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## *Diplazium mettenianum* (Miq.) C.Chr. (Woodsiaceae)- An addition to the pteridophyte flora of India from Arunachal Pradesh

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**ABSTRACT**

*Diplazium mettenianum* (Miq.) C.Chr. is reported for the first time in the flora of India. This species is distinguished from others by its long creeping rhizome, toothed pinna-margins, attenuated acuminate pinna-apex and shallow, rounded-truncate pinna-lobes. Following IUCN guidelines, the threat status of this species in India is assessed here as critically endangered. A description of the species, data on its phenology, geographical distribution, a distributional map for India and comparison with closely related species are included.

**Keywords:** Arunachal Pradesh, Morphology, Lower Subansiri

**1. INTRODUCTION**

The athyroid fern family, Woodsiaceae or alternatively Athyriaceae, contains 15 genera and about 700 species that are found almost everywhere, but species are most diverse in temperate and mountainous tropical areas (Kramer and Green, 1990). The majority of species are terrestrial, growing in forested areas or on rocks and cliffs. The genus *Diplazium* Sw., also known as a twin sorus fern, contains c. 350 species (PPG - I, 2016) that are mostly found in the old-world tropics and subtropical regions (Kramer and Kato, 1990). In India, the genus *Diplazium* is represented by 45 species and 4 sterile hybrids (Fraser-Jenkins et al., 2018) of them 10 species are present in the Western Himalaya (Khullar, 2000); 38 species, three hybrids and one variety in North East India (Fraser Jenkins et al., 2018) and 10 species in the Western Ghats of South India (Benniamin and Sundari, 2020).

During a botanical exploration tour to Tale Wildlife Sanctuary, near Hapoli, in Arunachal Pradesh, India, two of the authors (AKS and AK) collected an unrecognized *Diplazium* species (Figure-1). CRFJ sent our photographs of it to Dr. S.-Y. Dong, South China Botanical Institute, Guangzhou, who recognized it as the Chinese species *Diplazium mettenianum* (Miq.) C.Chr. is a polymorphic fern occurring from Japan to Taiwan, south

China, Vietnam and Thailand (Wang et al., 2013). *D. mettenianum* varies considerably in developmental growth form, particularly in the depth of lobing of the pinnae, which can be very shallowly lobed, to the lower ones almost pinnatifid. Varieties described in the past from Japan are not of taxonomic significance.

*D. mettenianum* has not previously been reported from or collected in India, but is reported a new here. Morphological comparison between *Athyrium atratum* Bedd., *Diplazium sylvaticum* (Bory) Sw. and *Diplazium mettenianum* is provided here (Table 1).

**Table 1** Morphological comparison between *Athyrium atratum* Bedd., *Diplazium sylvaticum* (Bory) Sw. and *Diplazium mettenianum*.

S. No	Characters	<i>Athyrium atratum</i>	<i>Diplazium sylvaticum</i>	<i>Diplazium mettenianum</i>
1.	Rhizome	Erect, tufted, furnished with wiry roots	Short-erect	Long creeping
2.	Scale	Pale colored, narrowly lanceolate	Ovate-lanceolate, long acuminate, margin shortly, sparsely toothed, uniformly dark in color.	Dark brown to black, shiny, narrowly lanceolate; minutely toothed at margin.
3.	Stipe	30-45 cm long, tramineous, glabrous throughout, grooved adaxially	40-50 cm long, tufted, pale brown above, dark at base, sparsely scaly throughout, grooved adaxially.	40 cm, 0.5 cm in diam., stout, glossy, shiny brown and sparsely scaly at base, non-puberulent on both surfaces, not grooved.
4.	Lamina	Ovate lanceolate, 30-50 cm in length	Ovate or ovate lanceolate, up to 55 cm	Ovate-lanceolate or triangular lanceolate, hardly 50 cm.
5.	Pinnae	Pinnae up to 15 pairs, basal pair sub-opposite, completely opposite above, stalked, largest pinna oblong acuminate, apex acuminate, base oblique, margin unequal serrate, otherwise rounded apex in smaller one, upper pinnae smaller in comparison to primary and secondary pinnae, sessile, pinnatifid	Pinnae up to 20 pairs, sub-opposite to alternate, apart with 0.5 to 0.8 cm stalk; lower pinnae with 2-3 cm long stalk, largest pinna linear-lanceolate, apex acuminate, base cuneate, margin usually serrate at apex, entire in the rest part, upper pinnae smaller, sessile, pinnatifid	Pinnae up to 10 pairs, alternately sub-opposite on lower half, distinctly stalked, attenuately acuminate at their apices, broadly cuneate at base, sub-entire to serrate, upper pinnae rather suddenly becoming smaller, adnate and gradually decurrent at their bases, acuminate at apex, subsessile at upper 1/3 portion
6.	Pinnae obes	The basal one distinctly separate, dimidiate, more cut away at the base and developed just above to 1/3 portion, cut down 1/3-1/2 in to several lobes towards the costae	Edges lobed to about 1/4 distance to costa, oblique, serrate or crenate in the rest.	1/3 way to costa, or more in lower pinnae, oblique, rounded to obtuse, subentire to serrate
7.	Veins	Anadromous with simple pinnate veinlets	With pinnate groups; 3-4 pairs of lateral veins	Isodromous, with many free all simple pinnate veinlets
8.	Veinlets	Basal one pair arising from costae, forked or pinnate in the lobes, reached to near the margin, just below the teeth, apparent abaxially	Parallel to each other, free, reached at the margin	Arising from costae, continuous and reached at the margin

9.	Sori	J-shaped, along the costae with one pair of acroscopic veinlets of each lobe	Along the basal one or two pairs of veinlets, passing about half way to the margin of the pinnae	Linear, medial, slightly curved, ca. 04-06 pairs per pinna lobe and arranged on all veinlets
10.	Indusia	Fugacious	Firm	Persistent, not shriveling

## 2. MATERIALS AND METHODS

Arunachal Pradesh is considered as a phytogeographical gateway of migration for species from the centers of diversity in S.W. China and N. Myanmar along the Himalayan ranges and has been recognized as the 25<sup>th</sup> biodiversity hotspot in the world and harbors a large number of rare, endangered and endemic plant species (Myers et al., 2000). Regular field trips were conducted to various areas of Tale Wildlife Sanctuary, Lower Subansiri District, Arunachal Pradesh, in different seasons from September to March during the years 2019–2021.

Specimens collected were identified partly by CRFJ and partly through consultation of relevant literature and comparing with images of voucher and type-specimens deposited in various herbaria. Geographical coordinates were taken by using a Garmin geographical positioning system (GPS) device and distributional maps were constructed using open-source Quantum geographic information system (QGIS) ver. 3.12.0. Microphotographs were taken by using Olympus stereo microscope SZ61 (New Delhi). The threat status of this species was estimated in accordance with the Guidelines for Using the IUCN Red List Categories and Criteria (Version 14, 2019). The area of occupancy (AOO) was calculated using Geo CAT (Geospatial Conservation Assessment Tool, Bachman et al., 2011), available in <http://geocat.kew.org/>. Plant specimens were processed and prepared accordance with standard herbarium methods (Jain and Rao, 1976) and deposited in the herbarium of the Botanical Survey of India, Arunachal Pradesh Regional Centre, Itanagar (ARUN).

### Taxonomic treatment

*Diplazium mettenianum* (Miq.) C.Chr., Index Filic 1906; 236. Tardieu & Christensen, Fl. Indo-Chine 1940; 7(2):253. Tagawa & Iwatsuki, South E Asian Stud 1967; 5:103. Boonkerd & Pollawatn, Pterid. Thailand 2000; 193. *Asplenium mettenianum* Miq., Ann Mus Bot Lugduno-Batavi 1867; 3:174. *Allantodia metteniana* (Miq.) Ching in Acta Phytotax Sin 1964; 9:51. *Asplenium textorii* Miq. in Cat Mus Bot Lugd-Bat 1870; 126. *Athyrium mettenianum* (Miq.) Ohwi in Bull. Natl Sci Mus Tokyo, 1956; 2(3):100. *Diplazium cavalerii* Christ in Bull. Acad Int Géogr Bot 1904; 3(13):114. (*Diplazium isobasis* Christ in Bull. Herb Boissier 1904; 2(4):618. *Diplazium lohfaunense* C.Chr. in Cat. Pl. Madagasc., Pterid 1932; 68. *Diplazium textorii* Makino in Bot Mag (Tokyo) 1899; 13:31.

### Botanical description

Plant terrestrial, 50–120 cm tall. Rhizome slender, creeping, stout, dark brown to black, about 0.1–1.5 cm diam., densely covered with profuse roots. Stipe-base and stipe scales peltate, concolorous, not clathrate, glossy, dark brown to black, narrowly lanceolate with long tapering, 0.5 cm long, 0.5 mm in width, thickly membranous, margins toothed. Fronds monomorphic, simply pinnate, up to 90 × 20 cm, oblong, apex acute; stipes 40 × 0.5 cm in diam., stout, glossy, shiny brown and sparsely scaly at base, dull stramineous upwards after drying, not grooved, non-puberulent on both surface; rachis straight, similar to stipes; lamina, ovate-oblong lanceolate, truncate at the base, 50 × 20 cm, with 10–13 pairs of lateral pinnae, tapered to a pinnatifid frond-apex, glabrous, dark green, drying almost black; pinnae separate, 10–13 pairs, alternately sub-opposite below, alternate upwards, distinctly stalked, attenuately acuminate at their apices, broadly cuneate at bases, pinnae lobed to 1/3 of the way to the costa, or more in lower pinnae; lobes oblique, rounded to obtuse, sub entire to serrate, upper pinnae rather suddenly becoming smaller, adnate and gradually decurrent at their bases; veins free, pinnate, veinlets arising from costae, isodromous. Sori linear, medial, slightly curved, indusiate, indusia membranous, light brown, not shriveling, persistent (Figure 1 A-G).

### Specimens Examined

India, Arunachal Pradesh, Lower Subansiri District, Ziro Valley, Hapoli Primary Forest, near Pi gate, 27.546 °N & 93.808753 °E, 1580 m, A. K. Soni 42778 & 42779, 09.01.2020, (ARUN); India, Arunachal Pradesh, Lower Subansiri District, Tale Wildlife Sanctuary, Pange Valley, on the way to orchid trail, near to medicinal plants nursery, 27.54913 °N & 93.900626 °E, 1950 m, A. K. Soni 42816, 15.02.2021 (ARUN).

**Distribution**

India (Arunachal Pradesh) (Figure 2), China, Japan, Taiwan, Thailand, Vietnam

**Habitat ecology**

*D. mettenianum* grows under the light tropical evergreen forest floor in the Pange valley range of Tale Wildlife Sanctuary, Arunachal Pradesh at an elevation  $\pm 1500$  m. Near to Pi gate, on the way to Zoram top at Hapoli, a small evergreen forest patch crossed by a motor road and very high interference of the area faced the great threatening of the plant diversity due to road construction. Countable individual plants of *D. mettenianum* are growing along the sides same road localities with other associated fern species such as *Coniogramme fraxinea* (D. Don) Fée ex Diels, *Diplazium esculentum* (Retz.), Sw. *Diplazium donianum* (Mett.) Tardieu, *Diplazium tibeticum* (Ching & S.K. Wu), *Arachniodes assamica* (Kuhn) Ohwi, *Arachniodes conifolia* (T. Moore), *Dryopteris atrata* (Kunze) Ching, *Dryopteris lepidopoda* Hayata, *Polystichum pseudotsus-simense* Ching, *Polystichum punctiferum* C. Chr., with some other epiphytic ferns species like *Asplenium phyllitidis* D. Don, *Vittaria doniana* Mett. Ex. Hieron, on unknown host tree species, grasses and angiosperms.

**Threat status for India**

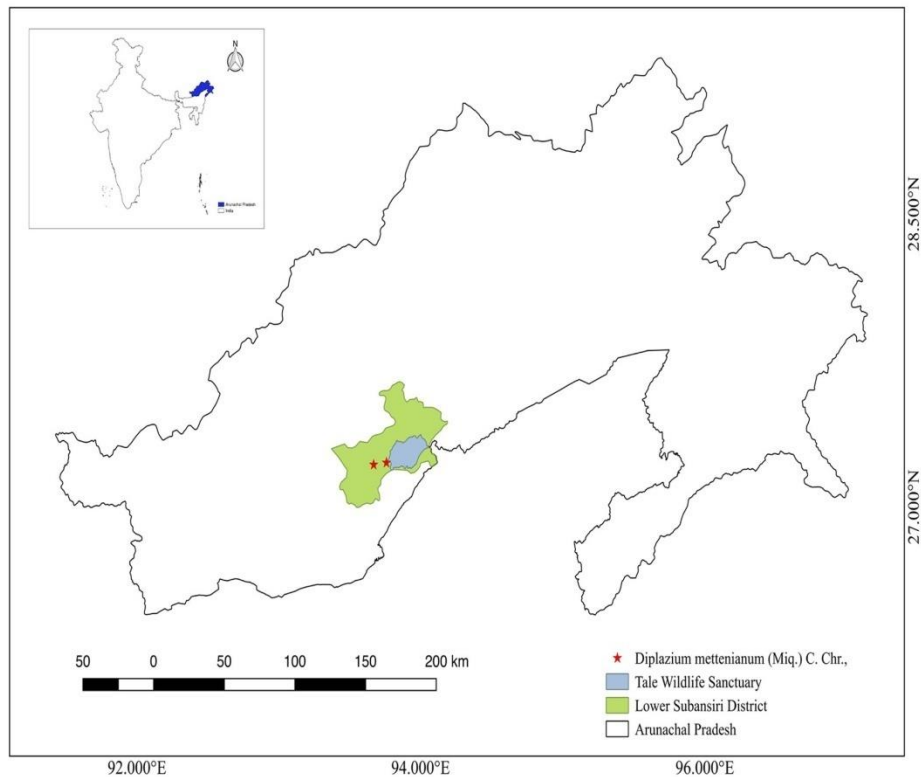
Critically Endangered Species (CES), (B2ab (v); D). The threat level of this species was assessed based on its geographical range and the number of mature individuals present in the population in India. This species is known from only one location in India (Lower Subansiri District, Arunachal Pradesh) (Criterion – B (a)). Active search for the species at additional localities in India has been unsuccessful. Based on detailed inventories, the number of mature individuals is estimated to be 10–15 (Criterion–D). Population size was estimated by direct observation and the area of occurrence (AOO) was estimated to be 8 km<sup>2</sup> (Criterion – B2). A decline in the number of mature individuals was observed between 2020 and 2021 (Criterion – B, b (v)). As a result, this species is primarily placed under the Critically Endangered (B2ab (v); D) category in India, though it is common in much of its range elsewhere.

**Conservation measures**

The geophytic habit of *D. mettenianum*, its adaption to humid areas of the forest under floor and its association with other plant species that together to form dense populations but the scarcity of records might be attributed with rarity of the species. At present the depicted species is collected only from single one gathering of Hapoli and Tale Wildlife Sanctuary in Lower Subansiri district of western Arunachal Pradesh and observed only 8-15 individuals within 8 km<sup>2</sup> area. However, other similar areas of these regions are yet to be explored wholly and it presumes that the species might be spread in similar ecological conditions. The habitat of the species is more close vicinity of motor road and cultivation lands. This population is facing great threat due to habitat destruction and road widening activities. Hence the attention needed for urgent conservation measures to protect the population from the erosion of rare *D. mettenianum*. Thus, more floristic surveys are required to determine and document the full range of distribution of for the same.



**Figure 1** A-C: *Diplazium mettenianum* (Miq.) C.Chr., D. Long Creeping Rhizome; E-Sori arrangement, F-G: Rhizome scale (Photo credit: Soni, AK).



**Figure 2** Showing localities of Lower Subansiri District and Tale Wildlife Sanctuary in Arunachal Pradesh where *Diplazium mettenianum* (marked in red star) were reported (Map credit: Benniamin, A).

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### Author's contribution in the study

Soni AK & Kumar A, have collected the plant specimens; Freser-Jenkins CR, identified the specimen with the help of Dr. Dong, S. Y. (South China Botanical Institute, Guangzhou); Soni AK & Freser-Jenkins CR, have finalized the manuscript and Benniamin A, provided the distributional map for the mentioned taxa.

### Ethical approval

*Diplazium mettenianum* (Miq.) C.Chr. (Woodsiaceae)- from Arunachal Pradesh was used in the study. The ethical guidelines for plants & plant materials are followed in the study for sample collection & identification.

### Funding

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### Conflicts of interests

The authors declare that there are no conflicts of interests.

### Data and materials availability

All data associated with this study are present in the paper.

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