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Research Article

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Selaginella likabalika Aran & Roy sp. nov: a new species from Arunachal Pradesh, India

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ABSTRACT

A new species of *Selaginella i.e.*, *Selaginella likabalika* is described in the present study. The species was collected from Likabali, under the Lower Siang district and Karsingsa, under the Papumpare district of Arunachal Pradesh. The new species can be easily confused to be mosses due to their similar appearance and habitat resemblance. The species is minute, prostrate and generally covers the ground like a carpet. The morphology of the new species is close to *Selaginella armata*, *S. apoda*, *S. confusa* and *S. flacca* but can be differentiated by leaf features.

Keywords: *Selaginella*, *S. likabalika*, Arunachal Pradesh, India

INTRODUCTION

Selaginella P.Beauv. the largest group among lycophytes representing the monotypic family *Selaginellaceae* (Weststrand & Korall, 2016a). The genus perhapes constitutes about 700 species (PPG I, 2016; Liu *et al.*, 2022; Valdespino *et al.*, 2022; Wei, 2023). Studies based on morphology and molecular analysis considered the family monophyletic (Korall *et al.*, 1999; Zhou & Zhang, 2015). The genus *Selaginella* has been divided into sub–generic levels by many (Hieronymus & Sadebeck, 1902; Walton & Alston, 1938; Jermy, 1986; Soják, 1992). Zhou and Zhang (2015) placed the members of the genus into six different subgenera *viz*. *Selaginella*, *Ericetorum*, *Boreoselaginella*, *Pulviniella*, *Heterostachys* and *Stachygynandrum*. A recent classification recognized seven subgenera of *Selaginella i.e.*, subg. *Selaginella*, subg. *Rupestrae*, subg. *Lepidophyllae*, subg. *Gymnogenum*, subg. *Exaltatae*, subg. *Ericetorum* and subg. *Stachygynandrum* (Weststrand & Korall, 2016b). Species of the family is distributed in different zones of the earth (Korall *et al.*, 1999). Fraser-Jenkins *et al.* (2017) in "Annotated checklist of Indian Pteridophytes" listed 58 species of the genus from India; Singh *et al.* (2020) and Aran and Roy (2022) added two species to the family.

The proposed species is placed under the subgenus *Stachygynandrum*. The interesting populations of the new species were initially found similar to *S. armata* Baker, *S. apoda* (L.) Spring, *S. confusa* Spring and *S. flacca* Alston in appearance. The present adjustment of this collection as new species to India was based on field observation, careful laboratory examination and survey of relevant literatures (Spring, 1838, 1840; Baker, 1883, 1884; Handel-Mazzetti, 1929; Peck & Buck, 1978; Jermy & Rankin, 1981; Schulz *et al.*, 2010). Taxonomic description and diagnostic features of the taxa, a comparison based on literature (Table 1) and photo plates (Figures 1 & 2) are provided.

METHODOLOGY

The species was a naturally occurring population collected in January 2021 and January 2022 from Arunachal Pradesh. During field collection, laboratory examination and herbarium preparation standard procedures were followed (Jain & Rao, 1977; Maden, 2004). For the microscopic study, two models of Compound microscope *i.e.*, Stereo microscope - COSLAB ZSM-115 LED and Compound microscope - Carl ZEISS Axiostar plus were used. The SEM study was carried out at the Central Instrumentation Facility (CIF) of Gauhati University, Assam. International (GBIF, NYBG, Y, K, etc.) and National (CAL, ASSAM, ARUN) herbaria were consulted for the study. Work of Panigrahi (1960), Dixit (1992), Korall *et al.* (1999); Ghosh *et al.* (2004), Schulz *et al.* (2010), Singh *et al.* (2014), Zhou and Zhang (2015), Shalimov *et al.* (2019), Zhang *et al.* (2020) and Valdespino *et al.* (2022) were followed for the taxonomic determination.

Taxonomic Treatment

Selaginella likabalika Aran and Roy sp.nov

Type: INDIA. Arunachal Pradesh, Lower Siang, Likabali, 26.01.2021, *K. Aran 169*

Table 1: Comparison of morphological characters of *Selaginella likabalika* with *S. confusa, S. armata, S. apoda, S. flacca* as described literatures

Characters	*S. likabalika* Aran & Roy	*S. confusa* Spring (Spring, 1838)	*S. armata* Baker (Baker, 1884).	*S. apoda* (L.) Spring (Spring, 1840; Schulz *et al*., 2010)	*S. flacca* Alston (Jermy & Rankin, 1981; Triana-Moreno, 2005)
Stem length	3-8 cm	7-10 cm	2.5-5 cm	upto 15 cm	upto 9 cm
Lateral leaves	Narrowly ovate, 0.4-0.6×0.7-1.1 mm	Suborbicular	Oblong-ovate, 0.8-0.89×1.5 mm	Round-ovate, acute, 0.7-0.9×1.1-2.2 cm	Ovate–elliptic, 0.7-1.5×1.1-2 mm
Axillary leaf	Narrowly ovate, 0.45-0.47×0.7-0.8 mm	Suborbicular			Ovate–elliptic
Median leaf	Orbicular, acute, 0.5-0.7×0.6-0.7 mm	Suborbicular, 3 times smaller than lateral leaves	Elliptic-lanceolate, 0.3-0.35×1.0-1.2 mm	Oblong-ovate, acuminate, 0.4-0.6×9-1.1 cm	Ovate-elliptic, cuspidate, 0.3-0.7×0.8-1.2 mm
Strobili	Upto 2.5 mm	20-50 mm	2-5 mm	Upto 26.6 mm	upto 5 mm long
Sporophyll	Dimorphic	Dimorphic	Monomorphic	Slightly dimorphic	Dimorphic
Megaspore	Glassy orange, ovoid - spherical, microrugulate, microverrucate, fossulated and perforated ca. 142.85 µm		White, deep yellow-Bright orange, reticulate, ob- scurely rugose to nearly smooth, c. 230 µm	Bright yellow, Globose-slightly flattened, thin, free rugulae, reticulate with a fine to coarse 280-380 mm in size	c. 325 µm
Microspore	Glassy orange, triangular, reticulate, with unevenly distributed spherules of unequal size, 16.8-2.85 µm		Red orange , granulate, globules of a waxy substance adhering, 26-34 µm	Red orange, globose to slightly ovoid, pebbled ap- pearance, finely echinulate, 23-34 µm	Yellowish brown

(Holotype ARUN), **Isotype**: INDIA. Arunachal Pradesh, Papumpare, Karsingsa, 13.12.2021, *K. Aran* 228 (ARUN).

Plants creeping, light green, shoots with first-order branches. *Stems* creeping, semi-prostrate, soft "3–8 cm" long (Figures 1A & B). The main stem branched alternately. The distance between two adjacent primary branches on the stem is *ca*. "0.3–0.35 cm". On maturity each branch is terminated by one-two Strobili. The stems are slightly overlapped by the acroscopic base of the lateral leaf (Figure 1D). Rhizophores arise from the axil and are generally restricted to the lower 2–3 axils of the stem in mature plant, ca. 0.14 mm in diameter. Thin and transparent roots arises from the apex of rhizophores. Leaves are heteromorphic, alternate, and distichous. *Lateral or ventral leaves* "0.4–0.6×0.7–1.1 mm", narrowly ovate-elliptic, base oblique, apex sub-obtuse, margins hyaline serrated and partially entire (Figure 1F). Epidermis comprises circular, square cells, which are hyaline but the leaf margin is with 2–3 layers of elongated, smooth-walled cells. *Axillary leaves* "0.45–0.47×0.7–0.8 mm", narrowly ovate, oblique, acute, similar to lateral leaf (Figure 1G). *Median* or *dorsal leaves*, "0.5–0.7×0.6–0.7 mm", orbicular, round, apex acute with two curved teeth pointing upward, margins hyaline serrated bearing teeth of ca. 29 µm (Figure 1H), comprises of circular and oval cells but two layers of wide, elongated, smooth-walled cells parallel to the margin; stomata distinct, paracytic, dense near the midrib and margins. *Strobili* asymmetrical, loose, "2–2.5 mm long", "0.11–0.19 mm" in diameter (Figure 1E). *Sporophylls* are dimorphic, loosely arranged. *Dorsal sporophylls* "0.3–0.4×0.6–0.7 mm", obovate with sporophyll-pteryx, round, apex acute with 1–3 tooth, hyaline serrated margins with tooth along the margins and concentrated towards the base, consisting of hyaline elongated smooth-walled parallel cells (Figure 1J); microsporangiate with 20-23 microsporangia per strobili. Microsporangia are arranged in 2 ventral and 2 dorsal rows except the base. *Microspores* "16.8–42.85 µm", glassy orange (Figure 1K), triangular, trilete, surface homobrochate with unevenly distributed homobrochate spherules of unequal size ranging from 321.5 nm–1.558 µm in diameter (Figures 2B, D, F & H). *Ventral sporophylls* "0.28-0.36x0.6-0.68 mm", obovate, rounded, apex subobtuse with single teeth; margin hyaline serrated with teeth of ca. 19 µm, hyaline elongated smooth-walled parallel cells (Figure 1L); microsporangiate but 1–2 megasporangiate at base of strobili; when microsporangiate with numerous microspores and megasporangiate with 3–4 megaspores of unequal size. *Megaspores* "142.85–150×114.28–142.85 µm, ovoid-spherical, glassy orange (Figure 1M), trilete with coarse laesurae extending $^{3}/_{4}^{th}$ of the length of the equator, microrugulate, microverrucate, fossulated (slightly hollowed/grooved), perforated, consisting of 331–526 nm size pore (Figures 2A, C, E & G).

Distribution

India: Arunachal Pradesh, Lower Siang District, likabali; India: Arunachal Pradesh, Papumpare District, Karsingsa (Figure 3).

Etymology

The specific epithet of the proposed species is named based on the type locality likabali in Lower Dibang Valley district of Arunachal Pradesh. Likabali is a small town in Lower Dibang Valley district of Arunachal Pradesh, resided by people of Galo Tribe.

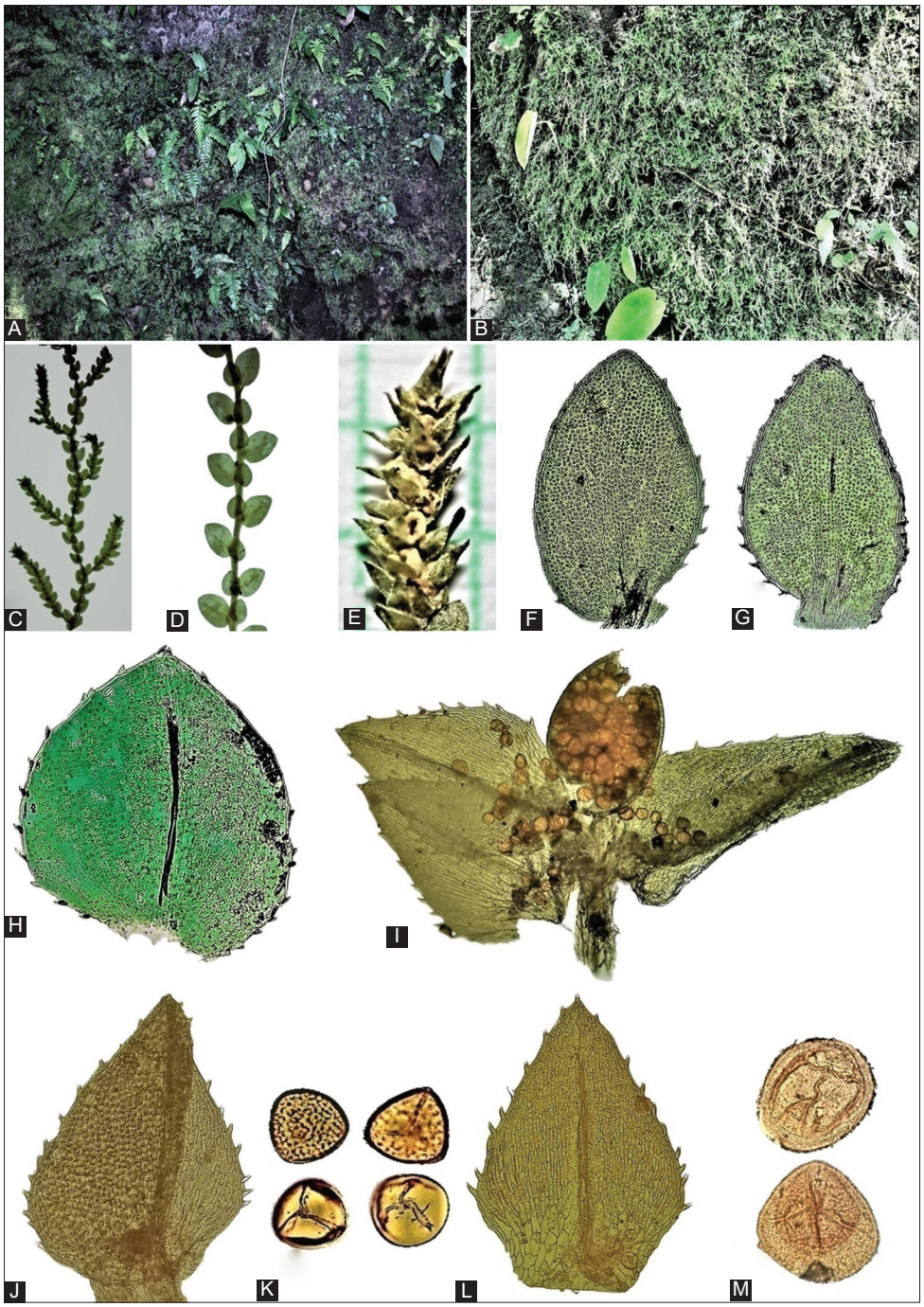

Figure 1: A-B) Habitat, C) Branching, D) Leaf arrangement, E) Strobili, F) Lateral leaf, G) Axillary leaf, H) Median leaf, I) Microsporangium with numerous microspores, J) Dorsal sporophyll, K) Microspore, L) Ventral sporophyll, and M) Megaspore

Specimen Examined

***Selaginella likabalika* Aran & Roy: TYPE-**INDIA, 26 Jan. 2021, K. Aran (ARUN); ISOTYPE-INDIA, 13 Dec. 2021, K. Aran (ARUN)

***Selaginella flacca* Alston: TYPE-**VENEZUALA, A.H.G Alston (1705, Barcode-BM000936528); VENEZUALA, 30 Sept. 1871, K. Mill (2935, HMP Barcode-P00559308)

***Selaginella confusa* Spring: Type-**JAMAICA, 1903, D.O.Mills (NHM, Barcode-BM000634282); **TOPOTYPE** –Republic of Cuba and the Greater Antilles, August 2002, M.G.Caluff (NHM, Barcode-BM000634283).

***Selaginella armata* Baker: HOLOTYPE-**Republic of Cuba and the Greater Antilles, August 2002, M.G.Caluff (K, Barcode-K000589150); **ISOTYPE**-CUBA, 1859-1860, C.Wright (1824, Barcode-BM000905671).

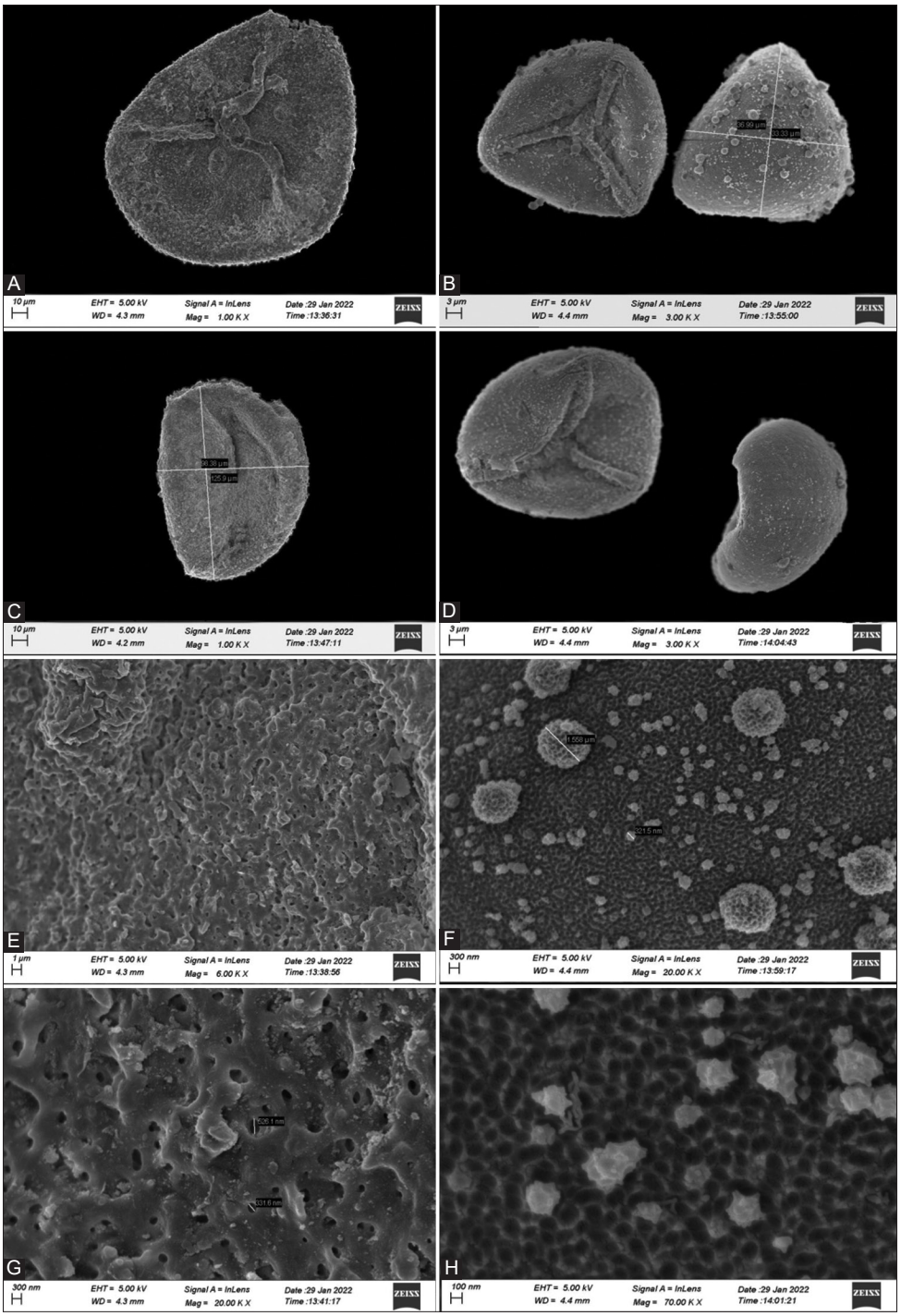

Figure 2: A,C,E,G-Megaspore, B,D,F,H-Microspore. A) Proximal surface, C) Distal surface, E & G) Surface ornamentation, B) Proximal & Distal surface, D) Proximal & Side view, F & H) Surface ornamentation

***Selaginella apoda* (L.) Spring:** UNITED STATES, 14 July 1995, Gety P. Fleming (10805, Barcode-GMUF-0035461); USA, Delaware, 20 July 2009, Robert F.C. Naczi, (NYBG Barcode-03505672).

Artificial key to the species:

1a. Leaves monomorphic 2
2a. Leaves ovate-elliptic.....*S. flacca*
2b. Leaves suborbicular.....*S. confusa*
1b. Leaves dimorphic.....3
3a. Sporophyll monomorphic.....*S. armata*
3b. Sporophyll dimorphic 4
4a. Median leaves orbicular, apex acute.....*S. likabalika*
4b. Median leaves oblong-ovate, apex acuminate....*S. apoda*

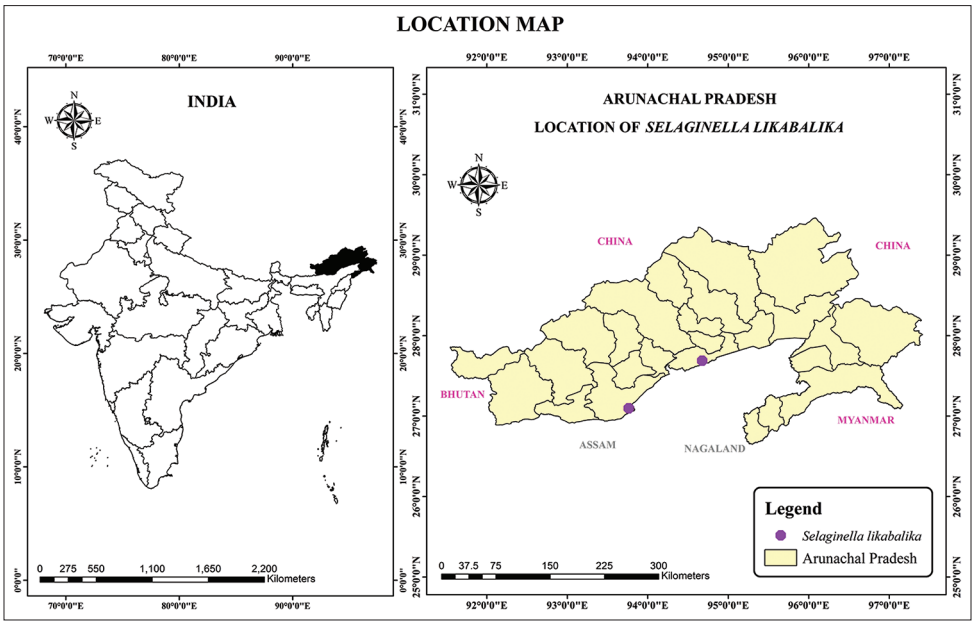

Figure 3: Distribution Map of *Selaginella likabalika* Aran & Roy sp.nov

DISCUSSION

The new species is described based on its habitat, habit and morphology. The new species population was found spreading up to an area of 10-15 meters in Likabali and two populations spread 50 meters apart in Karsingsa was found growing in semi-moist to moist slanting slopes in association with mosses near the stream bank forming a carpet. Matured plant drooping downward, tufted but young plants remain firmly attached to the substratum. The soil type of the habitat is sandy. Three populations of the species were collected, one from Likabali of Lower Siang district and two from Karsingsa of Papumpare district of Arunachal Pradesh. The habit of the species can be easily confused with that of mosses and can be differentiated due to presence of strobili. *S. likabalika* may be endemic to India. The species was differentiated base on morphology of leaves and sporophylls. The species can also be differentiated based on spore features from *S. apoda*, *S. armata*, *S. confusa* and *S. flacca*.

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REFERENCES

Aran, K., & Roy, H. (2022). *Selaginella opaca* (*Selaginellaceae*): New distribution record for North Eastern region, India. *Journal of Economic and Taxonomic Botany, 46*(3&4), 139-142.

Baker, J. G. (1883). A synopsis of the genus *Selaginella*. *The Journal of Botany, British and Foreign, 21*, 1-5.

Baker, J. G. (1884). A synopsis of the genus *Selaginella*. *The Journal of Botany, British and Foreign, 22*, 23-26.

Dixit, R. D. (1992). *Selaginellaceae of India*. Uttarakhand, India: Bishen Singh Mahendra Pal Sing. Dehra Dun.

Fraser-Jenkins, C. R., Gandhi, K. N., Kholia, B. S., & Benniamin, A. (2017). *An annotated checklist of Indian Pteridophytes*. Dehra Dun, India: Bishen Singh Mahendra Pal Singh.

Ghosh, S. R., Ghosh B., Biswas A., & Ghosh, R. K. (2004). Pteridophytic Flora of Eastern India. *Botanical Survey of India, 1*(4), 88-131.

Handel-Mazzetti, H. (1929). *Symbolae Sinicae*. Berlin, Germany: Verlag von Julius Springer.

Hieronymus, G., & Sadebeck, R. (1902). Selaginellaceae. In A. Engler & K. Prantl (Eds.), *Die natürlichen Pflanzenfamilien* (Vol. 1, part 4, pp. 621-716) Leipzig, Germany: Engelmann.

Jain, S. K., & Rao, R. R. (1977). *A Hand Book of Field and Herbarium Technique*. New Delhi, India: Today & Tomorrow Publication.

Jermy, A. C. (1986). Subgeneric names in *Selaginella*. *Fern Gazette, 13*, 117-118.

Jermy, A. C., & Rankin, J. M. (1981). The genus *Selaginella* in tropical South America. *British Museum (Natural History), 9*(4), 233-330.

Korall, P., Kenrick, P., & Therrien, J. P. (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

Liu, J. W., Huang, C.-L., Valdespino, I.-A., Ho, J.-F., Lee, T.-Y., Chesson, P., & Sheue, C.-R. (2022). Morphological and phylogenetic evidence that the novel leaf structures of multivein *Selaginella schaffneri* are derived traits. *Flora, 286*, 151976. https://doi.org/10.1016/j.flora.2021.151976

Maden, K. (2004). Plant collection and herbarium techniques. *Our Nature, 2*(1), 53-57. https://doi.org/10.3126/on.v2i1.327

Panigrahi, G. (1960). Pteridophytes of the Eastern India: I. Enumeration of the Species Collected and their nomeclature. *Nelumbo: The Bulletin of the Botanical Survey of India*, 2(3-4), 309-314.

Peck, J. H., & Buck, W. R. (1978). The Selaginella apoda complex in Iowa [Pteridophyta]. *American Fern Journal, 68*, 29.

PPG I. (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
Roy, H., & Borthakur, S. K. (2011). Taxonomic studies on Selaginellaceae of Assam, India. *Recent Studies in Biodiversity and Traditional Knowledge in India*, 101-107.
Schulz, C., Little, D. P., Stevenson, D. W., Bauer, D., Moloney, C., & Stützel, T. (2010). An overview of the morphology, anatomy, and life cycle of a new model species: The Lycophyte *Selaginella apoda* (L.) Spring. *International Journal of Plant Sciences, 171*(7), 693-712. https://doi.org/10.1086/654902
Shalimov, A. P., Wu, Y.-D., & Zhang, X.-C. (2019). A taxonomic revision of the genus *Selaginella* (Selaginellaceae) from Nepal. *PhytoKeys, 133*, 1-76. https://doi.org/10.3897/phytokeys.133.37773
Singh, S. K, Yadav, B. B., Srivastava, M., Shukla, P. K., & Srivastava, G. K. (2014). Micro-morphology of *Selaginella megaspores* from India. *Grana, 53*(3), 197-220. https://doi.org/10.1080/00173134.2014.919356
Singh, S. K., Shukla, P. K., & Dubey, N. K. (2020). *Selaginella odishana* (Selaginellaceae: Lycopodiophyta), a new species from Odisha, Eastern Ghats of India. *Kew Bulletin, 75*(3), 44. https://doi.org/10.1007/s12225-020-09897-1
Soják, J. (1992). Generische Problematik der Selaginellaceae. *Preslia, 64*, 151-158.
Spring, F. A. (1840). Flora Brasiliensis. *Brasilia, 1*(2), 1-119.
Spring. (1838). Flora oder Botanische Zeitung: welche Recensionen, Abhandlungen, Aufsätze, Neuigkeiten und Nachrichten, die Botanik betreffend, enthält. *Flora, 21*, 218-224.
Triana-Moreno, L. A. (2005). Helechos y plantas afines de Albán (Cundinamarca): El bosque subandino y su diversidad.
Valdespino, I. A., López, C. A., Ceballos, J., Palacios, J. M., & Slippey, T. (2022). *Selaginella ophioderma* (Selaginellaceae–Lycopodiophyta), a tropical rainforests new species from the Eastern slopes of the Andes mountains of northwestern South America in Colombia, Ecuador and Peru. *Nordic Journal of Botany, 2023*(3), 3411. https://doi.org/10.1111/njb.03411
Walton, J., & Alston, A.H.G. (1938). Lycopodiinae. In F. Verdoorn, A. H. G. Alston, I. Andersson-Kottö, L. R. Atkinson, H. Burgeff, H. G. Buy, C. Christensen, W. Döpp, W. M. Docters Leeuwen, H. Gams, M. J. F. Gregor, M. Hirmer, R. E. Holttum, R. Kräusel, E. L. Nuern-Bergk, J. C. Schoute, J. Walton, K. Wetzel, S. Williams, H. Winkler & W. Zimmermann (Eds.), *Manual of Pteridology* (pp. 500-506). New York, UK: Springer Dordrecht. https://doi.org/10.1007/978-94-017-6111-6_17
Wei, H.-J., Chen, B., Fang, S. L., & Zhou, X. M. (2023). *Selaginella austro-orientalis* (Selaginellaceae), a new species from Southeast China. *Phytotaxa, 579*(2), 87-97. https://doi.org/10.11646/phytotaxa.579.2.2
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
Zhang, X.-C., Shalimov, A. P., Kang, J.-S., & Zhang, M.-H. (2020). *Selaginella subvaginata* (*Selaginellaceae*), a new spikemoss from China. *Journal of Species Research, 9*(3), 221-232.
Zhou, X. M., & Zhang, L. B. (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