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Additions to the Pteridophyte Diversity of Gujarat, India

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Abstract
Biodiversity documentation is the first and one of the most important steps of any conservation action. In the present study, preliminary survey was carried out to assess the diversity and status of Pteridophyte plants in the state of Gujarat, India. During this study, three new records were reported for the first time from the state namely; *Ophioglossum lusitanicum*, *Ophioglossum thermale* and *Hypodematium crenatum*. The morphotaxonomy and ecological aspects, which include habitats and distribution of these species are documented in this paper.

Keywords: *Ophioglossum, Hypodematium*, Gujarat, pteridophytes, new record

1. Introduction
Gujarat is the western most state of India, and is unique in habitat diversity. Majority of the mountain ranges of Peninsular India, such as Satpuda, Vindhya, Aravalli and Western Ghats terminates in Gujarat. The varied topography and geology of these hills with and extensive xeric conditions of Kutch and Northern Gujarat results in high habitat diversity, which supports diverse and unique biota [1]. However, apart from few surveys, forests of Gujarat are unexplored in terms of Pteridophyte studies. Pteridophytes are among the least studied group of plants in Gujarat and so far only 32 species have been reported [2].

The Linnaean genus *Ophioglossum* commonly known as "adder's-tongue fern" belongs to the eusporangiate fern family Ophioglossaceae of order Ophioglossales. The genus is well known to botanist and cytologists of the world as its species are not only possessing high number of chromosomes but some species display the extremes. *Ophioglossum* L. is characterized by simple but rarely lobed trophophyll with a spike bearing two rows of sporangia [3]. It comprises more than 46 species along with varieties around the globe [4-6]. In India, it is represented by 14 species and recently described new species *O. malviae* [7-16]. In earlier studies of pteridophytes of Gujarat, seven species have been reported so far [17-21]. Since then, there has been no authenticated study on the genus *Ophioglossum* L.

Hypodematium Kunze is the only described genus in family Hypodematiaceae [22]. Species of this genus is mainly grows on limestone habitat and characterized by a distinct swollen scaly stipe base [23]. It comprises more than 16 species along with varieties around the globe mainly distributed in subtropical and temperate areas of Asia and Africa [24-25]. In India, it is represented by 2 species [26-30]. Since, no record of ferns belongs to genus *Hypodematium* is reported from the state Gujarat till date.

During the survey of Pteridophytic wealth from different regions of Gujarat, we collected three species namely *Ophioglossum lusitanicum* L., *Ophioglossum thermale* Kom. and *Hypodematium crenatum* (Forssk.) Kuhn which are reported here as an additions to the Pteridophytic flora of Gujarat state with detailed description and colour photographs.

2. Materials and methods
During botanical expeditions in July-January 2017, different Pteridophyte plants were collected from different localities of Gujarat state. Photographs of plant specimens were taken in their natural habitat. Plant specimens were collected and transferred to the laboratory for morphological as well as microscopic analysis and for herbarium preparation. The collected taxa were identified using appropriate floras, journals and monographs [13, 31-33]. Herbarium sheets were deposited in herbarium of Bapalal Vaidya Botanical Research Centre (BVBRC), Department of Biosciences, Veer Narmad South Gujarat University, Surat, Gujarat.

3. Results and discussion
Three species namely, *Ophioglossum lusitanicum*, *O. thermale* and *Hypodematium crenatum* are reported here as new for Gujarat state. The characteristic features of three species are as follows:

3.1 *Ophioglossum lusitanicum* Linn. sp. Pl., 2: 1063, 1753; Clausen, Mem. Torry Bot. Club, 19 (2): 159, 1938; Mahable, Bull. Bot. Surv. India, 4: 71, 1962; Panigrahi & Dixit, Proc. Nat. Inst. Sci. India 35: 251, 1969. (Fig. 1 A-C).

Ophioglossum loureirianum Presl, Suppl. Tent. Pterid, p. 55 (1845).

Ophioglossum alpinum Rouy, Bull. Soc. Bot. France, 44, 437 (1897).

Ophioglossum braunii Prantl, Ber deutsch bot. Ges, 1, 351 (1883).

Rhizome short, erect, tuberous, having numerous long fleshy roots, 0.5–1.2 cm in diameter to 0.4–1.0 cm long. Fronds 3–7 cm long, common stalk 0.5–1.5 cm long; most plants show brown colour at the base of the petiole, trophophyll one or

two, green, variable in size and form, elliptical-lanceolate, oblanceolate or spathulate in shape, cuneate at base, blunt, acute or minutely apiculate at apex, margin entire, 1–2 cm long, 0.5-1.0 cm broad; venation lax with few parallel veins forming large areoles without free endings in middle region but few present in the terminal area; thick, fleshy and often glossy in texture; fertile stalk 2-5.5 cm long; spikes 0.7–1.5 cm long; 8–12 sporangia in two rows; spores 32–42 µm in diameter, trilete with reticulate ornamentation.

3.1.1 Habitat: Growing in sandy or gravelly soils in open forest areas associated with other species of *Ophioglossum*.

3.1.2 Fertile: July to August

3.1.3 Specimen examined: India, Gujarat state, Jambughoda (22º21'49.55" N, 73º44'04.37" E, 105 m), Ahwa (23º45'10.29" N, 72º09'01.80" E, 74 m), Sagai (21º40'09.46" N, 73º47'36.17" E, 407 m) and Ratanmahal (22º34'35.13" N, 74º06'50.41" E, 270 m) *Mitesh Patel* BVBRC105. August, 2017.

3.1.4 Distribution
World: Iceland, France, Portugal, Italy, Madeira, Algeria, Afghanistan, India, Africa, Spain, Tanzania, Uganda and Iran.
India: Madhya Pradesh, Utter Pradesh, Andhra Pradesh, Jammu-Kashmir, Punjab, West Bengal, Assam, Bihar, Orissa, Karnataka, Tamil Nadu, Kerala, Maharashtra, Gujarat (new record).

3.2 *Ophioglossum thermale* Kom. (Miyabe et Kudo) Nishida in Tagwa, J. Jap. Bot., 33, 202 (1958); Nishida, Bull. Nat. Sci., 4 (3), 332 (1959); Panigrahi & Dixit, Proc. Nat. Inst. Sci. India 35.257 (1969); R.D. Dixit, Cens. Ind. Pterid.24 (1984) (Fig. 2 A-C).
Ophioglossum nipponicum Miyabe et Kudo, Trans. Sapporo Nat. Hist. Soc., 6, 122 (1916).
Ophioglossum japonicum Prantl, Ber. Deut. Bot. Ges., 1, 353 (1883); Mahabale, Bull. Bot. Surv. India, 4, 71 (1962).
Ophioglossum angustatum Maxon, Proc. Biol. Soc. Wash., 36, 169 (1923); Clausen, Mem. Torrey bot. Club, 19 (2), 129 (1938).
Ophioglossum nipponicum (non Miyabe et Kudo) Nakai, Bot. Mag. Tokyo, 39, 193 (1925).
Rhizome short, tuberous, bearing short fleshy roots, 0.4–1.2 cm in diameter to 0.6–1.0 cm long. Fronds slender, 8–12 cm long; common stalk 1–4 cm long; trophophyll usually 1 or sometimes 2 on a rhizome, light green, variable in size and form, elliptical, lanceolate or oblong in shape, cuneate at base, acute or mucronate at apex, margin entire or crenulate, 1.5–5.5 cm long, 1.0–1.5 cm broad; veins reticulate with midvein usually disappearing at the apex, elongated areoles visible with free ending veinlets; herbaceous in texture; fertile stalk 4–10 cm long; spikes 1.5–3 cm long; 6–14 pairs of sporangia in two rows; spores 30–42 µm in diameter, circular, trilete with smooth exine.

3.2.1 Habitat: Growing in moist soil in grassland habitat associated with other Gramminae members of angiosperm.

3.2.2 Fertile: August–September

3.2.3 Specimen examined: India, Gujarat state, Ahwa, (23º45'10.29" N, 72º09'01.80" E, 74 m), Jambughoda *Mitesh Patel* BVBRC107. August, 2017.

3.2.4 Distribution
World: Japan, China, Korea and India**.**
India: Madhya Pradesh, and Gujarat (new record).

3.3 *Hypodematium crenatum* (Forssk.) Kuhn & Deck. Reis. Bot. Ost-Afr. 3(3):37. 1879. (Fig. 3 A-C).
Polypodium crenatum Forssk. Fl. Aegypt.-Arab. 185, (1775).
Aspidium crenatum (Forssk.) Kuhn (1868), not Sommerfelt (1834), nor Mettenius (1856);
Dryopteris crenata (Forssk.) Kuntze; Hypodematium onustum Kunze; *H. Pilosum* Ching; *Nephrodium crenatum* Baker (1877), not Stokes (1812), nor Desvaux (1827), nor Keyserling (1873).
Plants 25–52 cm × 15–30 cm. Rhizomes creeping, thick, short, densely scaly together with stipe base; scales golden yellow, narrowly lanceolate about 0.5–2.5 cm, membranous, entire, apex acuminate. Stipes 12-45 cm long, green, glabrous at above, covered with golden scales at the base. Frond light green, herbaceous, deltate or pentagonal, lamina 3-pinnate-pinnatifid, hairy on both surfaces. Pinnae 6-12 pairs, basal 1 or 2 pairs largest, subopposite, deltate, upper pairs alternate, gradually reduced, ovate-lanceolate. Pinnules 6-10 pairs, alternate, deeply lobed, ovate-triangular, 2.3-6.4 × 2-4 cm, shortly stalked, pinnate-pinnatifid, apex acuminate, base cuneate, margin entire or undulate, apex obtuse. Veins on both sides, free, ending up to margin. Sori on dorsal side, pale grey, in the centre of veinlets, indusiate, indusia large, round, densely covered with hairs. Spores are ovoid with prominent, inflated folds.

3.3.1 Habitat: Grows on exposed rocks at medium to high altitudes.

3.3.2 Fertile: October–January

3.3.3 Specimen examined: India, Gujarat state, Junagadh, Girnar mountains (21º31'24.74" N, 70º31'50.98" E, 780 m), *Mitesh Patel* BVBRC112. August, 2017.

3.3.4 Distribution
World: Arabia, Vietnam, South and central China, Taiwan, Japan, Malaysia, Myanmar, Philippines, Africa, SW and subtropical regions of Asia and India**.**
India: Arunachal Pradesh, Uttarakhand, Madhya Pradesh, Rajasthan, Sikkim and Gujarat (new record).

Gujarat, ecologically and geographically diverse state of India in which most of the major mountain ranges of peninsular India like Aravalli, Vindhya, Satpura, and the Western Ghats are terminate. Although Pteridophytes (ferns and fern-allies) constitute a fairly good percentage of our flora and are often quite conspicuous in certain localities. Pteridophytes are neglected by most flora writers and except few preliminary

surveys in last few years, Gujarat remains Pteridologically unexplored. The present discovery of the world's smallest terrestrial Pteridophyte [16] and these records of three new species from Gujarat indicate that dedicated surveys across the state could yield additional Pteridological discoveries.

4. Figures

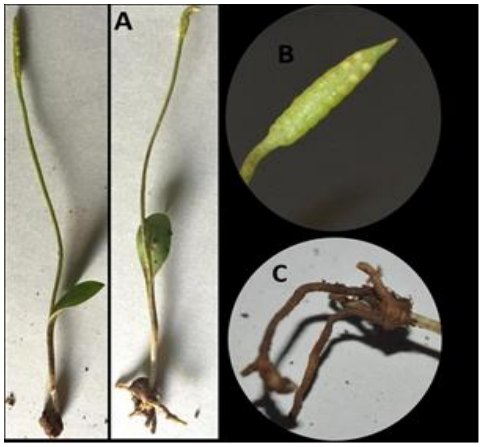

Fig 1: *Ophioglossum lusitanicum* A). Whole plant, B). Spike, C). Rhizome

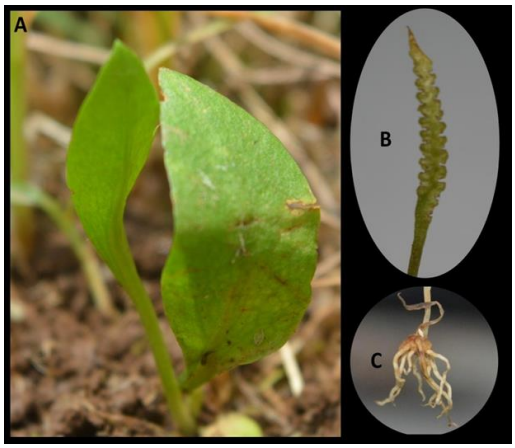

Fig 2: *Ophioglossum thermale* A). Whole plant, B). Spike, C). Rhizome

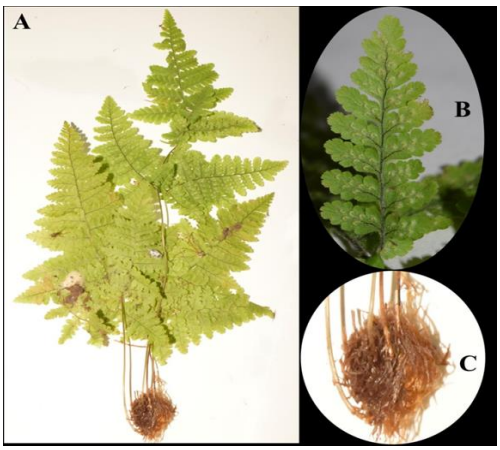

Fig 3: *Hypodematium crenatum* A). Whole plant, B). Lower surface of pinnules with sori, C). Base of stipes and scales

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