to 0.8 mm long. *Ventral leaves* asymmetrical, those on main stem similar to those on branches, imbricate on stem and branch throughout, ovate, 1.5–2.8 × 0.8–1.2 mm, apex slightly acute to acuminate, acroscopic base rounded, basicopic base slightly cuneate, margin conspicuously white-margins; acroscopic margins ciliate at the base, cilia up to 0.6 mm long, basicopic margins nearly entire at the base, ciliate or denticulate upward. *Dorsal leaves* symmetrical, ovate to oval, 0.8–1.6 × 0.6–0.9 mm, base rounded, apex aristiform, often reflexed, margins conspicuously white-callous, acroscopic margins sparsely ciliate, cilia up to 0.5 mm long, basicopic margins ciliate, cilia short, no more than 0.1 mm long. *Strobili* usually in pairs or rarely three on the branches, terminal, resupinate, 1–2 cm long, megasporangia usually present at basal sporophylls and microsporangia present at upper ones; dorsal sporophylls ovate-lanceolate, base nearly rounded, apex acuminate, 1.2–1.8 × 0.4–0.8 mm, margin conspicuously white-callous, ciliate along the margin of basal part, cilia short; ventral sporophylls membranous, ovate-lanceolate, base rounded, apex caudate, ca. 0.6 × 1.3 mm, ciliate along the margin, cilia ca. 0.3 mm long. *Megaspores* yellow, trilete, oblate spheroid to subglobose, equatorial diameter 240–260 µm; perispore reticulate ornamentation with fine muri. *Microspores* reddish orange, trilete, hemispheric, equatorial diameter 35–42 µm; verrucate ornamentation of microspore covered with dense rodlets.

Distribution and habitat. *Selaginella wuyishanensis* is known only from Fujian Province, East China. Three populations were observed to grow on rocks of the Danxia landform in evergreen broad-leaved forests at elevations of ca. 200–800 m.

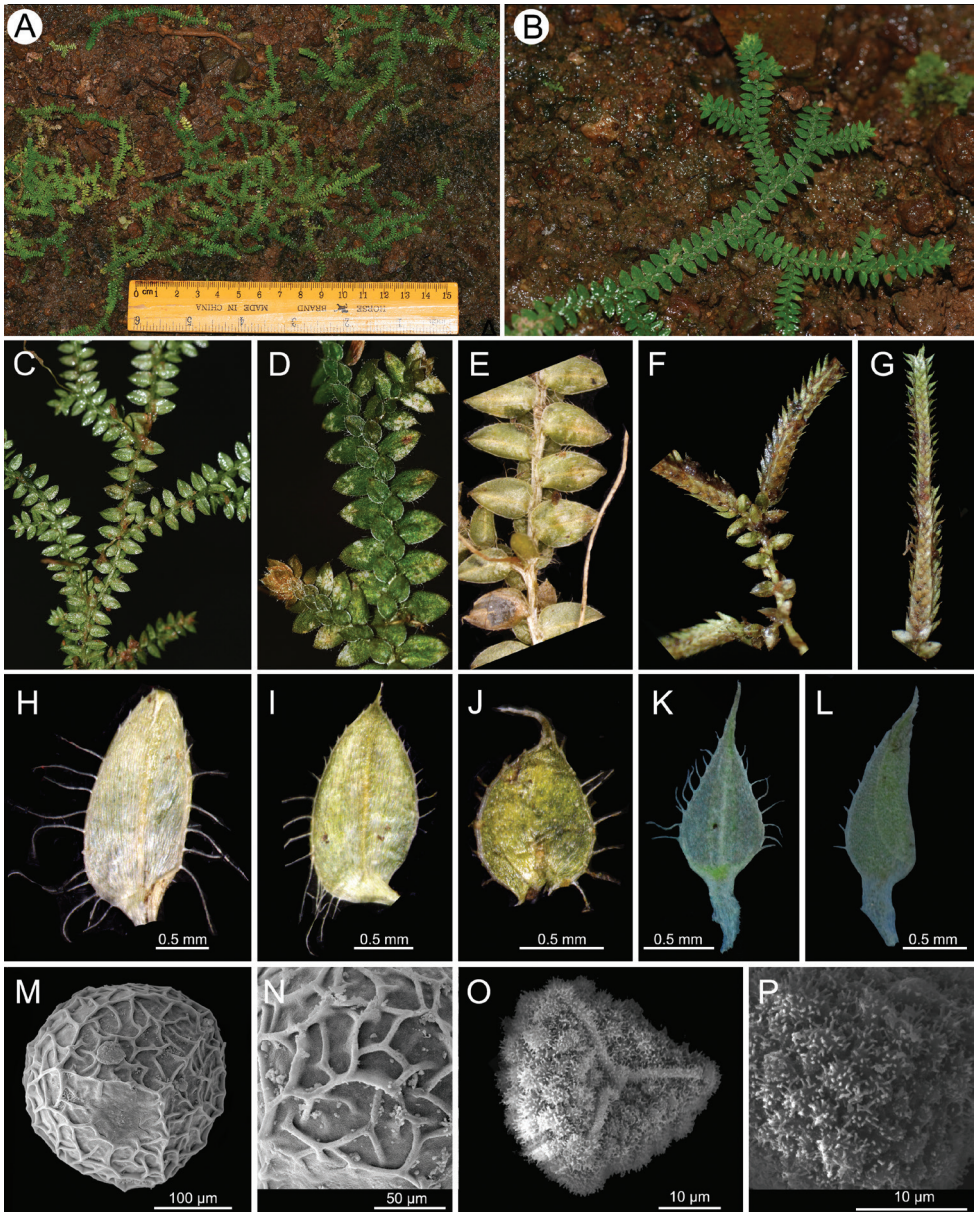


Figure 2. *Selaginella wuyishanensis* **A, B** habit **C** abaxial view of portion of branch **D** portion of branch showing the dorsal leaves **E** portion of branch showing the ventral and axillary leaves **F, G** strobili **H** axillary leaf **I** axillary leaf **J** dorsal leaf **K** ventral sporophyll **L** dorsal sporophyll **M** proximal surface of megaspores **N** detail of megaspore surface **O** microscopic structures of microspore surface **P** proximal surface of microspore.

Additional specimens examined. CHINA. Fujian: Wuyishan City, Mt. Wuyishan, alt. 327 m, 27°41'12.82"N, 117°56'12.24"E, 25 Nov. 2021, *Ke-Wang Xu et al.* WY521 (NF); the same locality, alt. 280 m, 27°39'17"N, 117°57'50"E, 27 Nov. 2021, *Ke-Wang*

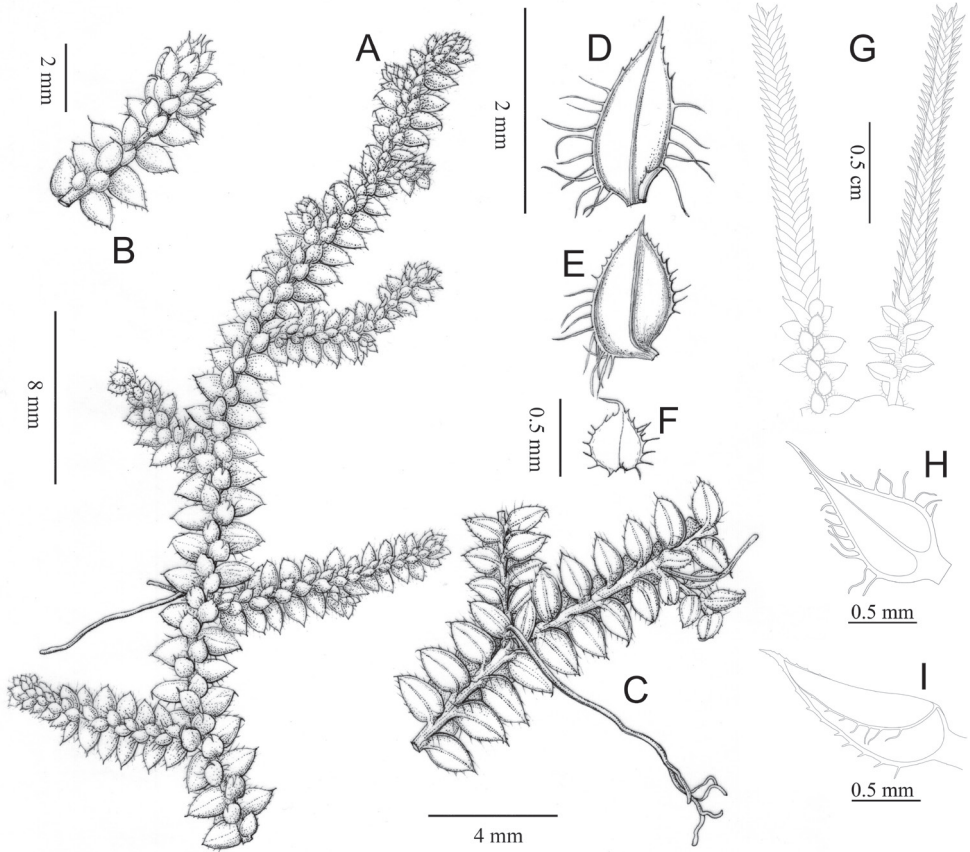


Figure 3. Illustration of *Selaginella wuyishanensis* **A** habit **B** adaxial view of branch **C** abaxial view of branch with rhizophore **D** axillary leaf **E** ventral leaf **F** dorsal leaf **G** strobili **H** ventral sporophyll **I** dorsal sporophyll (**A–F** drawn by Sun YB based on the isotype at NF **G–I** drawn by Wei HJ based on the paratype at CSH).

Xu et al. WY596 (NF); the same locality, *Ke-Wang Xu et al. WY597* (NF); the same locality, *Ke-Wang Xu et al. WY598* (NF); Yongan City, Tianbaoyan National Nature Reserve, 25°57'11"N, 117°33'14"E, 1 Nov. 2020, *Wei & Chen JSL7744A* (CSH).

Etymology. The species epithet is based on the name of the famous mount Wuyishan, referring to the type locality of the new species.

Key to *Selaginella wuyishanensis* and its closely related species and morphologically similar species in Fujian Province

- 1 Leave margins denticulate and not white-margined **2**
- Leave margins more or less ciliate and/or white-margined..... **3**
- 2 Strobili non-resupinate ***S. nipponica***
- Strobili resupinate..... ***S. heterostachys***

- 3 Leaves not white-margined, both sides of ventral leaves long ciliolate at margins **4**
- Leaves white-margined, acroscopic base of ventral leaves long ciliolate at margins, elsewhere denticulate or subentire ***S. xipholepis***
- 4 Ventral leave margins with short cilia up to 0.2 mm; dorsal leave margins loosely serrulate ***S. lutchensis***
- Ventral and dorsal leave margins with cilia up to 0.6 mm **5**
- 5 Ventral sporophylls ovate-lanceolate with length-to-width ratio of ca. 3.2; megaspore surfaces with fine and low papillae structure ***S. albociliata***
- Ventral sporophylls ovate with length-to-width ratio of ca. 2.4; megaspore surfaces smooth ***S. wuyishanensis***

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References

- Chang HM, Chen JF, Lu PF, Moore SJ, Wang JC, Chiou WL (2009) Supplements to the lycophytes in Taiwan (I): A newly recorded species *Selaginella lutchuensis* Koidz. (Selaginellaceae). *Taiwania* 54: 88–92.
- Darriba D, Taboada GL, Doallo R, Posada D (2012) jModelTest 2: More models, new heuristics and parallel computing. *Nature Methods* 9(8): 772–772. <https://doi.org/10.1038/nmeth.2109>
- Ebihara A, Nitta JH, Ito M (2010) Molecular species identification with rich floristic sampling: DNA barcoding the pteridophyte flora of Japan. *PLoS ONE* 5: e15136. <https://doi.org/10.1371/journal.pone.0015136>
- Hall TA (1999) BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series* 41: 95–98.
- He M, He ZR, Zhang LB, Zhou XM (2021) *Selaginella qingchengshanensis* (sect. *Heterostachys*; Selaginellaceae), a new species from Sichuan, China. *Phytotaxa* 522(4): 285–293. <https://doi.org/10.11646/phytotaxa.522.4.2>
- Jermy AC (1990) Selaginellaceae. In: Kubitzki K, Kramer KU, Green PS (Eds) *The Families and Genera of Vascular Plants, Pteridophytes and Gymnosperms*. Springer, Berlin, 1st edn., Vol. 1, 39–45. https://doi.org/10.1007/978-3-662-02604-5_11

- Katoh K, Standley DM (2013) MAFFT multiple sequence alignment software version 7: Improvements in performance and usability. *Molecular Biology and Evolution* 30(4): 772–780. <https://doi.org/10.1093/molbev/mst010>
- Korall P, Kenrick P, Therrien, JP (1999) Phylogeny of Selaginellaceae: evaluation of generic/subgeneric relationships based on rbcL gene sequences. *International Journal of Plant Sciences* 160(3): 585–594. <https://doi.org/10.1086/314137>
- Nitta J, Steier J, Schuettpelz E (2020) Biogeography of Pacific pteridophytes in a global context (Unpublished).
- Pérez JMM, Pascau J (2013) Image processing with ImageJ. Packt Publishing Ltd., Birmingham.
- Patel MB, Reddy MN (2020) Systematic studies on the Pteridophytes of Gujarat with their phytochemistry and pharmacological properties (Unpublished).
- PPG (2016) A community-derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution* 54(6): 563–603. <https://doi.org/10.1111/jse.12229>
- Rambaut A, Drummond AJ (2007) Tracer 1.4. <http://beast.bio.ed.ac.uk/Tracer> [accessed 15 Jan. 2022]
- Ronquist F, Huelsenbeck JP (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* 19(12): 1572–1574. <https://doi.org/10.1093/bioinformatics/btg180>
- Shalimov AP, Zhu YM, Zhang MH, Zhang XC (2019) *Selaginella dianzhongensis* (Selaginellaceae), a new spikemoss from China. *PhytoKeys* 118: 75–87. <https://doi.org/10.3897/phytokeys.118.30375>
- Steier J, Schuettpelz E (2020) The Evolution of Overrepresentation: exploring the biogeography of Marquesan pteridophytes (Unpublished).
- Thiers B (2018) Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/science/ih/> [Accessed 15 Jan. 2022]
- Wang HW, Dai JM, Chen ZX, Fan Q, Liao WB (2022) *Selaginella orientali-chinensis*, a new resurrection spikemoss species from southeastern China based on morphological and molecular evidences. *Acta Scientiarum Naturalium Universitatis Sunyatseni* 2022: E003. <https://doi.org/10.13471/j.cnki.acta.snus.2022E003>
- Weststrand S, Korall P (2016a) A subgeneric classification of *Selaginella* (Selaginellaceae). *American Journal of Botany* 103(12): 2160–2169. <https://doi.org/10.3732/ajb.1600288>
- Weststrand S, Korall P (2016b) Phylogeny of Selaginellaceae: There is value in morphology after all! *American Journal of Botany* 103(12): 2136–2159. <https://doi.org/10.3732/ajb.1600156>
- Wu YD, Zhang HR, Zhang XC (2017) *Selaginella guibaia* (Selaginellaceae): A new spikemoss species from southern China and northern Vietnam around the Gulf of Tonkin. *PhytoKeys* 80: 41–52. <https://doi.org/10.3897/phytokeys.80.11126>
- Ye ZY, Lu NT, Zhang L, Zhou XM, Zhang LB (2020) *Selaginella coriaceifolia* (sect. *Heterotachys*; Selaginellaceae), a new lycophyte species from central Vietnam. *Phytotaxa* 453: 121–129. <https://doi.org/10.11646/phytotaxa.453.2.3>
- Yi Y, He Y, Tan B (2007) The *Selaginella* of peninsular Malaysia (Unpublished).
- Zhang XC, Nooteboom HP, Kato M (2013) Selaginellaceae. In: Wu ZY, Raven PH, Hong DY (Eds) *Flora of China*. Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, Vol. 2–3, 37–66.

- Zhang XC, Shalimov AP, Kang JS, Zhang MH (2020) *Selaginella subvaginata* (Selaginellaceae), a new spikemoss from China. *Journal of Species Research* 9(3): 221–232.
- Zhang MH, Wei R, Xiang QP, Ebihara A, Zhang XC (2021) Integrative taxonomy of the *Selaginella helvetica* group based on morphological, molecular and ecological data. *Taxon* 70(6): 1163–1187. <https://doi.org/10.1002/tax.12565>
- Zhou XM, Zhang LB (2015) A classification of *Selaginella* (Selaginellaceae) based on molecular (chloroplast and nuclear), macromorphological, and spore features. *Taxon* 64(6): 1117–1140. <https://doi.org/10.12705/646.2>
- Zhou XM, He ZR, Zhang L, Zhang LB (2015a) *Selaginella chuweimingii* (Selaginellaceae) sp. nov. from Yunnan, China. *Phytotaxa* 231(3): 283–288. <https://doi.org/10.11646/phytotaxa.231.3.6>
- Zhou XM, Jiang LJ, Zhang L, Gao XF, He ZR, Zhang LB (2015b) Spore morphology of *Selaginella* (Selaginellaceae) from China and its systematic significance. *Phytotaxa* 237: 001–067. <http://dx.doi.org/10.11646/phytotaxa.237.1.1>
- Zhou XM, Rothfels CJ, Zhang L, He ZR, Le Péchon T, He H, Lu NT, Knapp R, Lorence D, He XJ, Gao XF, Zhang LB (2016) A large-scale phylogeny of the lycophyte genus *Selaginella* (Selaginellaceae: Lycopodiopsida) based on plastid and nuclear loci. *Cladistics* 32(4): 360–389. <https://doi.org/10.1111/cla.12136>

Appendix I

List of taxa sampled with information related to taxonomy, GenBank accession numbers (*rbcL*, 5.8S+ITS2), references, and voucher information. Herbarium acronyms follow Index Herbariorum (Thiers 2018).

***Selaginella albociliata* P.S.Wang** (1) *L.-B. Zhang et al. 5302* (CDBI), China (Guangxi), KT161379 (Zhou et al. 2016), KT161648 (Zhou et al. 2016); (2) *X.-C. Zhang 7242* (PE), China (Guizhou), MH814882 (Shalimov et al. 2019), —; (3) *L.-B. Zhang 526* (CDBI), China (Guizhou), ON994457 (this study), —. ***Selaginella alutacea* Spring** *Korall 2006-9* (S), Malaysia: KY022958 (Weststrand and Korall 2016b), —. ***Selaginella amblyphylla* Alston** (1) *X.-C. Zhang 2924* (PE), China (Yunnan), MH814883 (Shalimov et al. 2019), —; (2) *X.-C. Zhang 7951* (PE), China (Yunnan), MH814884 (Shalimov et al. 2019), —. ***Selaginella arbuscula* (Kaulf.) Spring** (1) *Schuettpelez 1941* (US), French Polynesia (Marquesas Islands): MT216108 (Steier and Schuettpelez unpublished); —; (2) *Wood 13746* (PTBG), Hawaii (Maui, Kipahulu): KT161388 (Zhou et al. 2016), KT161657 (Zhou et al. 2016). ***Selaginella banksii* Alston** *Grant 3563* (L), French Polynesia: KY022972 (Weststrand and Korall 2016b), —. ***Selaginella bebrmanniana* Hieron.** *Johns 8937*, (L), Indonesia: KY022973 (Weststrand and Korall 2016b), —. ***Selaginella bisulcata* Spring** *W.-M. Chu et al. 31292* (PYU), China (Yunnan): KT161404 (Zhou et al. 2016), KT161673 (Zhou et al. 2016). ***Selaginella bodinieri* Hieron.** ex Christ (1) *W.-B. Ju & H.-N. Deng HGX13005* (CDBI), China (Sichuan): KT161413 (Zhou et al. 2016), KT161678 (Zhou et al. 2016); (2) *L.-B. Zhang et al. 5177* (CDBI), China (Guangxi): KT161411

(Zhou et al. 2016), KT161679 (Zhou et al. 2016). *Selaginella boninensis* Baker TNS766618 (TNS), Japan (Tokyo): AB574642 (Ebihara et al. 2010), —. *Selaginella brachystachya* (Hook. & Grev.) Spring (1) *J. Klackenberg* 434 (S), Sri Lanka: KY022980 (Weststrand and Korall 2016b), —; (2) *W.A. Sledge* 913 (L), Sri Lanka: KY022979 (Weststrand and Korall 2016b), —. *Selaginella chaetoloma* Alston (1) *Z.-Y. Guo* 2016014 (PE), China (Guizhou): MH814888 (Shalimov et al. 2019), —; (2) *X.-C. Zhang* 7347 (PE), China (Guizhou): MH814889 (Shalimov et al. 2019), —. *Selaginella chingii* Alston (1) *L.-B. Zhang et al.* 6587 (CDBI, MO, VNMN, PYU), Vietnam (Lang Son): KT161417 (Zhou et al. 2016), KT161683 (Zhou et al. 2016); (2) *L.-B. Zhang et al.* 6594 (CDBI, MO, VNMN, PYU), Vietnam (Lang Son): KT161416 (Zhou et al. 2016), KT161868 (Zhou et al. 2016). *Selaginella chrysocaulos* (Hook. & Grev.) Spring (1) *D. E. Boufford et al.* 33036 (A), China (Sichuan): KY022955 (Weststrand and Korall 2016b), —; (2) *X.-C. Zhang* 86 (PE), China (Sichuan): MH814891 (Shalimov et al. 2019), —. *Selaginella ciliaris* (Retz.) Spring (1) *BVBRI035-20*, MT795923 (Patel and Reddy 2020), —; (2) *Jiang* 310 (PYU, CDBI), China (Hainan): KT161428 (Zhou et al. 2016), KT161691 (Zhou et al. 2016); (3) Unknown (Unknown), Peninsula Malaysia: EU126658 (Yi et al. 2007), —. *Selaginella coriaceifolia* X.M.Zhou, N.T.Lu & Li Bing Zhang (1) *L.-B. Zhang et al.* 7307 (CDBI, MO, VNMN), Vietnam (Quang Binh): MT386596 (Ye et al. 2020), MZ570596 (He et al. 2021); (2) *L.-B. Zhang et al.* 7371 (CDBI, MO, VNMN), Vietnam (Quang Binh): MT386598 (Ye et al. 2020), MT386595 (Ye et al. 2020). *Selaginella decipiens* Warb. (1) *L.-B. Zhang et al.* 6764 (CDBI, MO, VNMN, PYU), Vietnam (Bac Kan): KT161438 (Zhou et al. 2016), KT161698 (Zhou et al. 2016); (2) *L.-B. Zhang et al.* 6761 (CDBI, MO, VNMN, PYU), Vietnam (Bac Kan): KT161439 (Zhou et al. 2016), KT161697 (Zhou et al. 2016). *Selaginella denticulata* (L.) Spring *Korall & Eriksson* 715 (S), Unknown: AJ010853 (Korall et al. 1999), —. *Selaginella dianzhongensis* X.C.Zhang *Zhu Y.-M.* 8158 (PE), China (Yunnan): MH814909 (Shalimov et al. 2019), —. *Selaginella drepanophylla* Alston *L.-B. Zhang et al.* 5117 (CDBI), China (Guangxi): KT161447, KT161703 (Zhou et al. 2016); *Selaginella effusa* Alston (1) *S.-Y. Dong* 2470 (PYU), China (Guangdong): KT161453 (Zhou et al. 2016), KT161705 (Zhou et al. 2016); (2) *L.-B. Zhang et al.* 5438 (CDBI), China (Guangxi): KT161450 (Zhou et al. 2016), KT161706 (Zhou et al. 2016); (3) *L.-B. Zhang et al.* 5442 (CDBI), China (Guangxi): KT161451 (Zhou et al. 2016), KT161707 (Zhou et al. 2016). *Selaginella goudotiana* Spring *M. Thulin and H. Razafindralibe* 11750 (UPS), Madagascar: KY023039 (Weststrand and Korall 2016b), —. *Selaginella goudotiana* var. *abyssinica* (Spring) Bizzarri *R.E.G. Pichi Sermolli* 6756 (L), Ethiopia: KY023038 (Weststrand and Korall 2016b), —. *Selaginella kanehirae* Alston *Wood* 13568 (PTBG), F.S.M. (Caroline Is., Pohnpei): KT161495 (Zhou et al. 2016), KT161745 (Zhou et al. 2016). *Selaginella kurzii* Baker (1) *X.-M. Zhou et al.* PYU-S-2105 (PYU), China (Yunnan): MZ532022 (He et al. 2021); MZ570598 (He et al. 2021); (2) *X.-C. Zhang* 1934 (PE), China (Yunnan): MH814898 (Shalimov et al. 2019), —. *Selaginella labordei* Hieron. ex Christ (1) *X.-F. Gao et al.* DJY03894 (CDBI), China (Sichuan): KT161502 (Zhou et al. 2016), KT161750 (Zhou et al.

2016); (2) *H. Smith 2345* (S), China (Sichuan), KY023059 (Weststrand and Korall 2016b), —. ***Selaginella laxa* Spring** (1) *Schuettpelez 1913* (US), French Polynesia (Marquesas Islands), MT216111 (He et al. 2021); (2) *T. G. Yuncker 15994* (U); Tonga, KY023063, —. ***Selaginella leptophylla* Baker** (1) *L.-B. Zhang et al. 5199* (CDBI), China (Guangxi): KT161511 (Zhou et al. 2016), KT161758 (Zhou et al. 2016); (2) *X.-M. Zhou & al. DJY05380* (CDBI), China (Sichuan): KT161513 (Zhou et al. 2016), KT161756 (Zhou et al. 2016). ***Selaginella lutchuensis* Koidz.** (1) *TNS101683* (TNS), Japan: MT680176 (Zhang et al. 2021), —; (2) *TNS759343* (TNS), Japan (Okinawa): AB574648 (Ebihara et al. 2010), —. ***Selaginella megaphylla* Baker** (1) *X.-H. Jin 19301* (PE), China (Xizang): MH814901 (Shalimov et al. 2019), —; (2) *X.-M. Zhou YLZB2185* (CDBI, PYU), China (Xizang): ON994456 (this study), ON994203 (this study). ***Selaginella menziesii* (Hook. & Grev.) Spring** *D. P. Rogers s.n. (Die XI-10-46)* (U), Hawaii, KY023079 (Weststrand and Korall 2016b), —. ***Selaginella miniatospora* (Dalzell) Bak.** (1) *J. Klackenberg and R. Lundin 567* (S), India (Kerala): KY023081 (Weststrand and Korall 2016b), —; (2) *C. van Hardevelde and H. H. van der Werff 120* (U), India (Tamil Nadu): KY023080 (Weststrand and Korall 2016b), —. ***Selaginella minutifolia* Spring** *Larsen et al. 1389* (S), Thailand: KY023082 (Weststrand and Korall 2016b), —. ***Selaginella mittenii* Baker** *van Steenis 24105* (L), South Africa: KY023083 (Weststrand and Korall 2016b), —. ***Selaginella monospora* Spring** (1) *L.-B. Zhang & al. 6430* (CDBI, MO, VNMN, PYU), Vietnam (Vinh Phuc): KT161537 (Zhou et al. 2016), KT161782 (Zhou et al. 2016); (2) *L. Zhang 1296*, China (Yunnan): MZ532023 (this study), —. ***Selaginella morganii* Zeiller** *P. Korall 2006: 29* (S), Peninsular Malaysia: KY023088 (Weststrand and Korall 2016b), —. ***Selaginella neocaledonica* Baker** (1) KY985453 (Klaus et al. 2016), —; (2) *N. Wikström 244* (S); New Caledonia, KY023095 (Weststrand and Korall 2016b), —. ***Selaginella nipponica* Franch. & Sav.** *TNS738139* (TNS), Japan (Tokyo): AB574649 (Ebihara et al. 2010), —. ***Selaginella ornata* (Hook. & Grev.) Spring** (1) *L.-B. Zhang et al. 5200* (CDBI), China (Guangxi): KT161524 (Zhou et al. 2016), KT161770 (Zhou et al. 2016); (2) *W.-M. Chu & al. 8226* (PYU), China (Yunnan): KT161525 (Zhou et al. 2016), KT161767 (Zhou et al. 2016). ***Selaginella qingchengshanensis* Li Bing Zhang & X.M.Zhou** (1) *X.-F. Gao et al. DJY04053* (CDBI), China (Sichuan): KT161381 (Zhou et al. 2016), KT161649 (Zhou et al. 2016); (2) *Z.-L. Liang & X. Pu 056* (CDBI, PYU), China (Sichuan): MZ532027 (He et al. 2021), MZ570603 (He et al. 2021). ***Selaginella reineckei* Hieron.** (1) *K.R. Wood 16944* (PTBG), Samoa (Savaii): MT657902 (Nitta et al. 2020), —; (2) *H. S. McKee 2907 P7338* (L); Samoa, KY023129 (Weststrand and Korall 2016b), —. ***Selaginella repanda* (Desv. & Poir.) Spring** (1) *Z.-R. He & X.-M. Zhou 119* (PYU, CDBI), China (Yunnan): KT161583 (Zhou et al. 2016), KT161816 (Zhou et al. 2016); (2) *He & Jiang 405-1* (CDBI), China (Yunnan): KT161584 (Zhou et al. 2016), —. ***Selaginella reticulata* (Hook. & Grev.) Spring** *C.R. Fraser-Jenkins 1653* (L), Nepal: KY022956 (Weststrand and Korall 2016b), —. ***Selaginella subvaginata* X.C.Zhang & Shalimov** (1) *Liu H. 182* (PE) China (Sichuan): MT680177 (Zhang et al. 2020), —; (2) *X.-C. Zhang et al. 9450* (PE) China (Sichuan): MT680181 (Zhang et al. 2020), —.

Selaginella trichophylla* K.H.Shing** (1) *L.-B. Zhang et al. 6784* (CDBI, MO, VNMN, PYU), Vietnam (Cao Bang): [KT161624](#) (Zhou et al. 2016), [KT161849](#) (Zhou et al. 2016); (2) *W.-M. Chu & al. 29310* (PYU), China (Yunnan): [KT161622](#) (Zhou et al. 2016), [KT161846](#) (Zhou et al. 2016). ***Selaginella uncinata* (Desv.) Spring** *Zhang & Zhou DJY04101* (CDBI), China (Sichuan): [KT161626](#) (Zhou et al. 2016), [KT161852](#) (Zhou et al. 2016). ***Selaginella vaginata* Spring** (1) *X.-M. Zhou 012* (CDBI), China (Sichuan): [KT161434](#) (Zhou et al. 2016); —; (2) *X.-M. Zhou & al. DJY07488* (CDBI), China (Sichuan): [KT161432](#) (Zhou et al. 2016), [KT161694](#) (Zhou et al. 2016). ***Selaginella whitmeei* Baker** *K.R. Wood 17032* (PTBG), Samoa (Savaii), [MT657910](#) (Nitta et al. 2020), —. ***Selaginella wuyishanensis (1) *K.-W. Xu WY596* (PYU), China (Fujian): [ON994453](#) (this study), —; (2) *K.-W. Xu WY598* (PYU), China (Fujian): [ON994454](#) (this study), —; (3) *H.-J. Wei JSL7744A* (CSH), China (Fujian): [ON994455](#) (this study), [ON994202](#) (this study). ***Selaginella xipholepis* Baker** (1) *S.-Y. Dong 2377* (PYU), China (Guangdong): [KT161645](#) (Zhou et al. 2016), —; (2) *L.-B. Zhang & al. 6668* (CDBI, MO, VNMN, PYU), Vietnam (Bac Kan): [KT161646](#) (Zhou et al. 2016), [KT161867](#) (Zhou et al. 2016). ***Selaginella yunckeri* Alston** *T. G. Yuncker 15933* (U); Tonga, [KY023182](#) (Weststrand and Korall 2016b), —.