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Studies on the Genus *Ophioglossum* L. in Pachmarhi Biosphere Reserve, Madhya Pradesh-India

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ABSTRACT: The morphotaxonomy, species composition, distributional pattern and ecological studies of the genus *Ophioglossum* L. (Adder's tongue) in Pachmarhi Biosphere Reserve (PBR) of Madhya Pradesh have been accomplished. *Ophioglossum polyphyllum* A. Braun *ex* Seubert have been recorded for the first time which is a new addition to the pteridophytic flora of PBR. However, *Ophioglossum gramineum* Willd, *Ophioglossum nudicaule* L. and *O. reticulatum* L. has shown extended range of trans-geographical distribution within the Biosphere Reserve. The taxonomic characters, diversity between and within the species, and habitat of growth across the Biosphere Reserve have been extensively discussed.

KEY WORDS: *Ophioglossum* L., New addition, Taxonomy, Fern, Pteridophytes, Flora, Pachmarhi Biosphere Reserve (PBR), Madhya Pradesh, India.

INTRODUCTION

The PBR lying between 20°10' to 22°50' N latitude and 77°45' to 78°56' E longitude constitutes a major component of central Indian subtropical evergreen forest. The PBR, a composite of Satpura mountains ranging from 320-1352 meter altitude pertains 50-230 cm annual rainfall having large deep ravines between two steep mountains. This unique geographical architecture has christened more specific and distinct microclimate which has led the PBR to be biological richest territory next to the Himalayas and peninsular India. The Biosphere Reserve composed of three districts Hosangabad, Betul and Chindwara invariably provide auspicious distinct climatic conditions for frequent and continuous growth of plant diversity particularly pteridophytes. In India, the history to the study of pteridophytes goes dates back since the time of Clarke (1880), Beddome (1883) and Hope (1904) who largely emphasized the species composition of the pteridophytes in northern, southern and western India respectively. These studies were continued by Champion (1936), Chatterjee (1940), Chandra (1982, 1998), Chandra and Kaur (1987, 1994), Chandra (2000), Dixit (1984), Nayar (1970), Nayar and Kaur (1974), Singh and Panigrahi (2005) to provide pteridophytic wealth in different regions of Indian sub-continent. Except few scattered contributions *viz*. Gamble (1892), Graham (1915), Tiwari (1964), Panigrahi and Dixit (1966), Singh and Roy (1969), Singh (1970) and Dixit (1988, 1989), the Central Indian region particularly Satpura mountains range of PBR could not receive proper attention of pteridologists for documentation of pteridophytic wealth.

The first effort to enlist the pteridophytic diversity in Pachmarhi Biosphere Reserve was made by Bir and Vasudeva (1972, 1973) thirty five years back who chronicled 73 species altogether with fern and fern-allies. Subsequently, Vasudeva and Bir (1992, 1993), Vasudeva (1995) listed 68 species of ferns and 10 species of fern-allies from the PBR on the basis of the collections made during 1969-1978, where they mentioned three species viz. *O. gramineum* Willd., *O. nudicaule* L. and *O. reticulatum* L. under the genus *Ophioglossum*.

The genus *Ophioglossum* L. commonly known as Adder's tongue or Snake tongue fern of eusporangiate belonging to family Ophioglossaceae discovered by Bauhin (1620), is cosmopolitan in distribution. However, Linnaeus (1753) validated its generic status in his "Species Plantarum". Previously, the genus *Ophioglossum* was invariably treated to ascertain the phylogenetical relationship and the evolution pattern of eusporangiate ferns. But, the break through discovery of the maximum chromosome numbers (1260) in *O. reticulatum* made manifold interest of amateurs in the genus *Ophioglossum* (Chiarugi, 1960). Thus, the attempts of discovery and records of new species on this particular genus keep continued from time to time worldwide. About 40 species under the genus *Ophioglossum* are known so far worldwide, but in India the genus is represented by 12 species (Clausen, 1938; Khandelwal and Goswami, 1984; Khandelwal, 1987, 1989; Vasudeva and Bir, 1993; Yadav and Tripathi, 2002; Goswami et al., 2008). After a long gap of about four decades update and as a result of rigorous and unsustainable utilization of natural resources, numbers of species are facing threat for their survival and few of them are becoming extinct in the sanctity of biosphere reserve without coming to the knowledge of

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science. However, few of the species might have invaded or migrated from this geographical region. Following the pattern of speciation few may have evolved the genetic convergence leading origin of new species in the biosphere reserve. Hitherto, keeping above view in mind an attempt is made to provide a comprehensive and consolidated revised taxonomic account of Pteridophytic flora of PBR.

During investigation and preparation of floristic account of pteridophytic wealth, four species of genus *Ophioglossum* including new record of *O. polyphyllum* to the PBR have been encountered. In present paper these species are elaborately treated with their comparative taxonomic account (Table 1), key to the species, photographic plates, line drawing illustrations and distributional map.

MATERIALS AND METHODS

The plants were collected from different localities of Pachmarhi Biosphere Reserve in three subsequent exploration trips during August 2008, September 2008 and January 2009. The morpho-photographs of the plants were taken by Nikon Eclipse 80-I microscope. The line drawing illustrations were made with the help of Camera Lucida and morphological as well as anatomical observations were made under microscope (Olympus). The detailed observations made during present investigation have provided additional information on taxonomic characters, ecological and distributional patterns. The observations were made from populations of living plants as well as the herbarium specimens. The taxonomic characters considered in the investigation includes habitat, shape and size of the plants, rhizome length, rhizoids color, scales, shape and size of fronds, venation pattern, fertile spike, spike length and shape and size of spores. After identification, the plants were properly processed, poisoned, mounted on sheet and deposited in the Pteridophyte Herbarium of NBRI (LWG).

TAXONOMIC TREATMENTS

Key to the species of the genus *Ophioglossum* L. of Pachmarhi

1. Leaves originating from the very subterranean part of rhizome ….. 2
1. Leaves originating from the aerial part of the trophophore …….. 3
2. Leaves always more than two originating from the subterranean part of rhizome ……. *O. polyphyllum*
2. Leaves 1 or 2 in numbers originating from the subterranean part of rhizome ……..... *O. nudicaule*
3. Leaves away on the mid part of the plant, smaller (less than 0.8 cm), narrowed (less than 0.1 cm), lanceolate with acute apex, lamina 4-6 celled wide, costa not very prominent with less profuse venation ……... *O. gramineum*
3. Leaves not on the mid part of the plant, larger (up to 9.5 cm), wider (up to 3.9 cm), apex acute or rarely obtuse, lamina 17-19 cells wide, costa very prominent with profusely reticulate venation ……..…… *O. reticulatum*

Ophioglossum polyphyllum A. Braun *ex* Seubert., Fl. Azor. 17 (1844); Pichi Sermolli, Webbia 9: 632 (1954); Panigrahi and Dixit, Proc. Nat. Inst. Sci. India 35 B(3): 255 (1969); Dixit, Indian Fern J. 6: 146 (1989).

Figs. 1A-F, 2C-D, 3A-E, 6

Ophioglossum cuspidatum Milde, Bot. Zeit. 22: 107 (1864); *Ophioglossum aitchisonii* (Clarke) d' Almeida, J. Indian Bot. Soc. 3: 63 f. 12-13 (1922); Clausen, Mem. Torrey Bot. Club 19: 138 (1938); Mahabale, Bull. Bot. Surv. India 4: 71 (1962).

Plants green to dark green in color, medium sized, attaining a height of 5.5–7.7 cm, growing on soil in grassland, erect, spreading radially.

Rhizome bulbous or tufted, unbranched, 1.2–1.3 cm in length and 0.4–1.0 cm in width, pertaining in to the ground, dark brown in color, rhizoids numerous, limited downward from half part of the rhizome, scales very occasional, reduced, brown. Rhizome penetrates into the soil at a depth of 1.0 cm. Rhizoids cylindrical, unbranched, thick, brown in color, arising from lower half part of the rhizome, covered with brown colored hairs throughout its surface, apical part of rhizoids gradually narrowed, apex obtuse usually devoid of hairs. The length of rhizoids varies from 1.7–2.6 cm in length. In cross section the rhizoid is 716.5-921.95 µm in diameter and 16-17 cells across, rounded, and with hairs arising from epiblema, cells almost similar across the section or the outermost layer cells of epiblema becomes smaller, barrel shaped. The outer cells angular to barrel shaped, 33.67 × 26.35 µm; the inner layer of cortical cells parenchymatous, penta-hexagonal, cells 30.01 × 27.82 µm with mycorrhizal association; the innermost central conductive cells are thickened with poorly developed diarch xylem condition.

Sterile leaf (trophophyll) usually 4 but varies from 2-5 per plant, originating from apical portion of subterranean (below soil) rhizome, larger, elliptical-oblong or ovate-lanceolate, glabrous, narrowed at base and apex, wider medially, apex acuminate-obtuse, leaves semiquincuncially arranged, margin entire, costa not very prominent, replaced with less profused venation. Leaves green in color, 2.2-5.8 cm long, and 1.7-2.4 cm wide medially, sessile, originating from subterranean part of rhizome and the base of peduncle, stipe reduced and buried under soil. Leaf veins without free endings, anastomosing with simple included veinlets.

Fertile segments (strobilus) arise from the base of each sterile leaves under the soil. The larger lamina and strobilus grow parallel in vertical position; however three smaller fertile segments are closely appressed to the lamina. Peduncle is rounded in shape, 1.2-1.4 cm in length, bearing 1.3-2.13 cm long and 0.1-0.2 cm broad spike. Upper and

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Table 1: Comparative study on the species of the genus *Ophioglossum* L. in PBR-Madhya Pradesh.

Characters	*O. polyphyllum*	O. *nudicaule*	*O. gramineum*	*O. reticulatum*
Plants length	Medium sized, 5.5-7.7 cm	Tiny-medium sized, 5.4 - 5.8 cm	Very small-minute, 2.4 - 2.8 cm	Medium-large, 7.2-23.5 cm
Color	Green-dark green	Silvery green-green	Yellowish green-dark green	Light green-dark green
Rhizome shape	Bulbous or tufted, unbranched	Cylindrical, soft, tuberous, branched	Cylindrical, unbranched, tuberous basally	Cylindrical, erect and tuberous
Rhizome length	1.2-1.3 cm	0.7-1.5 cm	0.2-0.5 cm	0.6-1.3 cm
Rhizome width	0.4-1.0 cm	0.15-0.20 cm	0.1-0.2 cm	0.2-1.5 cm
Rhizoid shape	Cylindrical, unbranched	Cylindrical, branched	Cylindrical, unbranched, thick	Cylindrical, unbranched
Rhizoid length	1.7- 2.6 cm	0.3-0.4 cm	0.5- 0.7 cm	1.3-2.6 cm
Rhizoid width	716.50-921.90 µm	673.51-859.80 µm	616.19-630.52 µm	788.15-912.34 µm
Epiblema cells	33.67×26.35 µm	40.26×26.35 µm	36.60×17.57 µm	38.06×31.48 µm
Cortical cells	30.01×27.82 µm	56.36×35.14 µm	55.63×30.12 µm	39.53×24.89 µm
Rhizoidal cells across the diameter	16-17	23-25	17-18	19-21
Leaves per plant	Usually 4 or 2-5	Usually 1 or 1-2	Usually 1 or 1-2	Usually 1 or 1-2
Leaf length	2.2-5.8 cm	2.0-2.2 cm	0.7-0.8 cm	1.7-9.5 cm
Leaf width	1.7-2.4 cm	0.5-0.8 cm	0.03-0.1 cm	1.2-3.9 cm
Leaf color	Green	Silvery green-green	Yellowish green	Silvery green-green
Peduncle length	1.2-1.4 cm	1.1-2.1 cm	0.7-1.7 cm	4.0-14.5 cm
Leaf veins	Anastomosing with simple included veinlets and without free endings	Anastomosing, veinlets occasionally branched without free endings	Primarily parallel followed by anastomosing and without free endings	Anastomosing, branched, reticulate with included veinlets, without free marginal veins endings
Spike length	1.3-2.13 cm	0.34-0.69 cm	0.2-0.5 cm	1.7-2.7 cm
Spike width	0.1-0.2 cm	0.1-0.2 cm	0.01-0.1 cm	0.1-0.2 cm
Sporangia per spike	40-42 pairs	7-9 pairs	5-8 pairs	19-42 pairs

lower sporangia usually smaller and sterile. Sporangia lateral, in 40-42 pairs per spike. Spores yellow to dark brown in color, triangular, the distal end without any tri-radiate mark.

Distribution and Ecology: INDIA: CENTRAL INDIA: MADHYA PRADESH: Pachmarhi: Denwa Darshan (on the way to Matkuli). Plants growing on moist sandy soil in grassland mixed with other Gramminae members of angiospermic plants at an altitude of 1463 ft, 78º 25.536' E & 22º 34.526' N, Bastar; HIMACHAL PRADESH: Shimla; UTTARANCHAL: Garhwal: Dehradun. ABISSINIA, AFGANISTAN, AFRICA, ARABIA, ETHIOPIA, EUROPE, FRANCE and KENYA.

Specimens examined: INDIA: Central India: Madhya Pradesh: Pachmarhi: Denwa Darshan (on the way to Matkuli), 08.08.2008, Leg. Khare and party, 229729 (LWG). Det. A. P. Singh, S. K. Behera & P. B. Khare.

Ophioglossum nudicaule L., Suppl. Syst. Pl.: 443 (1781). Figs. 1G-L, 2G-H, 3F-J, 6

Ophioglossum capense Schlechtend. var. *nudicaule* (L.) Schlechtend., Fil. Prom. Bonae Sp.: 9 (1825). *Ophioglossum vulgatum* var. *macrorhizum* (Kze.) Luerssen, J. Mus. Godeffr. 3: 242, 244 (1875). *Ophioglossum luerssenii* Prantl, Ber. Deut. Bot. Ges.: 352 (1883). *Ophioglossum moluccanum* Schlechtend. fo. *pumilum* Rac., Nat. Tijd. Ned. Ind. 59: 237 (1908). *Ophioglossum pumilum* v.A.v.R., Mal. Ferns: 774 (1908). *Ophioglossum schlechteri* Brause, Engl. Jahrb. 49: 58 (1912). *Ophioglossum lineare* Schlechter *et* Brause, Engl. Jahrb 49: 59 (1912).

Plants silvery green to green in color, tiny to medium sized, attaining a height of about 5.4-5.8 cm, growing together with other gramminae members in the grassland on coarse sand soil, usually erect with radially spreading trophophyll.

Rhizome medium, erect, 0.7-1.5 cm long, penetrating in to the soil vertically, brown in color, cylindrical, soft, fleshy, tuberous, with pointed tip, branched, bearing few rhizoids on surface. The diameter of rhizome ranges from 0.15-0.20 cm. Rhizome penetrates in to the soil at a depth of about 0.7-1.5 cm. Rhizoids cylindrical, branched, narrowed, dull in color, slightly tuberous with a pointed tip, arising occasionally from the rhizome, covered with brown colored hairs throughout its surface, apex obtuse, devoid of hairs. The length of rhizoids varies from 0.3-0.4 cm. In cross-section the rhizoid is 673.51-859.80 µm in diameter and 23-25 cells across, irregular-rounded with scarce hairs arising from epiblema cells, cells distinct into two regions; the outer most epidermal cells single layered, smaller, thick, and elliptical-barrel shaped, 40.26 × 26.35 µm in diameter, epidermal cells are followed by penta-hexagonal parenchymatous cortical cells; the cortical cells 56.36 × 35.14 µm with numerous mycorrhizal association from central towards periphery region; the innermost central conductive cells are thickened, few with monoarch xylem condition.

Sterile leaves (trophophyll) 1-2 per plant, originating from the aerial part of the rhizome at the very base of plant on substratum, smaller- medium, broadly elliptical-ovate,

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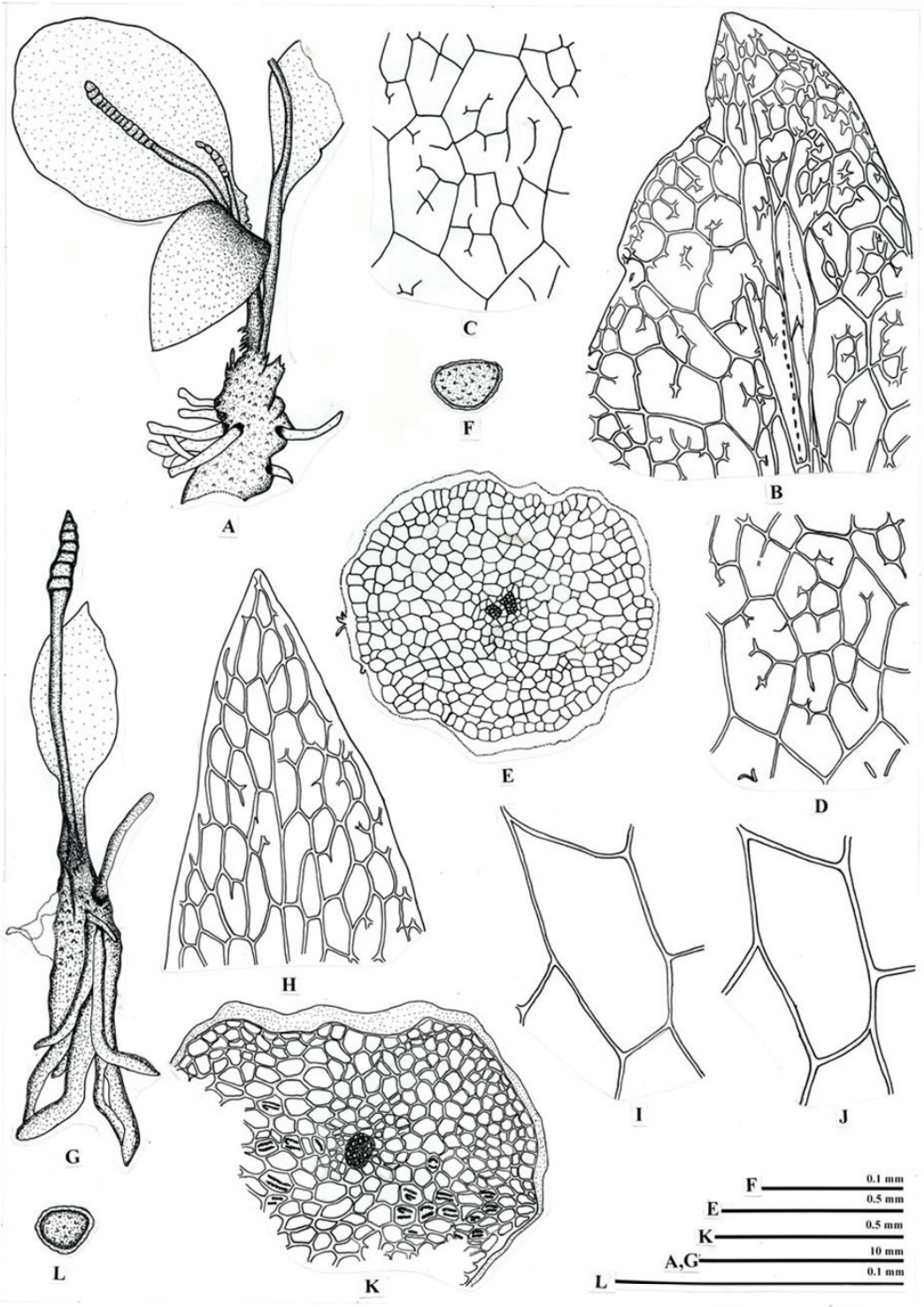


Fig. 1. ***Ophioglossum polyphyllum*** **A. Braun** ***ex*** **Seubert. and** ***Ophioglossum nudicaule*** **L. Figs. A-F:** ***Ophioglossum polyphyllum*** **(LWG-229729). A: Entire plant. B: Leaf venation pattern in apical region (not in scale). C & D: Venation pattern in median region (not in scale). E: Cross-section of rhizoid. F: Spore. Figs. G-L:** ***Ophioglossum nudicaule*** **L. (LWG-229725). G: Entire plant. H: Leaf venation pattern in apical region (not in scale). I & J: Magnified view of veins (not in scale). K: Cross-section of rhizoid. L: Spore.**

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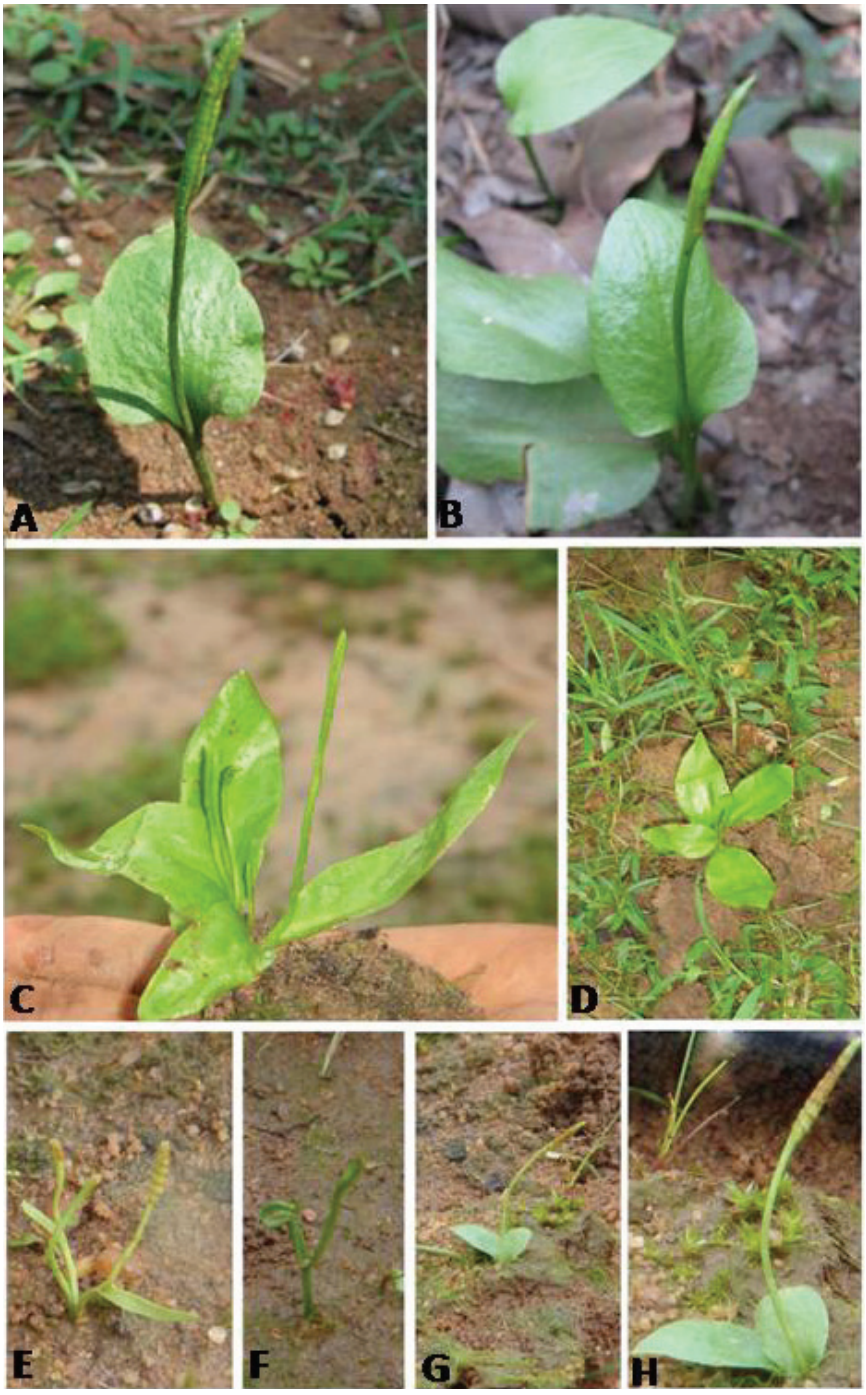


Fig. 2. Different species of *Ophioglossum* growing in PBR. A & B: *Ophioglossum reticulatum* L. C & D: *Ophioglossum polyphyllum* A. Braun *ex* Seubert. E & F: *Ophioglossum gramineum* Willd. G & H: *Ophioglossum nudicaule* L.

apex acute-obtuse, base cuneate, margin entire, costa not very prominent. Leaves silvery green to green, sessile, originating from the base of peduncle near the substratum, 2.0-2.2 cm long and 0.5-0.8 cm wide medially, with acute or obtuse apex, base cuneate, margin entire, lamina sheathing the peduncle, stipe reduced, buried under the soil. Leaf veins anastomosing, veinlets occasionally branched, absent in the marginal and submarginal areoles and without free endings, areoles elongated.

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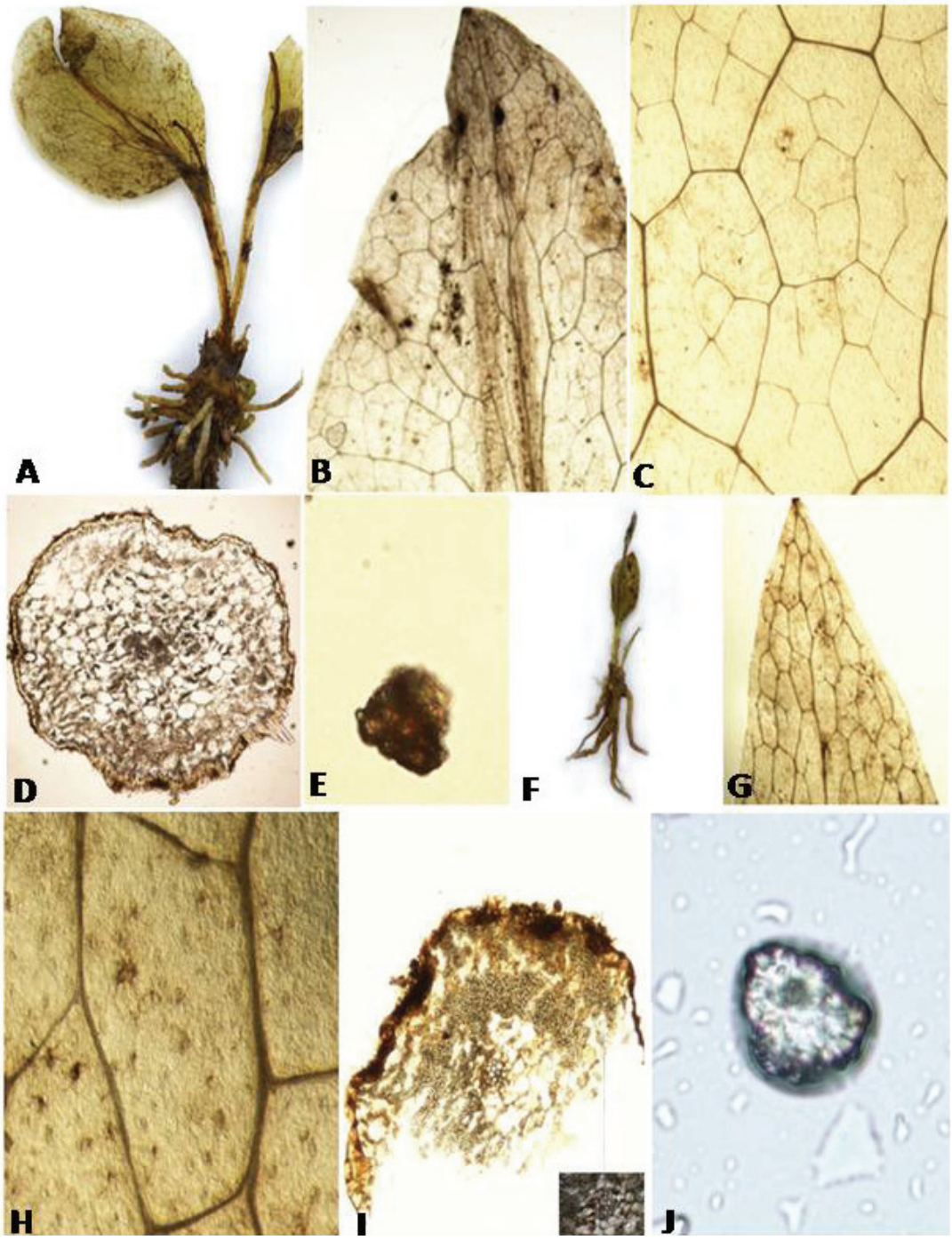


Fig. 3. *Ophioglossum polyphyllum* A. Braun *ex* Seubert. (A-E). A: Entire plant. B & C: Venation pattern. D: Cross-section of rhizoid. E: Spore. *Ophioglossum nudicaule* L. (F-J). F: Entire plant. G & H: Venation pattern. I: Cross-section of rhizoid. J: Spore.

Fertile segments (strobilus) arise from the base of sterile blade, vertical at right angle to lamina. Peduncle silvery green, rounded in shape, 1.1-2.1 cm in length, bearing 0.34-0.69 cm long and 0.1-0.2 cm broad spike. Upper and lower sporangia usually smaller and sterile. Sporangia lateral, in 7-9 pairs per spike. Spores yellow to brown in color, triangular, exine rough, the distal end without any tri-radiate mark.

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Distribution and Ecology: INDIA: CENTRAL INDIA: MADHYA PRADESH: Pachmarhi: Bioson Lodge near Deodaru. Plants growing on moist coarse sand soil in grassland mixed with other Gramminae members of angiospermic plants at an altitude of 1385 ft, 78º 25.233' E & 22º 37.049' N, Twynam Pool, Old Hotel Block, Dhoopgarh; NORTH WESTERN HIMALAYA: Kumaon: Almora; NORTH EASTERN INDIA: MEGHALAYA: Jaintia Hills; GANGETIC PLAINS: UTTAR PRADESH: Bundelkhand; WESTERN INDIA: GUJRAT: Dharampur; RAJASTHAN: Jhalawar; PENINSULAR INDIA: KARNATAKA, TAMILNADU: Anamallays, Palni Hills, Tirunelveli Hills. AFRICA, MADAGASCAR, MOLUCCAS, SRI LANKA, TIBET and PANTROPIC.

Specimens examined: INDIA: Central India: Madhya Pradesh: Pachmarhi: Bioson Lodge near Deodaru, 08.08.2008, Leg. Khare and party, 229725 (LWG). Det. A. P. Singh, S. K. Behera & P. B. Khare.

Ophioglossum gramineum Willd., Nov. Act. Acad. Erf. 2: 18 (1802).

Figs. 2E-F, 4A-E, 5F-K, 6

Ophioglossum vulgatum L. var. *gramineum* (Willd.) Hooker, Fl. Nov. Zel. 2: 50 (1854); *Ophioglossum clietrichiae* Prantl, Ber. Deut. Bot. Ges. 1: 352 (1883); *Ophioglossum moluccanum* forma *inconspicuum* Raciborski, Nat. Tijd. Ned-Ind. 59: 237 (1900); *Ophioglossum inconspicuum* (Rac.) v.A.v.R., Bull. Dep. Agr. Ind. Neerl. 21: 9 (1908); *Ophioglossum gregarium* Christ, Nova Guinea Bot. 8: 164 (1909); *Ophioglossum costatum sensu* Clausen, Mem. Torrey Bot. Club 19(2): 161 (1938); *Ophioglossum indicum* Khandelwal in Fras.-Jenk., New Species Syndrome Indian Pterid. 185 (1997).

Plants yellowish green to dark green in color, very small to minute in size, attaining a height of about 2.4–2.8 cm, growing together with other gramminae members in the grassland on humus enriched soil, usually erect or slightly bend toward the attached trophophyll.

Rhizome small, erect, 0.2–0.5 cm in length, perennating into the ground, brown in color, vertically cylindrical, basal portion tuberous, unbranched, bearing rhizoids all over its surface. The diameter of rhizome ranges from 0.1–0.2 cm. Rhizome penetrates into the soil at a depth of about 0.4 cm. Rhizoids cylindrical, unbranched, thick, brown in color, arising from the entire surface of the rhizome, covered with brown colored hairs throughout its surface, apex obtuse, usually devoid of hairs. The length of the rhizoids varies from 0.5–0.7 cm. In cross-section the rhizoid is 616.19–630.52 µm in diameter and 17–18 cells across, rounded with hairs arising from the epiblema, cells distinct into two regions, the outermost epidermal cells single layered, thick, brown, cells elliptical to barrel shaped, 36.60×17.57 µm in diameter, epidermal cells are followed by parenchymatous penta-hexagonal cortical cells; cortical cells 55.63×30.12 µm with scattered mycorhhizal association, the innermost central conductive cells are thickened with distinct diarch xylem condition.

Sterile leaf (trophophyll) usually 1 or varies from 1–2 per plant, originating from the aerial part of the trophophore, away on the mid position of the plant, smaller, narrowed, sickle-shaped, linear, elliptical to lanceolate, apex acute, margin entire, costa not very prominent, replaced with less profused venation, lamina 4-6 celled wide. Leaves yellowish green in color, 0.7-0.8 cm long and 0.03-0.1 cm wide at median and basal region, sessile, originating from the base of peduncle, lamina sheathing the peduncle, stipe cylindrical-flattened, about 1.0 cm in length, basal portion somewhat flattened and burried under the soil. Leaf veins primarily parallel up to the 2/3 of the lobe length, 1/3 portion of veins are anastomosing, without free endings, areoles elongated.

Fertile segment (strobilus) arises medially or below the middle from the base of sterile blade and sometimes it remains attached to the leaf more towards one side of the sterile blade i.e. unequally lateral. Lamina and strobilus grow parallel and are closely appressed to each other. Peduncle is rounded in shape, 0.7-1.7 cm in length, bearing 0.2–0.5 cm long and 0.01–0.1 cm broad spike. Upper and lower sporangia of the spike are usually smaller and sterile. Sporangia laterally paired with 5–8 pairs of sporangia per spike. Spores pale yellow in color, globular to round with trilete sporoderm.

Distribution and Ecology: INDIA: CENTRAL INDIA: MADHYA PRADESH: Pachmarhi: Bioson Lodge near Deodaru. Plants growing on moist sandy soil in grassland mixed with other Gramminae members of angiospermic plants at an altitude of 1463 ft, 78º25.537' E & 22º 34.527'N; NORTH WESTERN HIMALAYA: Kumaon: Almora, Pithoragarh; GANGETIC PLAINS: UTTAR PRADESH: Varanasi; WEST BENGAL, CENTRAL INDIA, WESTERN INDIA: RAJASTHAN: Jhalawar; MAHARASHTRA: Bombay; PENINSULAR INDIA: ANDHRA PRADESH: Karim Nagar; KARNATAKA: Dakshina Kannada, TAMILNADU: Koimbatore, Tirunelveli; KERALA: Malabar. AFRICA, NORTH UNIA-OYA, NEW GUINEA and SRI LANKA.

Specimens examined: INDIA: Central India: Madhya Pradesh: Pachmarhi: Bioson Lodge near Deodaru, 08.08.2008, Leg. Khare and party, 229730 (LWG). Det. A. P. Singh, S. K. Behera & P. B. Khare.

Ophioglossum reticulatum L., Sp. Pl. 2: 1063 (1753).

Figs. 2A-B, 4F-L, 5A-E, 6

Ophioglossum peruvianum Presl., Suppl. Tent. Pterid. 52 (1845); *Ophioglossum cordifolium* Roxb., Hort. Bengal.75 (1814).

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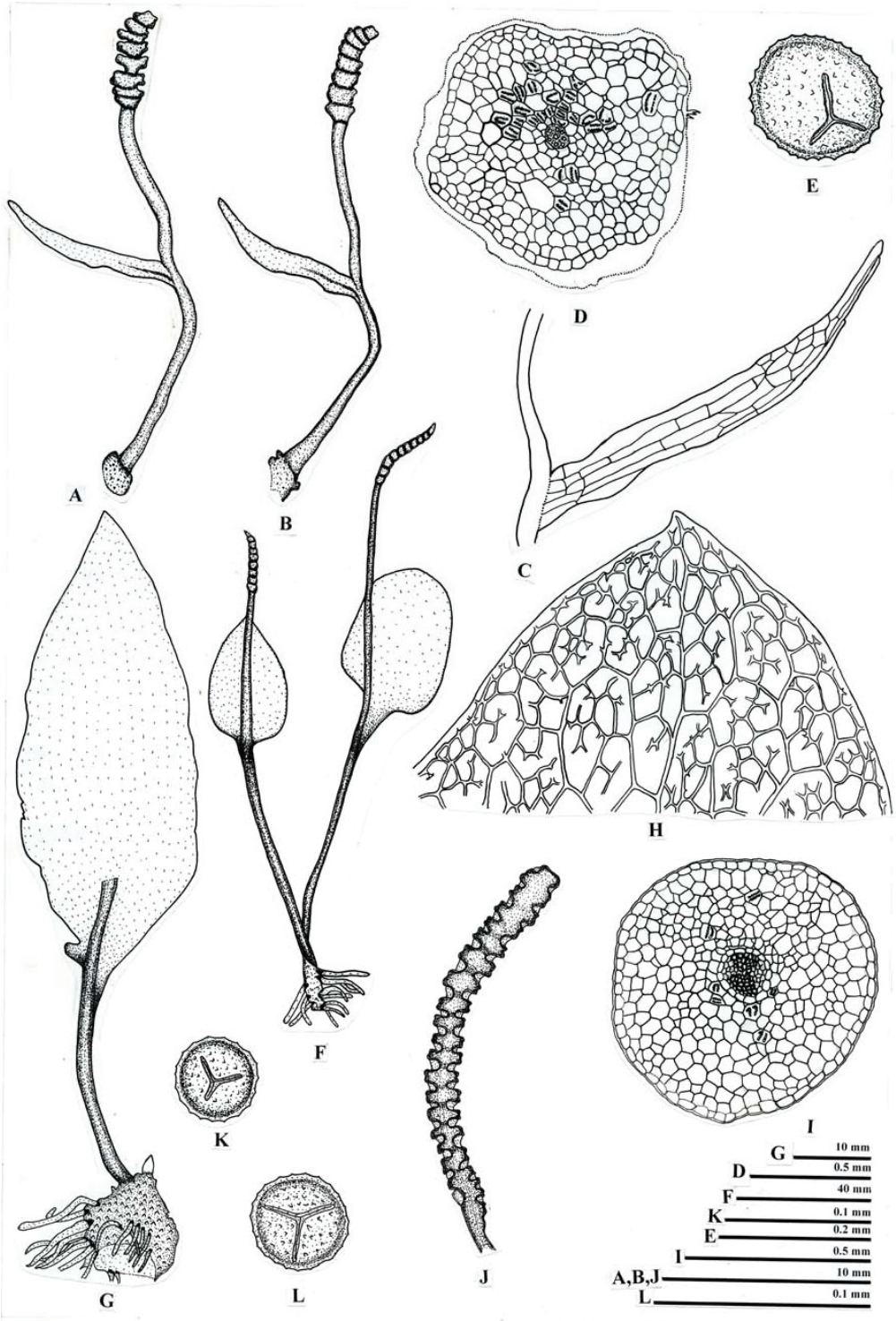


Fig. 4. ***Ophioglossum gramineum*** **Willd. and** ***Ophioglossum reticulatum*** **L. Figs. A-E:** ***Ophioglossum gramineum*** **(LWG-229730). A & B: Entire plants. C: Magnified view of leaf venation pattern (not in scale). D: Cross-section of rhizoid. E: Spore. Figs. F-L:** ***Ophioglossum reticulatum*** **(LWG-229794). F: Entire plant. G: Magnified view of rhizome and trophophore (LWG-229747). H: Leaf venation pattern in apical region (not in scale). I: Cross-section of rhizoid. J: Magnified view of strobilus. K & L: Spores.**

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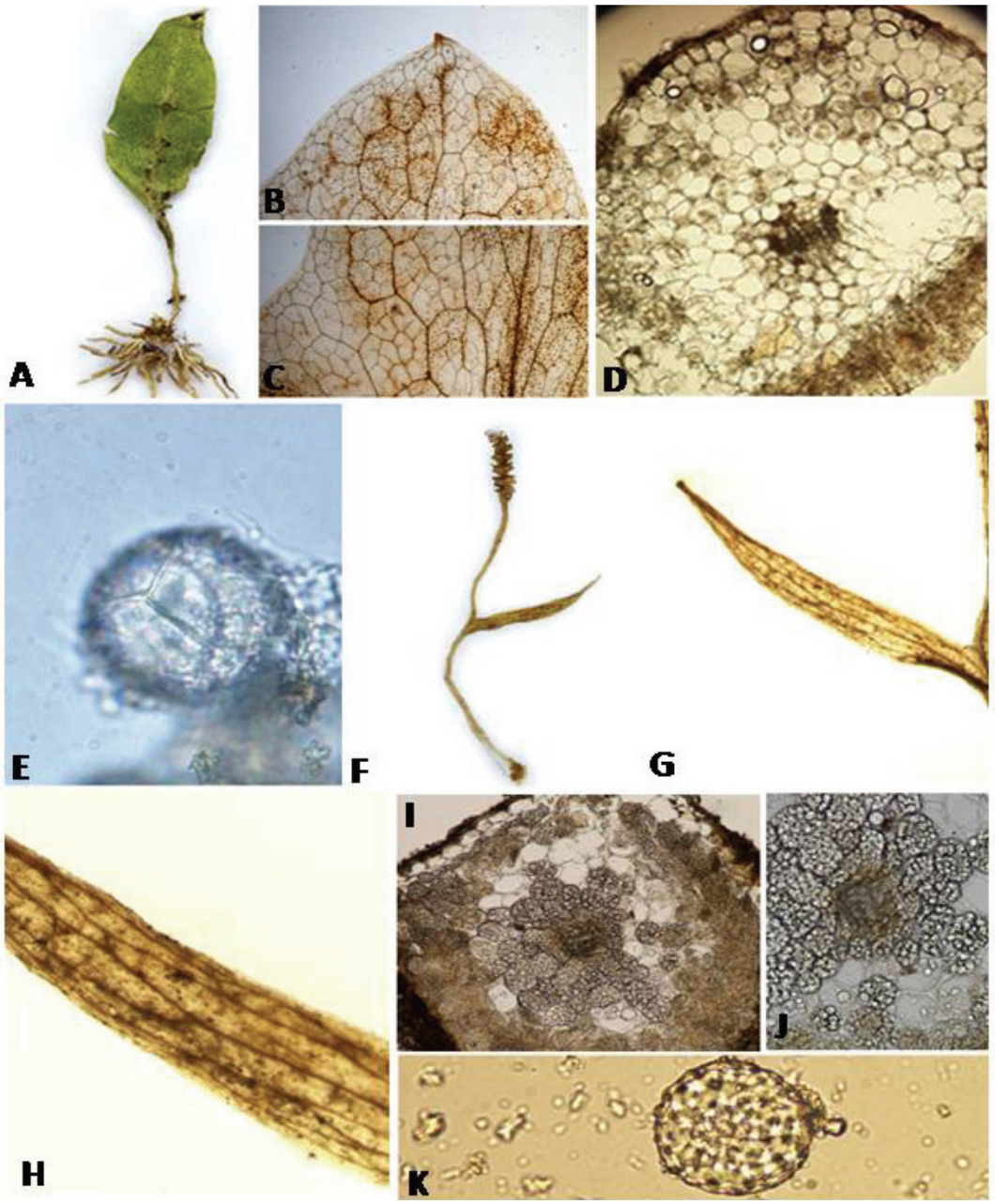


Fig. 5. *Ophioglossum reticulatum* L. (A-E). A: Entire plant. B & C: Venation pattern. D: Cross-section of rhizoid. E: Spore. *Ophioglossum gramineum* Willd. (F-K). F: Entire plant. G & H: Venation pattern. I: Cross-section of rhizoid. J: Cortical cells showing mycorhhizal association. K: Spore.

Plant light green to dark green in color, herbaceous, medium-large sized, 7.2-23.5 cm long, growing together with other gramminae members on humus enriched soil or under shade of dried leaves of other plants, erect, with radially spreading single leaf.

Rhizome larger, usually tuberous or cylindrical, erect, 0.6-1.3 cm long and 0.2-1.5 cm wide, unbranched with gregarious formation of stolons on the underground part, predominantly covered with small brownish scales, bearing rhizoids all over its surface. Rhizome penetrates into the soil at a depth of about 2.0 cm. Rhizoids cylindrical, unbranched, whitish brown in color, arranged acropetally on entire surface of the tuberous rhizome, apex obtuse, usually devoid of hairs, attaining length up to 2.6 cm.

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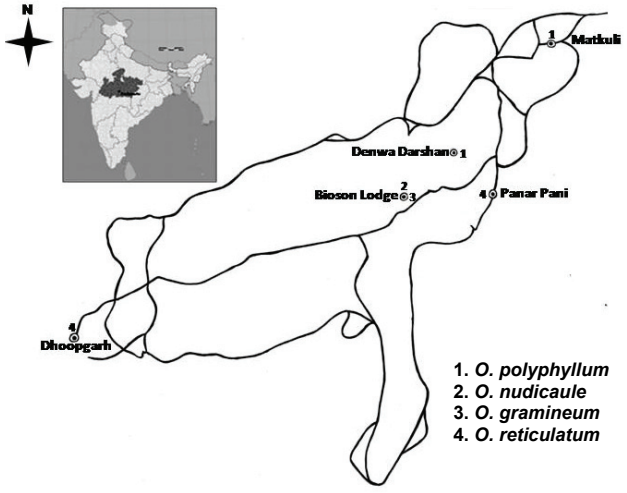


Fig. 6. Distributional pattern of *Ophioglossum* species in PBR, Madhya Pradesh, India.

In cross-section the rhizoid is 788.15-912.34 µm in diameter and 19-21 cells across, rounded with scarce hairs arising from the epiblema, cells distinct into two regions; the outer most epiblema cells single layered, brown, thick walled, smaller, elliptical to barrel shaped, 38.06 × 31.48 µm, epiblema cells are followed by parenchymatous angular-hexagonal cortical cells; cortical cells 39.53 × 24.89 µm, with scarcely mycorrhizal associated cells; the innermost central conductive cells are encircled with distinct single layered endodermis type cells, xylem diarch divided centrally by thin parenchymatous cells.

Sterile leaf (trophophyll) usually 1 or rarely varies from 1-2 per plant, originating from the aerial part of trophophore, away from the substratum, larger, cordate-lanceolate, medially wider and narrowed towards apex, apex acute or rarely obtuse, margin entire or very occasionally undulate, costa not very prominent, replaced with profused venation. Leaves silvery green-green in color, 1.7-9.5 cm long and 1.2-3.9 cm wide medially, sessile, originating above the ground and sheathing the peduncle, stipe cylindrical, 4.2-8.2 cm long and 0.1-0.2 cm wide, the basal portion of petiole ± 1.2 cm remains burried under the soil. Leaf veins reticulate, anastomosing, branched with included veinlets, without free marginal vein ending, areoles elongated.

Fertile segment (strobilus) arises from the base of sterile blade, vertical at right angle to lamina. Peduncle green, rounded in shape, 4.0-14.5 cm long, attached above the middle of the sterile lamina, bearing 1.7-2.7 cm long and 0.1-0.2 cm broad spike. Upper and lower sporangia usually smaller and sterile. Sporangia laterally paired with 19-42 pairs of sporangia per spike. Spores globular-tetrahedral, pale-yellowish brown in color, trilete, exine trabeculate.

Distribution and Ecology: INDIA: CENTRAL INDIA: MADHYA PRADESH: Pachmarhi: Panar Pani and Bioson Lodge. Plants growing on moist sandy soil in grassland mixed with other Gramminae members of angiospermic plants at an altitude of 2970 ft, 78º 26.695' E & 22º 30.426'N; on way to Dhoopgarh and Rorighat Forest Guest House. Plants growing on moist sandy soil in grassland mixed with other Gramminae members of angiospermic plants at an altitude of 3935 ft, 78º 22.252' E & 22º 27.492'N; Hosangabad; NORTH WESTERN HIMALAYA: Garhwal: Dehradun, Chamoli; Kumaon: Nainital, Almora, Pithoragarh; EASTERN HIMALAYA: ARUNACHAL PRADESH, SIKKIM, WEST BENGAL: Darjeeling; NORTH EASTERN INDIA: ASSAM: Guwahati; MEGHALAYA: Khasi & Jaintia Hills; GANGETIC PLAINS: BIHAR: Parasnath Hills, UTTAR PRADESH: Bahraich; WESTERN INDIA: RAJASTHAN: Jhalawar; PENINSULAR INDIA: KARNATAKA: Dakshina Kannada; TAMILNADU: Madras, Annamallays, Kolli, Shevaroy Hills, Kothayar; KERALA: Malabar. AFRICA, BORNEO BURMA, JAPAN, JAVA, FIJI ISLAND, MALAYA, MAURITIUS, MEXICO, MOLUCCAS, NEPAL, PAKISTAN, POLYNESIA, PHILIPPINES, SAMOA, SUMATRA, SRI LANKA, TIBET, TROPICAL AMERICA and WEST INDIES.

Specimens examined: INDIA: Central India: Madhya Pradesh: Pachmarhi: Panar Pani and Bioson Lodge, 08.08.2008, Leg. Khare and party, 229747 (LWG); on way to Dhoopgarh and Rorighat Forest Guest House, 20.10.2008, Leg. A. P. Singh & S. K. Behera, 229794 (LWG); Det. A. P. Singh, S. K. Behera & P. B. Khare.

Other specimens examined: INDIA: North India: Uttar Pradesh: Gorakhpur: Donakhand forest, 24.01.1968, Leg. G. K. Maheshwari, 81556 (LWG), 71280 (Accession No); Behraich district, 28.11.1954, Leg. P. Singh, 16618 (LWG), 56563 (Accession No); Katarniyaghat Wildlife Sanctuary Behraich district. 07.09.2005, Leg. S. D. Maliya, 227160 (LWG), 94270, 94271 (Accession Nos.), 227111 (LWG), 93430, 93431 (Accession Nos.). Gangetic Plain: Bihar, 12.08.1956, Leg. P. Chandra, 36579 (LWG), 56565 (Accession No.). North East India: Assam: Khasi & Jaintia Hills, 25.09.1962, Leg. Kapoor & party, 73437 (LWG), 62146 (Accession No.). Western India: Maharashtra: Mahabaleshwar, 04.12.1962, Leg. P. Chandra and party, 95121 (LWG), 62144, 62145 (Accession Nos.); Det. A. P. Singh, S. K. Behera & P. B. Khare.

DISCUSSION

The disjunction and additional record on many more pteridophytes species are urgently needed to keep update the ferns and ferns-allies wealth of any continent like India. In India, unlike the Eastern Himalayas and the Western Ghats, the pteridophytes wealth of Pachmarhi hills are abundant in the deep and dark ravines of steep rocks, along water streams on stony soils. Therefore, the floristic composition of pteridophytes in Pachmarhi hills is very distinct and evidently exhibit common ancestry of

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extension, origin, evolution to Himalayan and Western Ghats flora. The discontinued topography, dissimilar ecosystem and specific habitat of PBR have led many more species confined to this particular biosphere reserve. Thus, assessment of endemism, growth pattern, and new records of different unknown species in the PBR is of utmost importance.

Bir and Vasudeva (1972, 1973) Vasudeva and Bir (1993), and Vasudeva (1995) reported three species of *Ophioglossum*: *Ophioglossum gramineum* Willd, *Ophioglossum nudicaule* L. and *Ophioglossum reticulatum* L. from this biosphere reserve.

During present investigation four species namely *O. polyphyllum* A. Braun *ex* Seubert, *O. gramineum* Willd, *O. nudicaule* L. and *O. reticulatum* L. have been encountered from the biosphere reserve. The *O. polyphyllum* growing in grassland of Denwa Darshan (on the way to Matkuli) have been encountered for the first time which is a new addition to the pteridophytes composition of PBR. However, *O. gramineum*, *O. nudicaule* and *O. reticulatum* have shown extended range of trans-geographical distribution within the biosphere reserve. Earlier, the *O. nudicaule* was reported from Twynam Pool, Old Hotel Block, Dhoopgarh by Vasudeva and Bir (1993), but during recent exploration this species has been encountered from Bioson Lodge near Deodaru in PBR. Similarly, *O. gramineum* and *O. reticulatum* collected by Singh and Roy (1969) and Panigrahi (Coll. No. 4490B) respectively were reported without any exact locality in PBR. But during present investigation authors came across these species growing in Panar Pani, on way to Dhoopgarh, Rorighat Forest Guest House and Bioson Lodge in PBR, which has shown its extended range of distribution within the biosphere reserve.

Morphologically, *O. polyphyllum* shows similarity with *O. nudicaule,* but later differs with former in having small size of plants, 1-2 sterile leaves originating from the subterranean part of rhizome. However, the *O. polyphyllum* is distinct in having more than two (usually 4) leaves originating from the subterranean part of rhizome and the plants length which is always greater than the latter. Additionally, *O. polyphyllum* also resembles with *O. costatum* R. Br., but the former differ in having more than two (usually 4) leaves originating from the subterranean (below soil) part of rhizome and without distinct costa on the sterile leaves which are replaced by less profused venations. However, the *O. costatum* is distinct in having usually two leaves originating from the very base of the aerial part of rhizome (above soil surface) and with prominent and distinct costa on the sterile leaves (Goswami et al., 2008). The *O. gramineum* is distinct in being smaller in length; having smaller, narrowed, lanceolate leaves originating away on the mid part of the trophophores and leaf veins primarily parallel followed by anastomosing. The subsequent collective and comparative studies on the composition of pteridophytes has revealed that number of the species individuals are abundant than the species diversity. Thus, there is more possibility of new reports and records of the plant taxa.

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印度中央省潘洽瑪生態保留區瓶爾小草屬植物之研究

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摘要：本文乃針對位於印度中央省的潘洽瑪生態保留區 (PBR) 之瓶爾小草屬植物，就形態分類學、物種組成、分布型及生態學等進行研究。多葉瓶爾小草 (*O. polyphyllum*) 為潘洽瑪生態保留區之新記錄種。在本保留區裡，細葉瓶爾小草 (*O. gramineum*)、裸莖瓶爾小草 (*O. nudicaule*) 及網脈瓶爾小草 (*O. reticulatum*) 呈現地理連續分布。潘洽瑪生態保留區中的瓶爾小草屬植物之分類學的特徵、種間及種內的歧異度、廣泛之分布型，在本文中有較廣泛的討論。

關鍵詞：瓶爾小草屬、新紀錄、分類學、蕨類、植物相、潘洽瑪生態保留區 (PBR)、中央省、印度。

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