

Selaginella wakkainii: A new species from Longding District of Arunachal Pradesh, India

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Abstract

We describe a new species of the genus *Selaginella* from Arunachal Pradesh. The proposed taxon is collected from hill slopes of Wakka, a town in Longding district of Arunachal Pradesh, India. The described species is based on variation in spore morphology and features of median leaves. The variation recorded in spore morphology came into light when freshly collected samples were analysed under an electron microscope. The species is morphologically distinct and is very close to two species *i.e.*, *S. reticulata* and *S. odishana*. Taxonomic keys and a table are added to separate and compare the three species respectively. Diagnosis, description and relevant photo plates are provided for easy identification of the species.

1. Introduction

The genus *Selaginella* P. Beauv (*Selaginellaceae*) is widespread representing about 800 species throughout the world (Liu et al. 2022; Valdespino et al. 2022; Yu et al. 2022). India is represented by 59 species (Jenkins et al. 2016; Singh et al. 2020). The state of Arunachal Pradesh is represented by 25 species (Jenkins 2016; Soni et al. 2021; Aran & Roy 2022). Routine field survey as a part of our ongoing work on the family Selaginellaceae in the state led to the collection of an interesting population belonging to the family from inclined hill slopes in Wakka region lying within Longding district in Eastern most region of Arunachal Pradesh near to Myanmar Border. Based on the careful examination of the sample, an inspection of pertinent literatures (Spring 1843; Dixit 1985; Dixit 1992; Singh et al. 2014; Zhou et al. 2015; Jenkins et al. 2016; Wang et al. 2018; Shalimov et al. 2019; Singh et al. 2020), and consultation of virtual herbaria *i.e.*, K, NYBG, GBIF (<https://www.gbif.org>) etc. we confirmed that the present collected plant belong to undisclosed species which is having a close affinity to *S. odishana* and *S. reticulata*. Therefore, it is described and titled as new to botany.

2. Materials And Methods

The study is based on plant exploration to the Longding district of Arunachal Pradesh to collect the samples of *Selaginellaceae* during 2021. Standard technique was followed for preservation and herbarium preparation (Jain & Rao 1977; Maden 2004). Microscopic studies carried out using compound microscopes (COSLAB ZSM-115 LED and Carl ZEISS Axiostar plus (100...240 V AC). Scanning Electron Microscope (SEM) study on spores is carried out using "Carl ZEISS Sigma 300VP" at Central Instrumentation Facility (CIF) Gauhati University, Guwahati, Assam. International herbaria (GBIF, NYBG, Y, K etc.), regional herbaria (ARUN, ASSAM, CAL) and relevant literatures are consulted (Panigrahi 1960; Dixit 1984; Dixit 1992; Ghosh et al. 2004; Singh et al. 2014; Zhou et al. 2015; Fraser-Jenkins et al. 2016; Wang et al. 2018; Mandal et al. 2020; Singh et al. 2020; Yu et al. 2022; Valdespino et al. 2022) for identification.

3. Result

Type

INDIA. Arunachal Pradesh, Longding, Wakka, 20.01.2021, K. Aran 164. (holotype ARUN, isotype ARUN)

3.1. Diagnosis

Selaginella wakkainii is similar to *S. reticulata* and *S. odishana*, but *S. wakkainii* is easily distinguishable by its elliptic median leaves vs ovate or lanceolate (Spring 1843; Yadav et al. 2011; Shalimov et al. 2019; Singh et al. 2020), ventral sporophyll with acute apex vs cuspidate or acuminate apex (Spring 1843; Yadav et al. 2011; Shalimov et al. 2019; Singh et al. 2020), megaspore micro sculpture with porous and microfilaments vs spinulate or psilate micro sculpture, microspore ornamentation psilate with numerous gemmae vs verrucate or psilate without gemmae (Spring 1843; Yadav et al. 2011; Shalimov et al. 2019; Singh et al. 2020). Features of all the three species viz., *S. wakkainii*, *S. reticulata* and *S. odishana* has been summarized in Table.1.

3.2. Description

Plant minute, creeping, trailing, stramineous brown on drying, alternately branched from the base. *Rhizophore* hard when mature, born above the axillary leaf and growing towards the ventral, 0.5–1.5 cm in length. *Stem* 2–3.5 cm long, 0.2–0.9 mm in diameter, tufted, rooting from the axil up to basal half of the stem, decumbent. Branches alternate, 0.2–0.7 cm apart. *Leaves* heteromorphic, distichous all along the main stem. *Lateral leaf* 0.57–0.78×1.07–1.45 mm, ovate, subacute apex, rounded base; basiscopic base entire; acroscopic base slightly dentate (Fig. 1.f); leaf epidermal cells spherical, oval, rectangular, surrounded with 2–3 layers cells running parallel to the epidermis. *Axillary leaf* 0.72–0.97×1.10–1.61 mm, ovate, obtuse apex, oblique base, entire margin (Fig. 1.d); leaf cells spherical, oval, square, rectangular-hexagonal; well-defined midrib surrounded by 2–3 layers of cells parallel to the epidermis. *Median leaf* 0.41–0.87×0.75–1.48 mm, elliptic, acute apex, oblique base, serrated margin (Fig. 1g); leaf epidermal cells spherical-quadrangular with a layer of cells parallel to the epidermis. *Strobili* 0.2–0.5 cm long, resupinate, 1–2 born at each branch terminal. Sporophylls dimorphic, dorsal sporophylls 0.5–0.66×1.08–1.32 mm, ovate-oblong, acute-obtuse apex, rounded base, serrated margin, laminar flap with indistinct dentate margin (Fig. 1h). *Ventral sporophylls* 0.55–0.79×0.91–0.97 mm, ovate, acute apex, rounded base, dentate at apices, ciliate at the base (Fig. 1.i); epidermal cells elongated. *Megaspore* yellow, globose, trilete, flattened straight laesurae extending 3/4th of the length to the equator, foveolate ornamentation, scabrate microsculpture having microfilaments, 110–150×114–240 µm (Fig. 3.e-h). *Microspore* orange, triangular, trilete, flattened curved laesurae extending 3/4th of the length to the equator, gemmate ornamentation, with unevenly distributed spherules of 226–771 nm in diameter, clavate micro sculpture, 42.85–49.98 µm (Fig. 4.e-h).

3.3. Distribution

Two population of the new species which were lying few meters away from each other were found thriving on the mud wall in the hill slopes of forest between Wakka town and Chongkhaw Village of Longding district in Arunachal Pradesh. India: Arunachal Pradesh, Longding District, Wakka Town.

3.4. Etymology

The specific designation of the proposed species is named after the type locality Wakka town in Longding district of Arunachal Pradesh. Wakka is a small town in longding district of Arunachal Pradesh, resided by people of Wancho tribe. The district is bordered by the Country Myanmar to its south, the State Nagaland to its West, the District Tirap to its East and the State Assam to its North.

3.5. Notes

The proposed species is known only from Wakka in the Longding district of Arunachal Pradesh, North East India. A tiny population of species is found growing on the slopes in the forest of Wakka at an altitude of 1180 ^m. *S. wakkainii* may be endemic to India.

3.6. Discussion

Different species with the same spore morphology within the genus was never recorded as evidenced (Korall & Taylor 2006; Singh et al. 2014; Singh et al. 2015; Wang et al. 2018; Yan et al. 2016; Zhou et al. 2015), which indicates the significance of spore morphology in the systematic of the genus. However, very less study has been carried out on spore morphology of the genus in India except Singh et al. (2014), Singh et al. (2015), Singh et al. (2020), Aran et al. (2022). Megaspores and microspores examination were found significant in distinguishing different taxa under the genus (Singh et al. 2014; Zhou et al. 2015; significant in distinguishing different taxa under the genus (Singh et al. 2014; Zhou et al. 2015; Yan et al. 2016; Wang et al. 2018; Singh et al. 2020; Chun 2021; Aran et al. 2022). Zhou et al. (2015) considered spore features along with molecular study and macro morphology to significantly classify *Selaginella* into six sub-genera (1. *S. subg. Selaginella*, 2. *S. subg. Boreoselaginella*, 3. *S. subg. Pulviniella*, 4. *S. subg. Ericetorum*, 5. *S. subg. Heterostachys*, and 6. *S. subg. Stachygynandrum*). The proposed taxa can be characterized under *S. subgenus Stachygynandrum* in Section 4. *Selaginella* sect. *Heterophyllae* because of the presence of sub-erect, creeping stems, ventral rhizophores, dimorphic leaves, resupinate strobili with dimorphic sporophylls in accordance with Zhou et al. 2015 & Weststrand & Korall (2016b).

S. reticulata has a synonym *S. nairii* (Jenkins et al. 2017). The species *S. nayarii* was described by Dixit (1985) as new species and mentioned the name *S. nairii* in the nomenclatural type (CAL0000063573). Later works mentioned the name *S. nairii* (Nisha & Nampy 2008, Singh et al. 2014; Jenkins et al. 2016 and GBIF portal), probably a spelling mistake. Singh et al. (2014) studied the megaspore morphology of 20 species of *Selaginella*, where *S. nairii* was also included, since the study was only on megaspore morphology, other features of the examined samples were not mentioned by Singh et al. (2014) that raise question at least on the identity of *S. nairii*. The species that was mentioned as *S. nairii* (Singh et al. 2014) probably belong to the present new taxon, as the megaspore morphology of the present new taxon matches the study of Singh et al. (2014).

3.7. Conservation

Selaginella wakkainii is known only from one location, only two population was found lying few meters away from each other. More study is required to ascertain its conservational status.

3.8. Taxonomic Key to the species

1a. Median leaves elliptic, megaspore micro sculpture porous with micro filaments.....*S. wakkainii*

1b. Median leaves lanceolate, megaspore micro sculpture non-porous and without micro filaments.....2

2a. Microspore ornamentation verrucate.....*S. reticulata*

2b. Microspore ornamentation psilate.....*S. odishana*

Declarations

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Conflict of interest

The authors declare no conflict of interest.

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Tables

Table.1.Comparison of *Selaginella wakkainii*, *Selaginella reticulata* and *Selaginella odishana*. Character information is based on present study.

Sl. No.	Characters	<i>S. wakkainii</i> Aran & Roy	<i>S. reticulata</i> (Spring 1843; Yadav et al. 2011; Shalimov et al. 2019)	<i>S. odishana</i> (Singh et al. 2020)
I	Rhizophore	Thin, soft-hard, born above the axillary leaf upto basal half	Thin, soft, restricted to base	Straminous when dry, restricted to the base.
II	Stem	Hard, prostrate, tufted, 2-3.5 cm long, 0.2-0.9 mm in diameter,	Erect, soft, 4-8 cm long, 0.1-0.2 mm in diameter.	Sub-erect. 2 - 5 cm long, 1.5 - 2.1 mm in diam
III	Lateral leaf	Ovate-elliptic, apex subacute, base rounded, slightly serrated margin, 0.57-0.78×1.07-1.45 mm.	One sided, apex rounded, base oblique, serrated margins, 0.70-0.96×1.45-1.89 mm. (Fig..2.f)	Ovate to lanceolate, apex acute, base obtuse, serrated margins and ciliated base, 1.9 - 2.4×1.1 - 1.6 mm.
IV	Axillary leaf	Ovate, apex obtuse, base oblique, margins slightly serrated, 0.72-0.97×1.10-1.61 mm.	Elliptic-ovate, apex rounded - acute, base rounded, margins serrated, 0.48-0.94×1.26-1.80 mm. (Fig.2.g)	Ovate-lanceolate, apex acute, base obtuse, margins serrate and minutely ciliate at base, 2.1 - 2.6 × 1.1 - 1.5 mm
V	Median leaf	Elliptic, apex acute, base oblique, margin serrated, 0.41-0.87 × 0.75-1.48 mm	Ovate-Lanceolate, apex cuspidate-acuminate, base rounded, margin serrated, 0.26-0.34 × 0.72-1.04 mm. (Fig.2.h)	Lanceolate, apex acute, base oblique, margin entire-serrate, 1.1 - 1.2 × 0.4 - 0.6 mm.
VI	Strobili	1-2 born at apex of each branch terminal, 0.2-0.5 cm in length,	1-2 born at the apex of each branchlets, 0.20.9 cm in length, (Fig.2.e)	1 or 2 occasionally at each branchlets, 4 - 8 × 2.5 - 3 mm,
VII	Dorsal sporophyll	Ovate-oblong, apex acute-obtuse, base rounded, margin serrated, 0.5-0.66×1.08-1.32 mm.	Cordate-deltoid, acuminate, rounded, margins blunt dentate, 0.52-0.74×0.33-0.42 mm.(Fig.2.k)	ovate-oblong, bases obtuse, apex sub-acute, margins entire-serrate, 2.4-2.6×1-1.4 mm.
VIII	Ventral sporophyll	ovate, acute, rounded, apical dentate, base ciliated, 0.55-0.79 × 0.91-0.97 mm	Deltoid, cuspidate, rounded/obtuse, dentate, 0.44-0.45 × 0.95-1.13 mm. (Fig.2.i)	ovate, bases obtuse, apex acuminate, margins ciliate-serrate 1.1-1.3×0.7-1 mm.
IX	Megaspore	Globose, trilete, faveolate ornamentation, porous micro	Globose-sub globose, papillate-irregular verrucae, spinulate microsculpture. (Fig.3.a-d).	Sub-rounded, trilete, faveolate ornamentation, smooth microsculpture.

sculpture having
micro filaments

X	Microspore	Psilate with numerous gemmae on distal surface, clavate micro sculpture.	Verrucate ornamentation on distal surface, irregular interconnected verrucae, verrucae microsculpture (Aran et al. 2022) (Fig.4.a-d)	Sub-rounded, trilete, psilate ornamentation with no gemmae..
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Figures

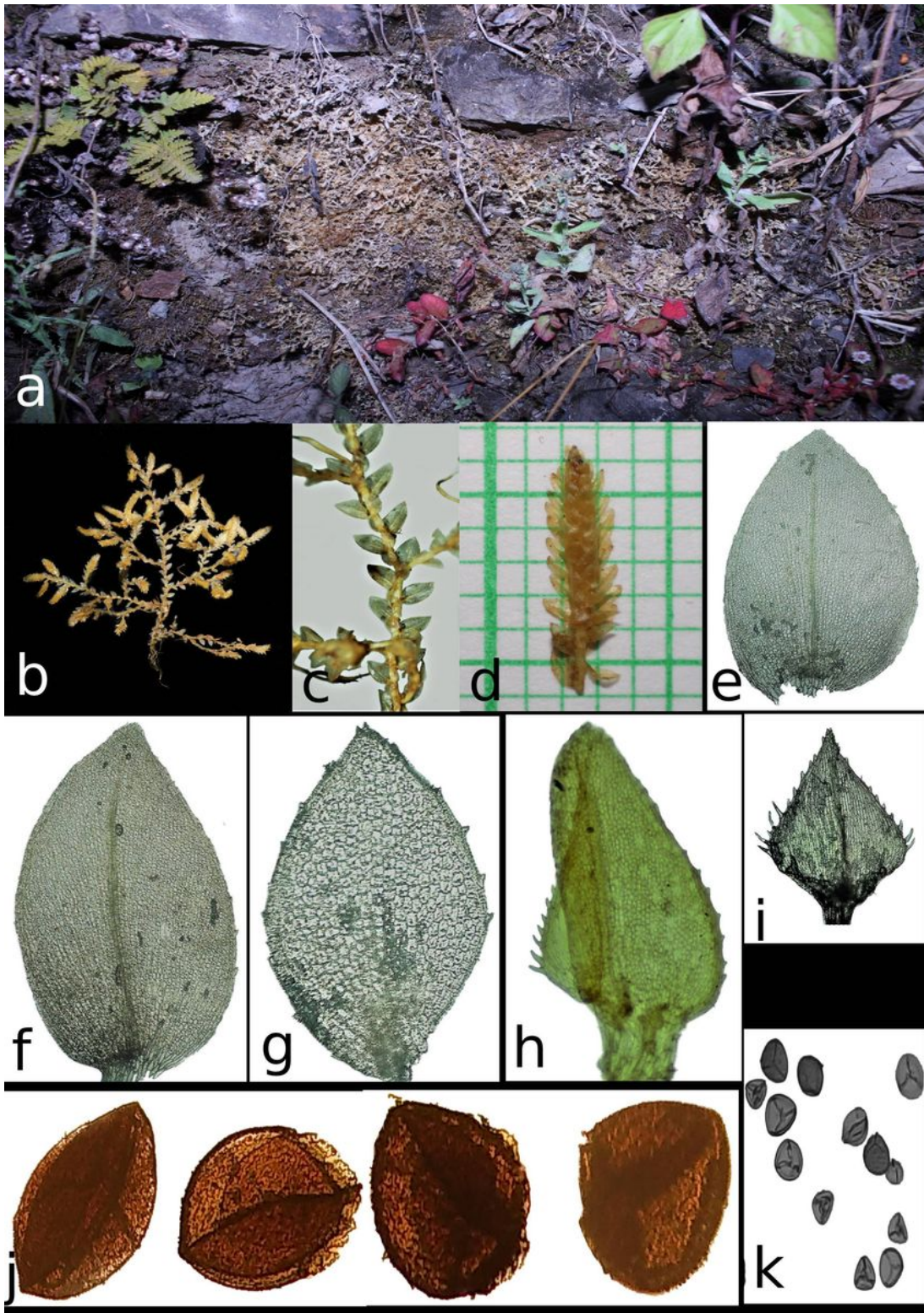


Figure 1

a. Habitat, **b.** Morphology, **c.** leaf arrangement, **d.** Strobili, **e.** Axillary leaf, **f.** Lateral leaf, **g.** Median leaf, **h.** Dorsal sporophyll, **i.** Ventral sporophyll, **j.** Megaspore, **k.** Microspore.

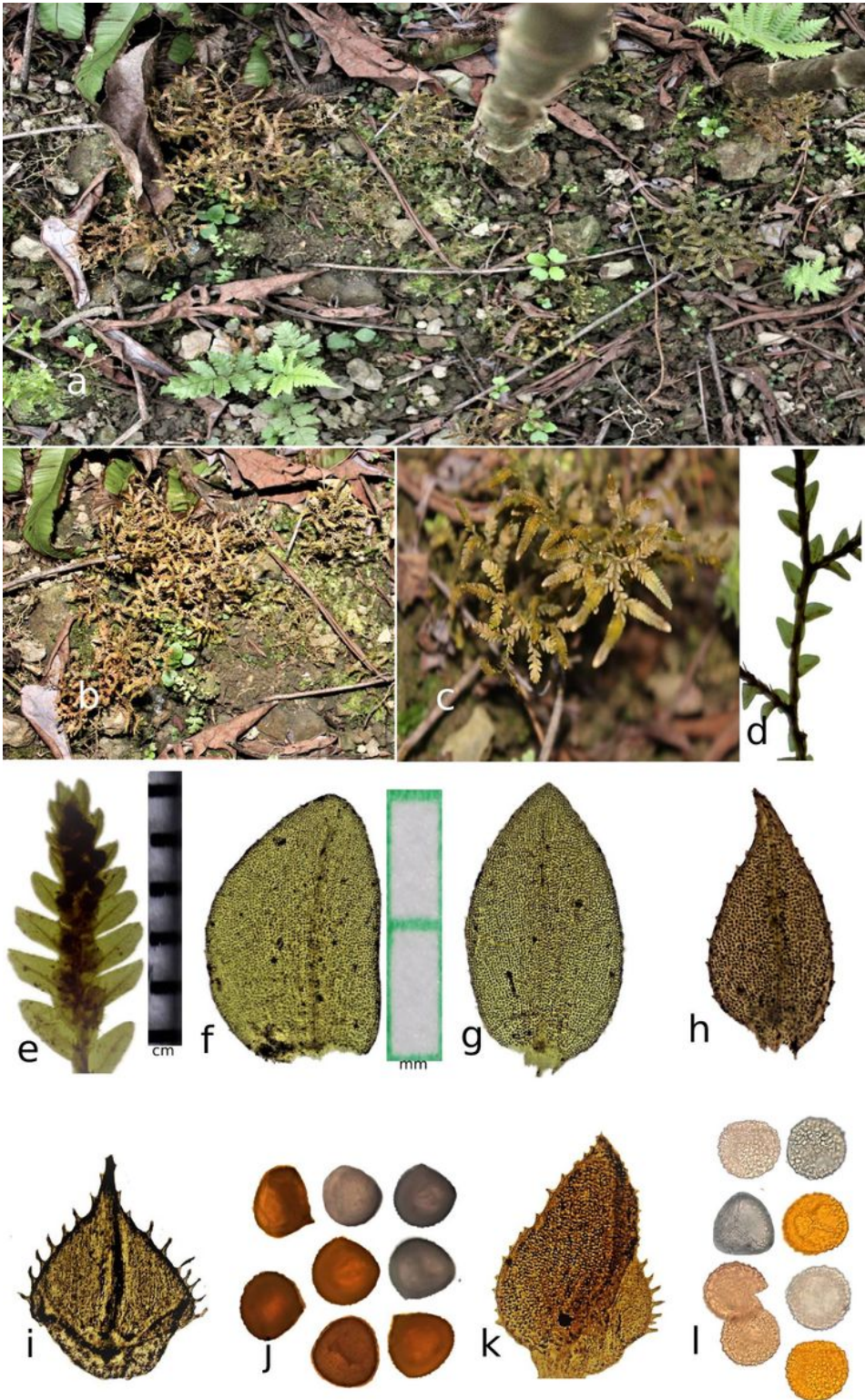


Figure 2

a. Habitat, b&c. Morphology, d. Leaf arrangement, e. Strobili, f. Lateral leaf, g. Axillary leaf, h. Median leaf, i. Ventral sporophyll, j. Megaspore, k. Dorsal sporophyll, l. Microspore.

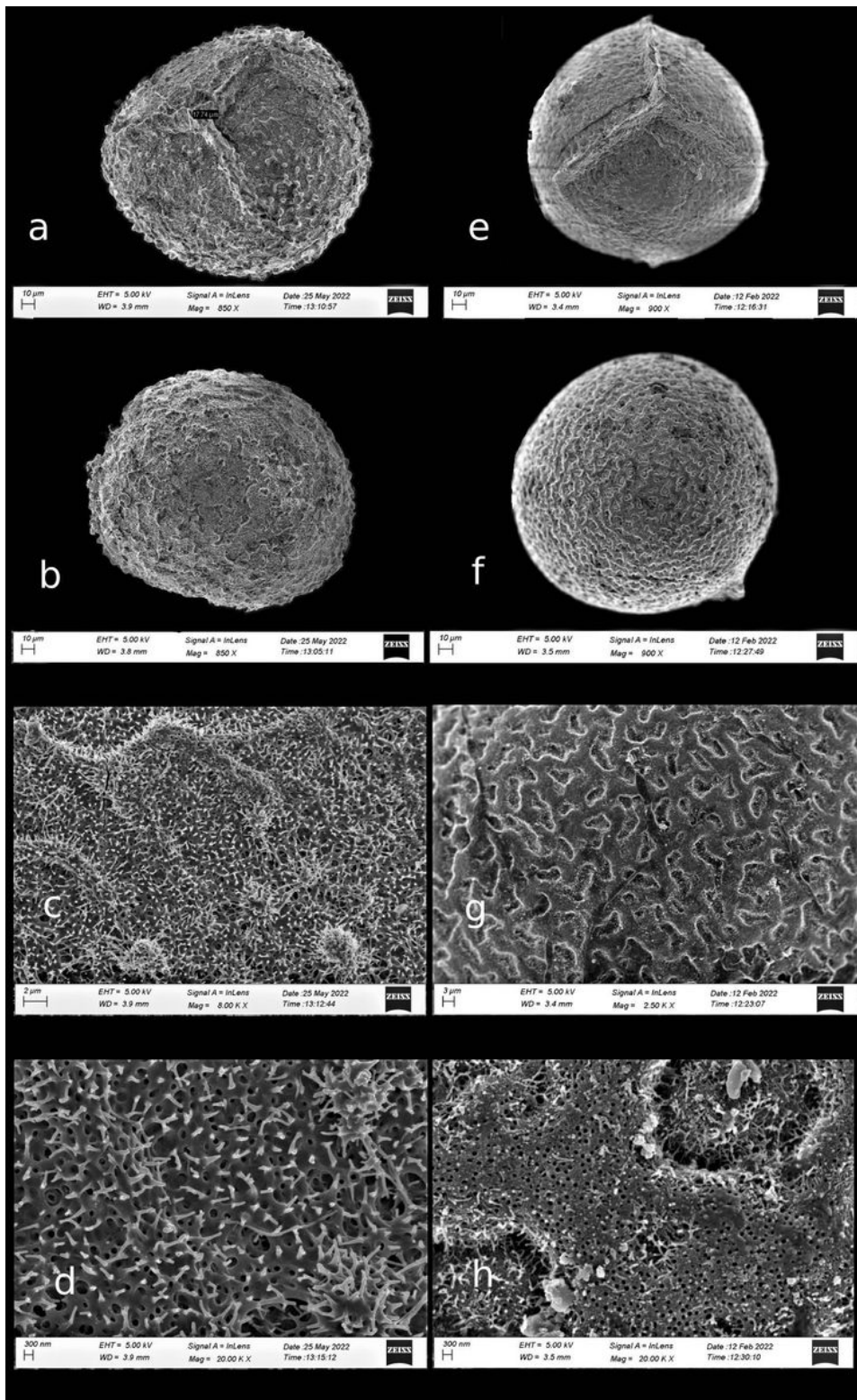


Figure 3

SEM Photomicrographs of *Selaginella* megaspore. a-d. *Selaginella reticulata*. a. Proximal surface, b. Distal surface, c-d. Magnified portion to show infrastructural detail. e-h. *Selaginella wakkainii*. e. Proximal surface, f. Distal surface, g-h. Magnified portion to show infrastructural detail.

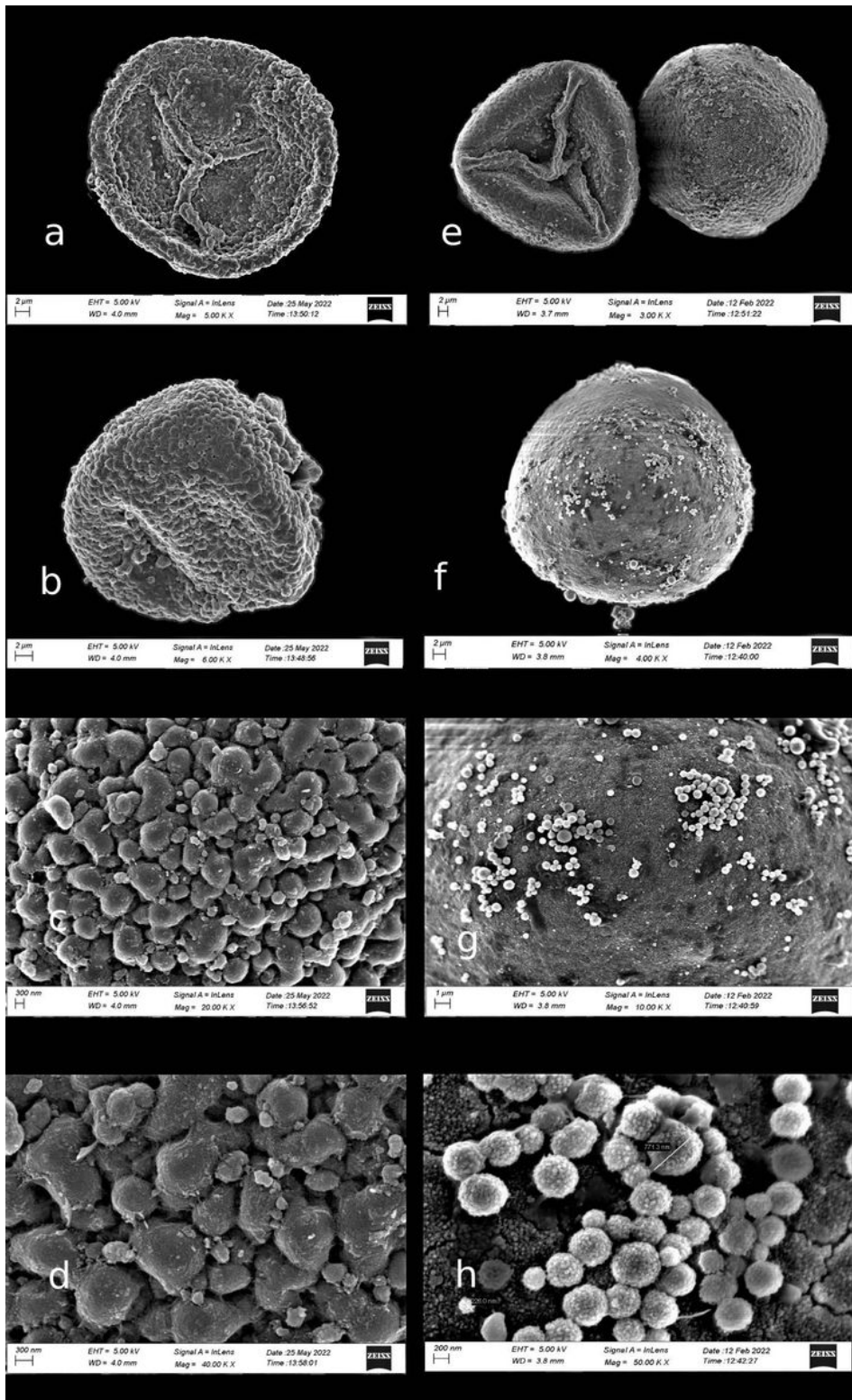


Figure 4

SEM Photomicrographs of *Selaginella* microspore. a-d. *Selaginella reticulata*. a. Proximal surface, b. Distal surface, c-d. Magnified portion to show infrastructural detail. e-h. *Selaginella wakkainii*. e. Proximal surface, f. Distal surface, g-h. Magnified portion to show infrastructural detail.

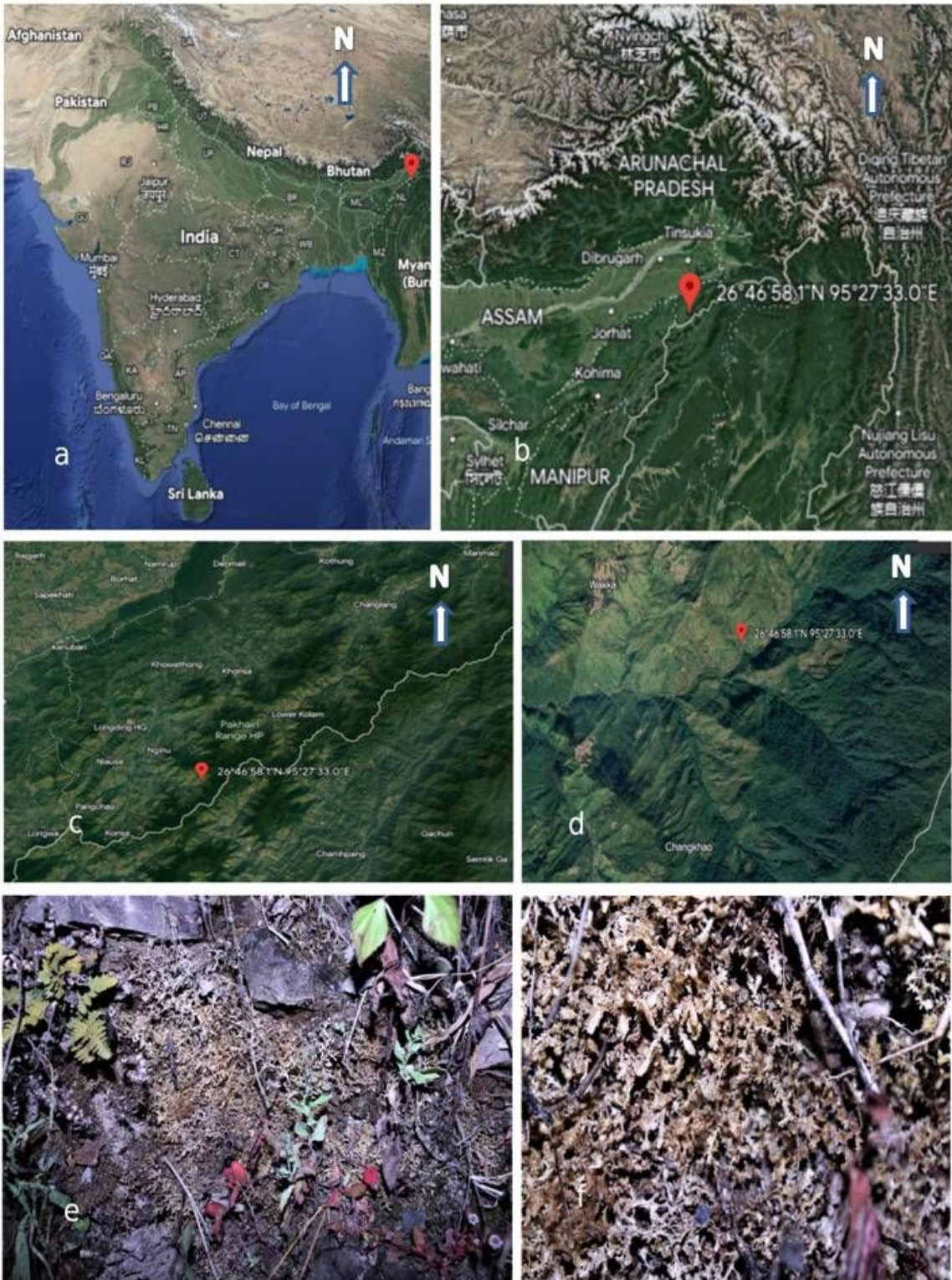


Figure 5

Selaginella wakkainii. Map images extracted from <https://earth.google.com/web/>, a. Map of India showing the type locality of the species; b. A map of Arunachal Pradesh showing the type locality of the species; c. A district map showing the locality of the species, d. A part of hill slope of the forest in Wakka. e&f. Habitat image of the species.