

DISTRIBUTION AND OCCURRENCE OF SOME PTERIDOPHYTES IN GUJARAT : A NEW RECORD FOR THE STATE

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Extensive field work in hilly regions, plain lands, wet lands, agricultural fields and arid regions of the Gujarat state was carried out in all 33 districts in 2013-14. From the total collection, five species differed from the earlier reported species. On critical study and detailed analysis they were identified as *Ophioglossum parvifolium* Grev. & Hook, *Aleuritopteris bicolor* (Roxb.) Fraser-Jenk., *Athyrium hohenackerianum* T. Moore, *Tectaria coadunata* (Wall. ex Hook. & Grev.) C. Chr. and *Salvinia molesta* D.S. Mitch. All newly identified species are found to be new record for the Gujarat state. Previous studies reported other species of *Ophioglossum* and *Aleuritopteris* while genera like *Athyrium*, *Salvinia* and *Tectaria* is reported for the first time from Gujarat forest. Present paper recommends further extensive studies to survey the diversity of pteridophytes in Gujarat. Moreover, *Aleuritopteris bicoloris* common in different forests while *Tectaria coadunata* is reported from only at two locations and possibly it may occur at other locations.

Keywords : Diversity of Pteridophytes, Distribution, Gujarat state, new addition

Gujarat possess wide range of habitat due to drastic differences in the temperature and rainfall which makes unique climate for harbouring wide range of plant and animal diversity. Gujarat is endowed with great diversity of natural ecosystems ranging from evergreen to moist deciduous, dry deciduous to semiarid and pure desert conditions. On the basis of the Champion and Seth (1968), out of all 16 different forest types in the country, four types of forests are found in Gujarat state : i) Tropical moist Deciduous Forest ii) Tropical Dry Deciduous Forest iii) Northern Tropical Thorn Forest iv) Littoral and Swamp Forest. Tropical moist deciduous forest occurs at the southern part of the state and is considered to be the part of Western Ghat that ends in Dang, Ahawa and Dharmpur districts (Tadvi 2013).

Central part of the Gujarat and some portion of Saurashtra region of the state which receive rainfall between 600 to 1200 mm are generally called tropical dry deciduous forests. Central part of the Gujarat is also blessed with wet lands. The area is also known for Savana type of grass field. Northern part of the Gujarat receives relatively less rainfall; thus, it is dominated

with thorny plant species and is categorised as tropical thorn forest. Areas like Kutchh, Jamnagar, Junagadh and Bhavnagardistrict fall into littoral swamp forest where mangroves are found at the coastal region. In earlier studies 18 species of pteridophytes are reported in wild from different regions of the Gujarat state (GEC 1996) while 15 species of pteridophytes are reported by Modi (2015) from Gujarat state. Subsequent field researchers repeatedly collected common species of genera like *Adiantum*, *Aleuritopteris*, *Azolla*, *Marselia* and *Ophioglossum* which are already known to occur in Gujarat. Thus, it is a general notion that state is represented with poor diversity of pteridophyte flora in Gujarat state. Since Gujarat state is known for its varying climatic condition like moist deciduous to pure desert conditions, state is having good number of species but no sincere efforts are made to explore their diversity. Therefore, the main aim of the present study is to report five species as new record and document the diversity of pteridophytes in Gujarat, western part of India.

MATERIALS AND METHODS

Extensive fieldwork was carried out in

undisturbed forest, secondary forests, wetlands, agricultural fields, bush fallow and farmers' trails in all 33 districts of the Gujarat state. Specimens were collected from a wide range of habitats such as terrestrial, mesophytic, aquatic and lithophytic. The morphological features were recorded and photographed in their natural habitat using Canon SLR 1200D. Collected specimens were immediately pressed using field press while rest of them were packed in the sterile polythene bags for further study in the laboratory. Collected specimens were studied in the laboratory by using Leica DME 2000 compound microscope and Leica MSZE6 stereo zoom microscope (Germany). Field press samples were used for the preparation of herbarium and voucher specimens which are deposited in BARO herbarium of the Botany Department, The Maharaja Sayajirao University of Baroda, Vadodara. After complete drying, samples were poisoned by 0.05% mercuric chloride dissolved in ethanol and air dried under fan. Dry specimens were mounted on herbarium sheet with the help of thin strip of sticky tapes followed by stitching on herbarium sheets with thread and needle.

Collected specimens were identified upto the family level by following the artificial key proposed by Woods and Diamond (2008) while detailed morpho-taxonomic identification of the specimens were carried out with the help of The Ferns of Bombay (Blatter and d'Almeida 1922), Ferns and Fern-allies of Sikkim Pictorial Handbook-2 (Kholia 2014), Pteridophytic Flora of Eastern India (Ghosh *et al.* 2004), Ferns of Southern India and British India (Beddome 1876), Ferns of North-west Himalayas (Dhir 1979), Pteridophytic Flora of Pachmarhi, Tamia and Patalkote in Central India (Vasudeva and Bir 1994), Hand Book to the Ferns of British India (Beddome 1892) and compared with the specimens available in e-herbaria of (<http://apps.kew.org/herbcat/navigator.do>) website. Further confirmation of the identity was done by Dr. Sachin Patil from Department of Botany, Shivaji University

Kolhapur, Maharashtra state.

Aleuritopteris bicolor and *Tectaria caudonata* were identified by molecular method for which genomic DNA was extracted using fresh leaves. Extraction was carried out using Plant/Fungi DNA isolation kit (Sigma Aldrich Cat# E5038) and manually by CTAB method by Doyle and Doyle (1990). PCR was carried out using 1X final concentration of ReadyMix™ Taq PCR Reaction Mix (Sigma) and, template DNA (50 ng/μl). Amplification of the DNA was performed in Thermal cycler (Applied Biosystems Veriti®). The genomic DNA was amplified by PCR machine with the primers rbcLaF and rbcLaR as described by Levin, (2003) and Kress and Erickson (2007). The amplified products were purified using Purelink™ Quick PCR Purification kit (Cat# K310001). Successful PCR purified products were sent for sequencing to Eurofins Genomics India Pvt Ltd., Bangalore.

RESULTS

Field studies were carried out in plains, hilly regions and aquatic bodies throughout the Gujarat during 2013-2014. From the total collection 31 species are reported earlier while five species differed from the earlier documented pteridophyte diversity of Gujarat (Figure 1-3). On careful observations and critical study these specimens were identified as *Ophioglossum parvifolium*, *Aleuritopteris bicolor*, *Athyrium hohenackerianum*, *Tectaria coadunata* and *Salvinia molesta*. The characteristic features of these species are as follows :

***Ophioglossum parvifolium* Grev. & Hook (Fig. 1A-D) :** Plants small, usually bearing only one or sometimes two fronds which are horizontally attached to the ground or slightly uplifted, stalk reduced or most part of the stalk is being buried or underground. Non-fertile lamina elliptic or elliptic-ovate, or circular, measuring 10-11 mm in length and width, base shortly cuneate, margin entire and apex acute or rounded; veins indistinct. Sporophore arises from the base of sterile

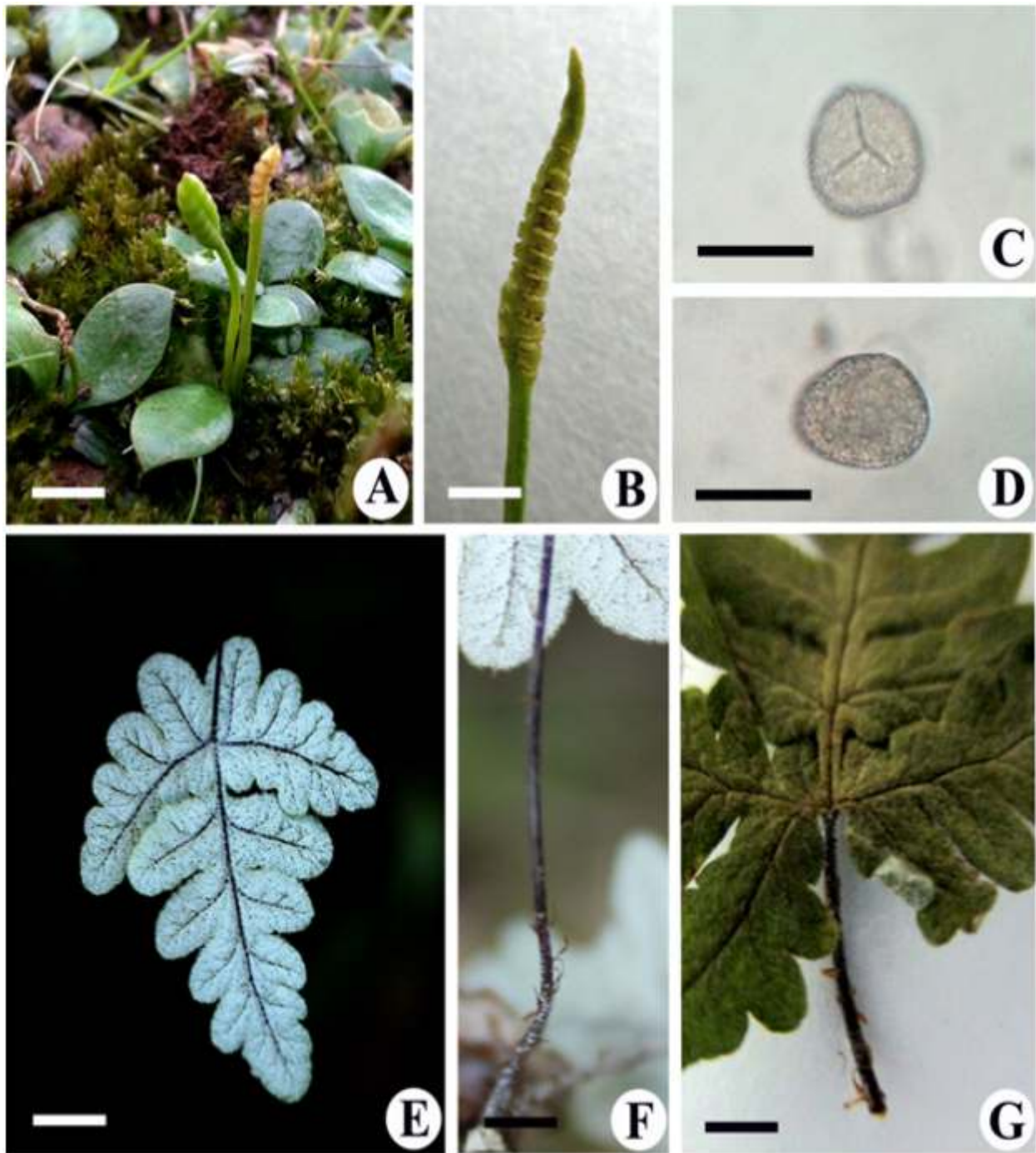


Figure 1 (A-G) : A. Enlarged view of *Ophioglossum parvifolium* habit B. *O. parvifolium* sporangia C and D. Spore surface of *O. parviflorum* E. Ventral surface of *Aleurites bicolor* F. base of the *A. bicolor* rachis G. Dorsal surface of *A. bicolor* showing portion of stipe. **Scale bar :** A = 10 mm B = 1.5 mm C, D = 40 μ m E, F = 12 mm G. = 5 mm.



Figure 2 (A-F) : A. *Athyrium hohenackerianum* habit B. Rachis of *A. hohenackerianum* with sori C. Part of the *A. hohenackerianum* rachis showing distribution of sori D. *Tectaria coadunata* habit E. Part of the *T. coadunata* showing reproductive structure F. Part of the leaf showing position of sori on ventral side of the *T. coadunata*. Scale bar : A = 50 mm B = 10 mm C = 6 mm D = 55 mm E = 11 mm F = 3 mm.



Figure 3 (A-D) : A. *Salvinia molesta* habit showing sporocarp (arrowhead) B. Transverse view of *S. molesta* papillate leaflet C. Enlarged view of figure 3B showing papillae D. Enlarged view of *S. molesta* sporocarp. Scale bar : A = 10 mm B = 1 mm C = 0.5 mm D = 4 mm.

lamina. Spike short, 38-42 mm high and surpassing sterile lamina, apex acute; sporangia 8–16 pairs. Spore surface coarsely reticulate. Rhizomes erect, thick with numerous fibrous roots.

Distribution

World : India, China, South America, Malaysia, Thailand, Sumatra. **India :** Gujarat, Madhya Pradesh, Maharashtra, West Bengal, Uttar Pradesh, Tamil Nadu.

Gujarat : Dharmpur forest (20°30'36.28" N and 73°21'6.27" E), Polo Forest (23°54'9.69" N and 73°13'45.36" E), Mahal (20°55'3.1" N and 73°39'42.9" E), Hathani Mata (22°28'03.55" N and 73°43'28.04" E), Zand Hanuman (22°22'16.47" N and 73°39'41.66"E)

Phenology : June-September

Ecology : Grows among grasses in open areas of forests at low and high altitude range.

***Aleuritopteris bicolor* (Roxb.) Fraser-Jenk. (Fig. 1 E-G) :** A small plant that forms loose rosette, reaching 10-15 cm in height. Rhizomes erect, short; frond triangular or deltate, stipe dark brown or black, stipe-scales do not extend to the top of the stipe; scales bi-colours, rachis and costae same colour as stipe. Lamina pinnate-bi-pinnatifid, papery after drying, deltate, lower surface with white farina, upper side glabrous; pinnae in 4-6 pairs, separated along rachis, pinnules smaller towards apex and largest towards base, lanceolate and pinnatifid. Second pair of pinnae shorter and narrower than the basal one and oblong-lanceolate shaped. Sori consists numerous sporangia which become confluent at maturity. Sori covered by

relatively broad and false indusia, membranous and interrupted.

Distribution

World : West Africa, Bangladesh, Sumatra, Myanmar, Thailand, Laos, South East China and New Guinea (Papua). **India** : Gujarat, Maharashtra, West to North-East Indo-Himalaya, Rajasthan, Bihar, Central India, Orissa and Southern part of India.

Gujarat : Junagadh (21°32'4.00" N and 70°31'26.90" E), Mahal (20°55'3.1" N and 73°39'42.9" E) Dharmpur (20°30'36.28" N and 73°21'16.27" E), Don (20°43'59.50" N and 73°51'23.98" E), Saputara (20°34'11.25" N and 73°44'52.45" E), Zavara Zavari (20°19'10.4" N and 73°19'18.2" E), Vavar (20°20'10.1" N and 73°23'10.2" E), Vasada (20°46'2.4" N and 73°28'49.9" E) and Sagai (21°39'32.99" N and 73°48'51.08" E)

Phenology : June- October

Ecology : A common species preferring shady, semi-open slopes, walls of the old constructions including forts and temples.

***Athyrium hohenackerianum* T. Moore (Fig. 2A-C)** : An ephemeral small herb, lamina ovate-lanceolate, pinnae in numerous pairs, deeply lobbed and cut down upto the rachis into ovate or oblong serrated segments, tip serrate, texture herbaceous, venation free, rachis scaly below and uncovered upward. Sori linear-oblong, numerous, conspicuous, horse shoe-shaped, Spores brown and wrinkled, monolet, bilateral and perisporiate. Rhizome densely ferrugineo-paleaceous, short, horizontal, caespitose, stipe tufted, closely covered with linear-subulate scales.

Distribution

World : India, Sri Lanka. **India** : Gujarat, Maharashtra, Central India (Pachmarhi), South India (Anamallays, Nilgiris, Wynad, Palghat, Coorg, South Canara)

Gujarat : Dharmpur (20°30'36.28" N and 73°21'16.27" E), Saputara (20°34'11.25" N and 73°44'52.45" E), Don (20°43'59.50" N

and 73°51'23.98" E), ZavaraZavari (20°19'10.4" N and 73°19'18.2" E), Vavar (20°20'10.1" N and 73°23'10.2" E), Vasada (20°46'2.4" N and 73°28'49.9" E), Mahal (20°55'17.7" N and 73°42'56.8" E) and Sagai (21°39'32.99" N and 73°48'51.08" E).

Phenology : June- October

Ecology : A common species preferring moist shaded environment and found in rock crevices, on road side walls, shaded forest slopes and along streamlets.

***Tectaria coadunata* (Wall. ex Hook. & Grev.) C. Chr. (Fig. 2D-F)** : A small seasonal plant reaching 30-60 cm tall. Fronds appear in clusters; stipe brown, bases densely scaly, covered with brown hairs, glabrescent upward. Leaf lamina pinnatisect, deltoid-ovate, with slightly cordate base and both surfaces are glabrous. Rhizome erect, short, stout, scaly at apex and stipe bases; scales dark-brown, linear-lanceolate or lanceolate, membranous, entire, apices long acuminate. Rachises and costae dark, raised, pubescent on abaxial surface, glabrous adaxially but sparsely covered on abaxial side with light brown hairs. Terminal pinna oblong or oblanceolate, larger than lateral ones and has acuminate-caudate apex. Lateral pinnae ovate-lanceolate, sessile, sub-opposite, oblique, bases cuneate-attenuate and apices acuminate-caudate. Basal pinnae are large. Sori orbicular, terminal, arranged in two irregular rows. Indusia reniform, glabrous, brown coloured.

Distribution

World : India, Bhutan, Burma, China, Sri Lanka, Laos, Madagascar, Malaysia, Nepal, Thailand, Vietnam. **India** : Gujarat, Uttarakhand

Gujarat : Saputara (20°34'11.25" N and 73°44'52.45" E), Malegaon (20°35'7.73" N and 73°44'51.58" E)

Phenology : Fertile fronds from October-December

Ecology : On edges of forests, shaded rocks

along roadside, in semi exposed but moist sites

***Salvinia molesta* D.S. Mitch., (Fig. 3A-D) :**

A free floating aquatic herb, rhizome (stem) horizontal, hairy at each node. Leaves trimorphic two of them are floating while third one is submerged into water and dissected. Floating leaves petiolate, oblong elliptic to obovate, cordate at base, boat shaped, lower portion curved upward from the water. Upper surface of leaf is papillate and are in regular rows. Every papillae crowned with four uniseriate, colourless hairs whose tip unit into thick dark or brown coloured cells. Midrib of floating leaves prominent, under surface covered with straight multicellular hairs. Sporocarp heterosporous (macro- and microsporocarp), the former one is glabrous or sub-glabrous, stalked while latter one is sessile or sub-sessile, globose and hairy.

Distribution :

World : India, Sri Lanka, Indonesia, Western Australia, South and Central Africa, Brazil, China. **India :** Gujarat, Maharashtra, Kerala, West Bengal

Gujarat : Ghuntvel (21°00'39.7" N and 73°34'50.2" E), Vadodara (22°19'17.10" N and 73°10'46.28" E), Waghai (20°45'14.1" N and 73°29'55.4" E)

Phenology : December-February

Ecology : Floating on river and Pond

DISCUSSION

Saxton and Sedgwick (1918) initiated studies on pteridophytes of Gujarat by reporting *Ceratopteris thalictroides* from the bank of Watrak River about a century ago. Thereafter, Mahabale (1948, 1963) collected the same from Sabarmati River at Ahmedabad. Main work on pteridophytes diversity in Gujarat initiated after 1950 by Phatak *et al.* (1953), Chavan and Mehta (1956), Gaekwad and Deshmukh (1956), Chavan *et al.* (1961, 1962), Chavan and Padate (1963), Shah and Vaidya (1964) and Inamdar (1970). Perusal of literature indicates that all these reported

species are collected from Baroda and environ, while forest areas are almost neglected which is a real home of this group of plants. That is one of the foremost reasons that diversity of pteridophyte is poorly reflected in the state. Moreover, Compared to angiosperms, this group could not fascinate more researchers. Recently, Modi (2015) documented 15 species of pteridophytes from different regions of Gujarat state.

From the total collection of our field visits, five specimens differed from the already recorded species of pteridophytes in Gujarat. On critical observation and detailed study, it was noticed that they are not reported previously from the Gujarat and stand as new record for the state. It is surprising to note that *Athyrium hohenackerianum* is abundantly growing throughout the major forests central and southern part of Gujarat while *Salvinia molesta* throughout the wetlands of the Gujarat but it stands to be new record for the state. *Aleuritopteris bicolor* (Roxb.) Fraser-Jenk., which is observed frequently in most of the forests but *Tectaria coadunata* is found growing only at Malegaon and Saputara. Different species of *Aleuritopteris* are common throughout the state; therefore, it is expected to occur in other forests of Gujarat but only few individuals of *T. coadunata* are recorded only from Malegaon and Saputara. It is well known hill station of Gujarat which is situated at high altitude (925 m) and is one of the moist and dense forests with abundant leaf litter. Such thick forest is rare in other forest regions of Gujarat. Therefore, its occurrence in other forest regions is unexpected, since *Tectaria* is saprophyte (Erfteimeijer and Hamerlynck 2005) flourishes well in dense forest with abundant organic matter. Occurrence of *Tectaria circularis* and *Athyrium solanopteris* from Girnar has been documented in earlier reports (Nayar and Santha Devi 1964). However, the diversity of Girnar forest has been drastically changed in last three decades. Our several visits in different parts of Girnar forest could not locate the same and needs further

investigation in this area.

In conclusion, Gujarat forest is rich pteridophyte diversity. Out of total collection during our field work, we collected five species viz. *Ophioglossum parvifolium*, *Athyrium hohenackerianum*, *Tectaria coadunata*, *Aleuritopteris bicolor* and *Salvinia molesta* are added as new record for the state. Common occurrence of *Athyrium hohenackerianum* throughout the Gujarat forests indicates that the studies on pteridophytes are neglected. Further, *Aleuritopteris bicolor* may be occurring in other forest regions along with other species of *Aleuritopteris* but no special efforts are made to locate them. All the pteridophytes occurring in the Gujarat are data deficient and needs further studies in different forest regions of the Gujarat state. We observed only few individuals of *Tectaria coadunata* in the Saputara forest and if it is restricted only to this area of the state, in such case it falls under the category of critically endangered but pteridophyte diversity of the state is data deficient therefore it is difficult to comment on their status. Therefore, present paper recommends extensive field studies on the pteridophyte diversity and suggests necessary management action plans to conserve them as the state is known for its various climatic conditions starting from moist deciduous to pure desert conditions.

Authors are thankful to Gujarat Biodiversity Board for financial support and forest range officers for providing necessary permission for the collection of herbarium specimens. Thanks are also due to Prof. S.P. Khullar for the identity confirmation and Prof. Y. Vimala (Chief Editor) and anonymous reviewers for their critical suggestions on the manuscript.

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