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Research Article

Assessment of Pteridophyte Diversity and their Status in Gujarat State, Western India

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Abstract

An intensive field survey was carried out from the hilly regions, plains of different climatic regimes and agricultural land of Gujarat state. About 23 species were collected from Gujarat state, from which eight species *viz.*, *Actiniopteris radiata* (Sw.) Link, *Adiantum caudatum* L., *A. incisum* Forssk., *Lygodium flexuosum* (L.) Sw., *Pteris vittata* L., *Selaginella ciliaris* (Retz.) Spring, *S. delicatula* (Desv. ex Poir.) Alston, and *S. repanda* (Desv. ex Poir.) Spring. were added as new distributional record for the Gujarat state. Increasing anthropogenic pressure, destruction of forest ecosystem and development of infrastructure facilities including road widening and rainwater harvesting program by deepening of the natural ponds are additional reasons for declining terrestrial and aquatic pteridophyte diversity respectively. Our survey concludes that *E. debile* is regionally extinct in the wild while *Isoetes coromandeliana*, will be lost from its natural habitat in short time if not conserved properly. Therefore, there is an urgent need of *in situ* conservation by developing action plans in collaboration with the state forest department.

Keywords

Diversity of Pteridophytes; Distribution; Gujarat state

Introduction

Pteridophytes are the considered one of the early land dwellers and most primitive group of vascular plants that appeared on this planet in the mid-Palaeozoic era (*i.e.* approx. 438 million years ago) during the Silurian period (Dudani *et al.*, 2011, 2014). Their adaptation to terrestrial condition by evolving specialized tissues for the translocation of water and food is responsible for their greater colonization in terrestrial ecosystems. Development of vascular tissue not only contributed in water and food translocation but also played crucial role in mechanical support. Therefore, many of them such as *Cyathea* and *Wilsonia* (tree ferns) could attain

great heights like trees. This interesting group of plants form an important component of forest ecosystem and act as connecting bridge between the non-vascular cryptogams and the seed plants and occupy various niches on the land, in marshes, swamps and in water bodies (Dudani *et al.* 2011). They flourish in moist tropical and temperate forests while, they also occur in different eco-geographical regions of the world where the conditions are not conducive for growth (Dixit, 2000). The majority of them thrive well in shady and moist places but a few survive in rock crevices and dry places while some of them such as *Salvinia* and *Azolla* grow in aquatic habitats (Bower, 1923, 1963).

According to Smith *et al.* (2006), it is estimated that there are about 9000-15000 species of pteridophytes that occur throughout the world while Moran (2008) predicted it to be approximately 13,600 species. Due to diversified topography, variable climatic conditions and geographical position, about 1200 species of pteridophytes are reported from India (Dixit, 1984, 2000; Sukumaran *et al.*, 2009; Dudani *et al.*, 2011; Patil and Dongare, 2013, Kavitha *et al.*, 2015; Kachhiyapatel *et al.*, 2015; Patel *et al.*, 2015; Patil *et al.*, 2012, 2014, 2016; Rajput *et al.*, 2016), in which nearly 17% species are endemic (Sanjappa and Venu, 2010). However, similar studies are lacking on the diversity of the state of Gujarat.

First report on pteridophyte (*Ceratopteris thalictroides*) of Gujarat comes from the Flora of North Gujarat written by Saxton and Sedgwick (1918). Subsequent studies on pteridophyte of Gujarat were taken up by contemporary researchers such as Phatak *et al.* (1953), Chavan and Mehta (1956), Gaekwad and Deshmukh (1956), Chavan and Sabnis (1961), Chavan and Padate (1962, 1963), Mahabale (1948, 1963), Shah and Vaidya (1964), Nayar and Devi (1964), Padate (1969), Inamdar and Shah (1967) and Inamdar (1970). Gujarat Ecological Commission (1996) documented 16 species of pteridophytes from different parts of the state, including forest areas. Thereafter, this group of plants was completely neglected and studies on them lagged behind. However, recently few sporadic reports about the occurrence of pteridophyte have been carried out by Patel *et al.* (2010), Dabgar (2012), and Modi and Dudani (2013). However, these reports lack location specific data on species reported from the state. This emphasizes the necessity for in-depth inventorization and documentation of pteridophytes. Thus, it was thought worthwhile to study the diversity of pteridophytes from Gujarat state.

Materials and Methods

The field survey was carried out from Gujarat state during different seasons of the year 2013 to 2015. Field photographs were taken by using digital camera (Cannon SLR 1200D). The collected specimens were properly processed in laboratory for the preparation of herbariums (Bridson and Forman, 1992). The herbariums have been deposited in the BARO herbarium of the Department of Botany, Faculty of Science, the Maharaja Sayajirao University of Baroda, Vadodara, Gujarat (India). Identification of specimens was carried out by the help of various flora *viz.*, Beddome (1883), Blatter and d'Almeida (1922), Dixit (1984), Khullar (1994, 2000), Ghosh *et al.* (2004), Fraser-Jenkins (2008), Chandra (2000), Kholia (2014) and Fraser-Jenkins *et al.* (2015). After identification and verification of correct identity, further confirmation of identity was done by Dr. Sachin Patil from Department of Botany, Shivaji

University Kolhapur (Maharashtra state). The classification of families and genera is followed according to Fraser-Jenkins (2009).

Information on the distribution pattern of pteridophytes in Gujarat is data deficient. However, on the basis of our last three years extensive survey in different regions and discussion with the field taxonomist, their status is categorized in the present study into RET species by following the guidelines for application of IUCN red list criteria at regional and national level (Version 3.1 2nd Edition and Version 12, <http://www.iucnredlist.org/documents/RedListGuidelines.pdf>).

Result and Discussion

The present comprehensive survey of Gujarat state records 23 (22 in wild and one under cultivation) species belonging to 11 families and 15 genera of pteridophytes (Table 1). Most number of species were observed in Pteridaceae (7 species), Ophioglossaceae (5 species) and Selaginellaceae (3 species) while Equisetaceae, Isoetaceae, Lygodiaceae, Azollaceae, Marsileaceae, Salviniaceae, Dryopteridaceae and Woodsiaceae represents one species. Amongst these species of pteridophytes, maximum diversity was found in Dang (forest) District, Shoolpaneshwar wildlife sanctuary (Narmada district) and Wilson hills in Dharampur district of the state. In the present study about 08 species *viz.*, *Actiniopteris radiata* (from Chotila, Than, Pavagadh, Chotta Udaipur and common in most part of the North Gujarat), *Adiantum caudatum* (frequently observed in most of the forest regions throughout the state), *A. incisum* (commonly observed in most of the forests throughout the state), *Lygodium flexuosum* presently observed throughout south Gujarat but expected in other parts), *Pteris vittata* (presently observed on the banks of major rivers and in rock crevices of south Gujarat forest and expected more in other parts), *Selaginella ciliaris*, *S. delicatula* and *S. repanda* (at several places in south Gujarat, Narmada district and expected other forests also) were added as new distributional record for the Gujarat state (Fig. 1-4). Some of the specimens collected from different forest regions were found to be biotypes of *Ophioglossum* (Fig. 5). Biotypes are the specimens that differ in size or shape of the particular organ like fronds or whole plant however they are identical in physiology physiological and anatomical characteristics (Anonymous, 2003-2015). Panigrahi and Dixit (1967) and Goswami (2007) reported occurrence of biotypes in the genus *Ophioglossum*. In the present study, we also noticed several variations in size of the specimen or number of trophophylls. The species *viz.*, *Ophioglossum costatum*, *O. reticulatum* and *O. nudicaule* are most common species for Gujarat state and the species *viz.* *Isoetes coromandeliana*, *Lygodium flexuosum*, *Ophioglossum gramineum* and *Tectaria coadunata*

Table 1: List of species reported by earlier workers and in the present study. *Abbreviations:* T= Terrestrial, L= Lithophyte, A= Aquatic and UC= Under Cultivation. Threat status as per regional level IUCN criteria: REW= Regionally Extinct in the Wild, CE= Critically Endangered, EN= Endangered, LC = Least Concerned, DD= Data Deficient. # may be typographical error in species name.* Species reported by earlier researchers with other name, which is synonym at present, ** Identification remains restricted up to genera level only.

Sr. No.	Name of Species	Family	Habit	Localities	IUCN category (Local threats, if any?)	References
1	<i>Actiniopteris australis</i>	Pteridaceae	L	Hampheswar, Kavant	Not seen in field	GEC (1996)
2	<i>Actiniopteris radiata</i>	Pteridaceae	L	Ambaji, Balaram, Chotila, Chotta Udaipur, Jambughoda, Jessore, Junaraj, Pavagadh, Polo Forest, Than, Zarwani	LC	Newly reported
3	* <i>Adiantum philippense</i> (syn. <i>A. lunulatum</i>)	Pteridaceae	T, L	Kavant, Navsari, Sagai, Vandsa Common in all Forest	LC	GEC (1996) Present study
4	<i>Adiantum caudatum</i>	Pteridaceae	T, L	Common in all Forest	LC	Newly reported
5	<i>Adiantum incisum</i>	Pteridaceae	T, L	Common in all Forest	LC	Newly reported
6	# <i>Aleuritopteris-favinos</i> (Probably <i>A. farinosa</i>)	Pteridaceae	L	Kavant	Probably <i>A. bicolor</i> (common in all forests)	GEC (1996)
7	* <i>Aleuritopteris bicolor</i> (syn: <i>A. farinosa</i>)	Pteridaceae	L	Dharampur, Don, Junagadh, Junaraj, Mahal, Sagai, Saputara, Vandsa, Vavar, Zarwani, Dabkhal (Common in all forest)	LC	Kachhiyapatelet <i>al.</i> (2015), Present study
8	<i>Athyrium solenopteris</i>	Woodsiaceae	T, L	Girnar, Saurashtra	Not seen in the Field, DD	Nayar and Devi (1964)
9	<i>Athyrium hohenackerianum</i>	Woodsiaceae	T, L	Dharampur, Don, Junaraj, Mahal, Sagai, Saputara, Vandsa, Vavar, Zarwani, Dabkhal (Common in all forest)	LC	Kachhiyapatel <i>et al.</i> (2015), Present study
10	<i>Azolla pinnata</i> subsp. <i>asiatica</i>	Azollaceae	A	Ahmedabad, Dabhoi, Kavant, Savli, Tuwa, Vadodara Common in wetlands throughout the state	LC	Chavan and Sabnis (1961), Chavan and Padate (1962), GEC (1996), Dabgar (2012), Modi and Dudani (2013) Present study
11	<i>Ceratopteris thalictroides</i>	Pteridaceae	A	Dharampur, Junagadh, Khedbrahma, Navsari, Rajpipla, Ratanmahal, Sabarmati river, Savli, Tuwa, Vandsa, Vyara, Vatrak river Barda, Jessore, Karjan river (N. Dediapada), Panjara ghat (N. Dediapada), Rajpipla (Khunta amba), Vandsa	LC	Saxton and Sedgwick (1918), Mahabale (1948, 1963), Chavan and Padate (1962, 1963), Padate (1969), GEC (1996) Present study
12	** <i>Cheilanthes</i> sp.	Pteridaceae	L	Vandsa	Probably <i>Aleuritopteris bicolor</i> (due to common occurrence in all forests)	GEC (1996)
13	<i>Equisetum debile</i>	Equisetaceae	UC	Savli Presently under cultivation in MSU Botanical Garden	REW	Chavan and Padate (1962), Padate (1969), GEC (1996) Patel <i>et al.</i> 2015 and Present Study
14	<i>Isoetes coromandeliana</i>	Isoetaceae	A	Talod, Tuwa, Vadodara, Vaktapur (Nr. Gandhinagar)	CE	Gaekwad and Deshmukh (1956), Chavan and Sabnis (1961), GEC (1996), Patel <i>et al.</i> (2015), Dixit (1984) and Present study
15	** <i>Lygodium</i> sp.	Lygodiaceae	T	Vandsa	Probably <i>L. flexuosum</i>	GEC (1996)
16	<i>Lygodium flexuosum</i>	Lygodiaceae	T	Chavshala (Nr. Kaprada), Dhulda, Mahal, Ratanmahal, Vandsa, Wilson Hill	EN	Newly reported
17	* <i>Marsilea minuta</i> (syn: <i>M. quadrifolia</i>)	Marsileaceae	A	Ahmedabad, Borsad, Dabhoi, Fulsar, Kavant, Navsari, Savli, Vadodara	LC	Chavan and Sabnis (1961), Chavan and Padate (1962), GEC (1996), Patel <i>et al.</i> (2010),

				Throughout the state in ponds, rivers and dams etc.		Dabgar (2012), Modi and Dudani (2013) Present Study
18	<i>*Ophioglossum costatum</i> (syn: <i>O. fibrosum</i>)	Ophioglossaceae	T	Dharampur, Kavant, Vadodara Ahwa, Chinchli, Dang, Don, Hathnimata, Jambughoda, Junagadh, Junaraj, Malegaon, Polo Forest, Ratanmahal, Sagai, Vansda, Wilson hills, Zandhanuman, Zarwani	LC	Phatak <i>et al.</i> (1953), Inamdar (1970), GEC (1996) Present study
19	<i>Ophioglossum reticulatum</i>	Ophioglossaceae	T, L	Dang Ahwa, Chinchli, Dang, Dharampur, Don, Hathnimata, Jambughoda, Junagadh, Junaraj, Mahal, Malegaon, Polo forest, Ratanmahal, Sagai, Vansda, Zand Hanuman, Zarwani	LC	Phatak <i>et al.</i> (1953), Shah and Vaidya (1964) Present study
20	<i>Ophioglossum gramineum</i>	Ophioglossaceae	T	Vadodara Jambughoda, Zand Hanuman	CE	Chavan and Mehta (1956) Rajput <i>et al.</i> (2016), Present study
21	<i>Ophioglossum nudicaule</i>	Ophioglossaceae	T	Dharampur, Tuwa Ahwa, Chinchli, Dang, Don, Hathnimata, Jambughoda, Junagadh, Junaraj, Malegaon, Polo forest, Ratanmahal, Sagai, Vansda, Wilson hills, Zand Hanuman, Zarwani	LC	Phatak <i>et al.</i> (1953), Inamdar and Shah (1967), Inamdar (1970), GEC (1996), Dixit (1984) Present study
22	**Ophioglossum spp.	Ophioglossaceae	T	Vansda	Probably <i>O. costatum</i> (due to its common occurrence in all forests)	GEC (1996)
23	<i>Ophioglossum vulgatum</i>	Ophioglossaceae	T	Vadodara	Not seen in field	Phatak <i>et al.</i> (1953)
24	<i>*Ophioglossum parvifolium</i> (syn. <i>O. nudicaule</i> var. <i>macrorrhizum</i>)	Ophioglossaceae	T	Dharampur forest, Hathnimata, Junaraj, Mahal, Polo forest, Sagai, Wilson hills, Zand Hanuman, Zarwani	LC	Inamdar and Shah (1967), Inamdar (1970) and Dixit (1984), Kachhiyapatel <i>et al.</i> (2015), Present study
25	<i>Pteris vittata</i> (reported in wild)	Pteridaceae	T, L	Ahwa, Dhulda, Don, Kaprada, Vansda, Waghai, Wilson hills	LC	Newly reported
26	<i>Salvinia molesta</i>	Salviniaceae	A	Ghuntvel, Vadodara, Waghai	LC	Kachhiyapatel <i>et al.</i> (2015), Present study
27	**Selaginella spp.	Selaginellaceae	T, L	Kavant, Ninai ghat, Vansda	Probably <i>S. ciliaris</i> (due to its common occurrence in all forests)	GEC (1996)
28	<i>Selaginella ciliaris</i>	Selaginellaceae	T, L	Ahwa, Dharampur, Kaprada, Mahal, Narmada, Sagai, Vansda, Wilson hills (common in all forest)	LC	Newly reported
29	<i>Selaginella delicatula</i>	Selaginellaceae	T, L	Ahwa, Junaraj, Kaprada, Mahal, Sagai, Vansda, Wilson hills, Zarwani	LC	Newly reported
30	<i>Selaginella repanda</i>	Selaginellaceae	T, L	Ahwa, Dharampur, Junaraj, Kaprada, Karjan Dam, Mahal, Malegaon, Saputara, Vansda, Waghai, Wilson hills, Zarwani	LC	Newly reported
31	<i>Tectaria coadunata</i>	Dryopteridaceae	T, L	Chinchli, Don, Junaraj, Malegaon, Saputara, Zarwani	EN	Kachhiyapatel <i>et al.</i> (2015), Present study
32	<i>Tectaria cicutaria</i>	Dryopteridaceae	T, L	Girnar, Saurashtra	Not seen in the field	Nayar and Devi (1964)

falls under RET category (Table 1). However, *Equisetum debile*, is regionally extinct in the wild while few saplings are under cultivation in the botanical garden of the Maharaja Sayajirao University of Baroda.

Earlier researchers reported 16 species of pteridophytes in wild, which represents a very poor status of pteridophyte diversity in the state (GEC, 1996, Modi, 2015). However from these 16 species, they identified four specimens only up to the generic level while other five species are the synonyms as per recent nomenclatural changes. During the present survey, most of the species were collected by us from the same or different localities as reported by earlier workers. However, we failed to recollect *Isoetes coromandeliana* and *Equisetum debile* from the reported localities. Both *I. coromandeliana* and *E. debile* lost their previously recorded habitat due to the urbanization and developmental policies such as road widening, water harvesting programs or habitat destruction due to deforestation and anthropogenic activities. Perusal of literature indicates that *Isoetes coromandeliana* at Harni (Gaekwad and Deshmukh, 1956, Chavan and Sabnis, 1961 and GEC, 1996) and *E. debile* at Savali (Chavan and Padate, 1962, Padate, 1969 and GEC, 1996) were commonly available in the aquatic pockets. Nevertheless, these localities are now converted into housing colonies as a suburban area of the Vadodara city. Thereafter, authors of the present study relocated this species from Talod and Vaktapur (Patel *et al.*, 2015). Similarly, *Ophioglossum gramineum* was recorded by Chavan and Mehta (1956) from Harni village that has been now completely replaced with residential colonies and housing societies which resulted in loss of habitat forever. Nayar and Devi (1964) also documented *Tectaria cicutaria* from Girnar and other parts of Saurashtra and *Athyrium solenopteris* from Girnar forest (Saurashtra region) of Gujarat. Chavan and Padate (1962), and Padate (1969), reported *Equisetum debile* from only one location *i.e.* Savli. Patel *et al.* (2015) worked on this species; however they could not found the same in wild after several visits on the same location, which indicates its extinction from its natural habitat. According to earlier reports, that *Pteris vittata* is cultivated as ornamental but in the present study we collected it growing wild in deep forest of Ahwa, Don, Waghai, Vansda, Kaprada forest and Wilson hills. It is also under cultivation throughout the state as ornamental in gardens as well as indoor plant. In 1996, Gujarat Ecological Commission (GEC) compiled pteridophyte diversity of Gujarat state and enlisted about 16 species belonging to 12 genera. We succeeded in the collection of all the species (excluding synonymous species and *Equisetum debile*) either from the same or another (new) location from the state (Table 1). The species *viz.*, *Marsilea quadrifolia*, *Aleuritopteris farinosa*, *Ophioglossum fibrosum*, *O. nudicaule* var. *macrorrhizum* and *Adiantum*

lunulatum that are reported by earlier researchers are synonym to *Marsilea minuta*, *Aleuritopteris bicolor*, *Ophioglossum costatum*, *O. parvifolium* and *Adiantum philippense* respectively.

Pteridophytes are plenty in the tropical, sub-tropical and moist deciduous forests of India. However, due to large scale destruction of forests has extremely affected the diversity of pteridophyte flora throughout the country. They flourish well in thick forests and their life-cycle depends upon the quality of forests. In the race of technology development and development of infrastructure facilities and anthropogenic pressure led to habitat destruction, which is consequently resulted in reduction in forest cover and destruction of natural habitat of many plant species. Several species of them are now rare or on the verge of extinction (Fraser-Jenkins, 2012). Based on the field observations, herbarium collections and available secondary data from the literature, Chandra *et al.* (2008), and Fraser-Jenkins, assessed the status of rare and threatened pteridophytes of India and Asia respectively. According to proposed list of Chandra *et al.*, *Ophioglossum gramineum* and *Isoetes coromandeliana* falls under the category of endangered species. Recently, Fraser-Jenkins updated the status of pteridophyte and above said both the species are documented as “near threatened” species in Asian continents. After consulting local residents of Talod and Vaktapur, it is observed that population of *I. coromandeliana* has drastically decreased within last two years because of deepening of the water pond under rain water harvesting program.

According to guidelines of IUCN, red list categories (IUCN 2001, 2012, 2016) may be used unaltered at regional level except three categories *viz.* taxa regionally extinct (RE) *i.e.* taxa extinct within region but existing in other region, Extinct in Wild (EW) *i.e.* extinct in natural habitat but they are under cultivation and Not Applicable (NA) *i.e.* introduced taxa which are not eligible for assessment at regional level. Beside these categories, there are other possible categories to access the taxa regionally. These categories are as follows: Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least concern (LC), Data deficient (DD), Not evaluated (NE). Since, there are no studies on diversity of pteridophytes of Gujarat, their status falls under Data deficient (DD) or Not evaluated (NE). In the present study, we have kept those taxa in the Least concern (LE) category which are abundantly available in the forest areas while other genera which are either available in other areas but authors have not collected from that locality are kept in DD while species like *O. gramineum* and *I. coromandeliana* are extensively surveyed but found only at one or two locations respectively. As per IUCN guidelines (for regional level assessment), *O. gramineum* and *I. coromandeliana* fall under CE category and *Lygodium flexuosum*

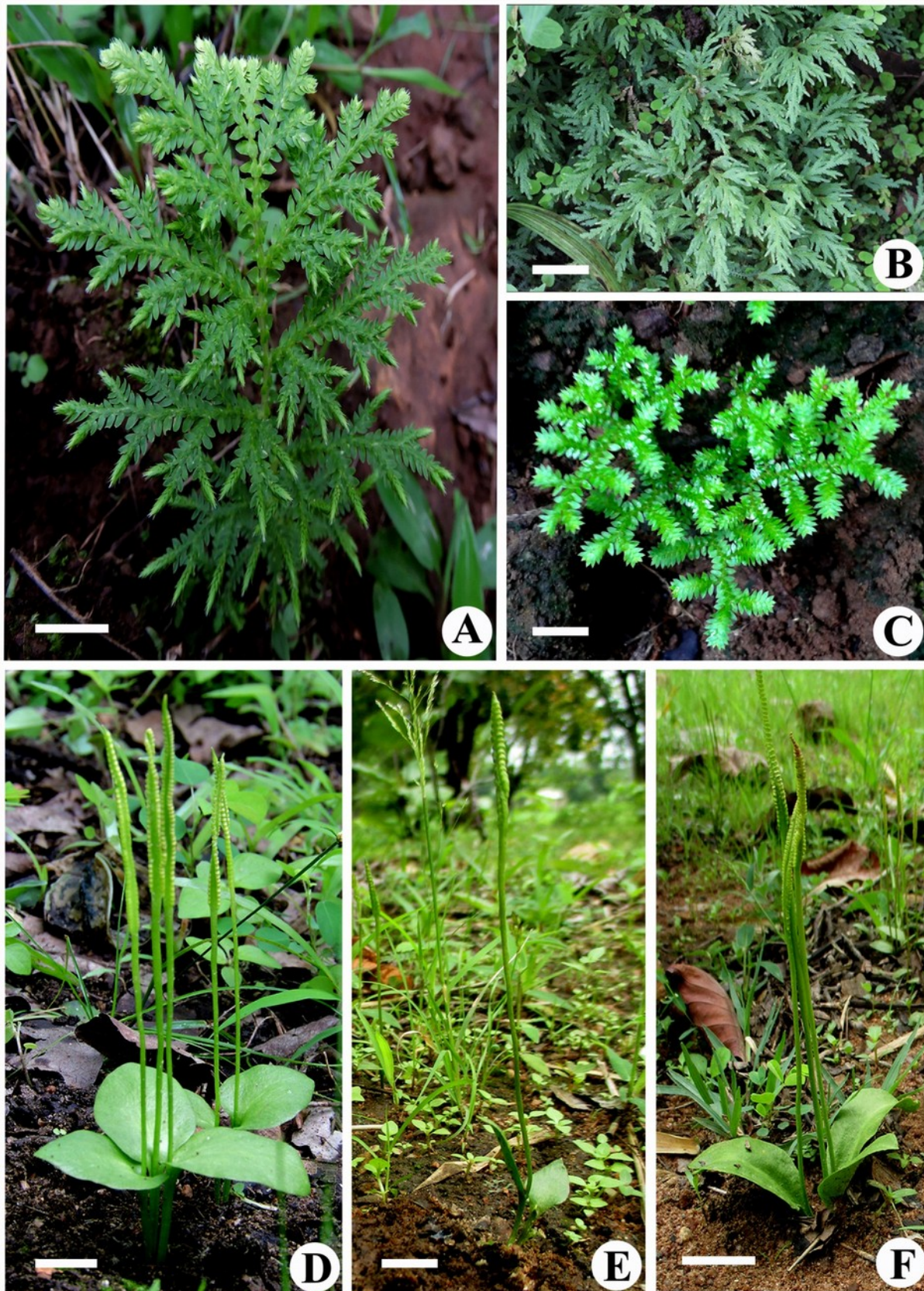


Fig. 1. Pteridophytes collected from different regions of Gujarat. A. *Selaginella delicatula* (Habit); B. *Selaginella repanda* (Habit); C. *Selaginella ciliaris* (Habit); D. *Ophioglossum reticulatum* (Habit); E. *Ophioglossum nudicaule* (Habit); F. *Ophioglossum costatum* (Habit). Scale bar: A, C, D, E, F = 10 mm, B = 2 cm

and *Tectaria coadunata* fall under EN. In contrast, *E. debile* is treated under regionally extinct in the wild (REW) since it is not found at the reported locality. For this purpose, we discussed with field taxonomist as well as local residents of that area

from where Chavan and Padate (1962) and Padate (1969) collected *E. debile* and found that it is not available in wild.

In conclusion, studies on pteridophyte diversity in Gujarat state are completely neglected

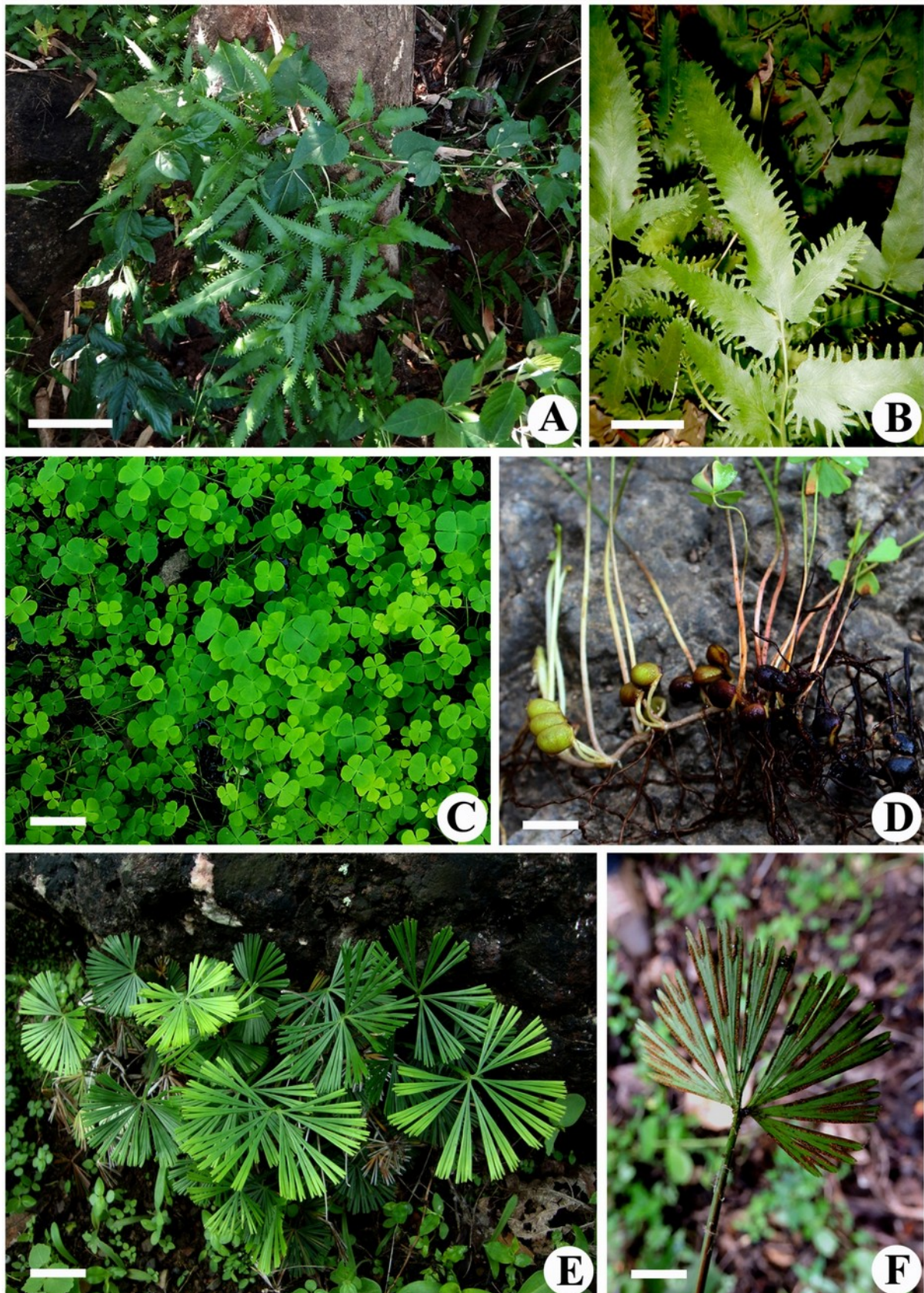


Fig. 2. Pteridophytes collected from different regions of Gujarat. A. *Lygodium flexuosum* (Habit); B. *Lygodium flexuosum* (Enlarged view of fertile branch); C. *Marsilea minuta* (Habit); D. *Marsilea minuta* (Enlarged view with sporocarp); E. *Actiniopteris radiata* (Habit); F. *Actiniopteris radiata* (Enlarged view of fertile portion). Scale bar: A = 35 mm, B = 20 mm, C = 15mm, D = 10 mm, E= 13 mm, F = 10 mm.

since last four decades. However, present survey reported 23 species of pteridophyte from which eight species are reported for the first time which indicates that Gujarat state is rich in pteridophyte

diversity and we expect much more number of species in further studies. From the earlier reported pteridophytes, *E. debile* is lost in the wild (REW) while *I. coromandeliana* lost its original

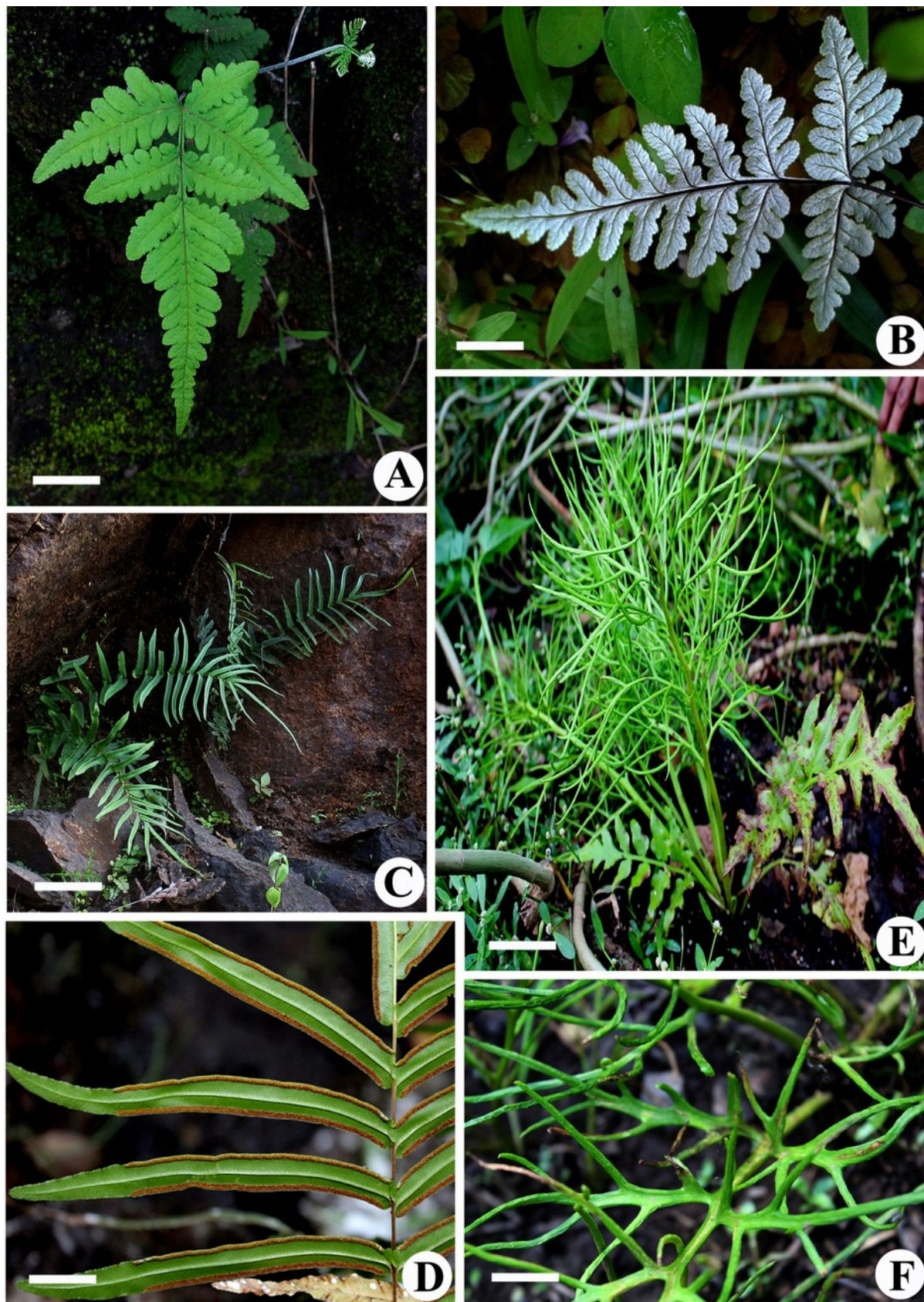


Fig. 3. Pteridophytes collected from different regions of Gujarat. A. *Aleuritopteris bicolor* (Habit: adaxial View); B. *Aleuritopteris bicolor* (Habit: abaxial View); C. *Pteris vittata* (Habit); D. *Pteris vittata* (Enlarged view of fertile pinnae); E. *Ceratopteris thalictroides* (Habit); F. *Ceratopteris thalictroides* (Enlarged view of fertile portion). Scale bar: A = 20 mm, B = 12 mm, C = 150 mm, D = 10 mm, E = 75 mm, F = 10 mm

habit but reported from the new home at Talod, and Vaktapur in Gandhinagar district. At both these localities, population is less than 100 plants at each location. Increasing urbanisation,

industrial areas, development of infrastructural facilities including rain water harvesting programmes by deepening of natural ponds, widening of roads, land sliding on road sides,

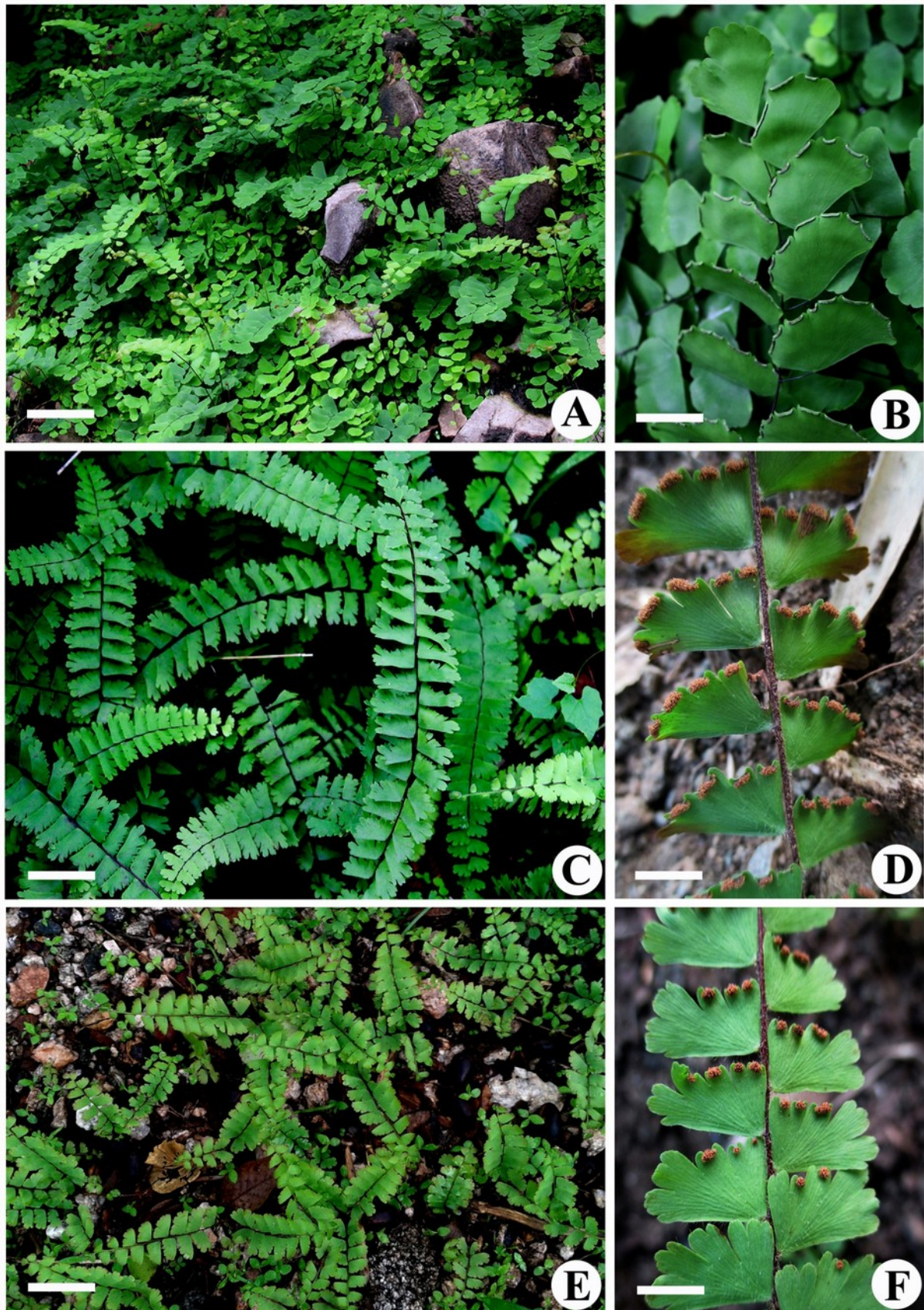


Fig. 4. Pteridophytes collected from different regions of Gujarat. A. *Adiantum philippense* (Habit); B. *A. philippense* (Enlarged view of fertile pinnae); C. *Adiantum caudatum* (Habit); D. *A. caudatum* (Enlarged view of fertile pinnae); E. *Adiantum incisum* (Habit); F. *A. incisum* (Enlarged view of fertile portion). Scale bar: A = 250 mm, B = 25 mm, C = 40 mm, D = 10 mm, E = 75 mm, F = 10 mm

decreasing forest areas and increasing grazing areas etc. are the major threats to declining pteridophyte diversity of the state. Since, there is

no enough information on the pteridophyte diversity of the Gujarat; thus, no much effort is made to conserve their diversity. Therefore, for

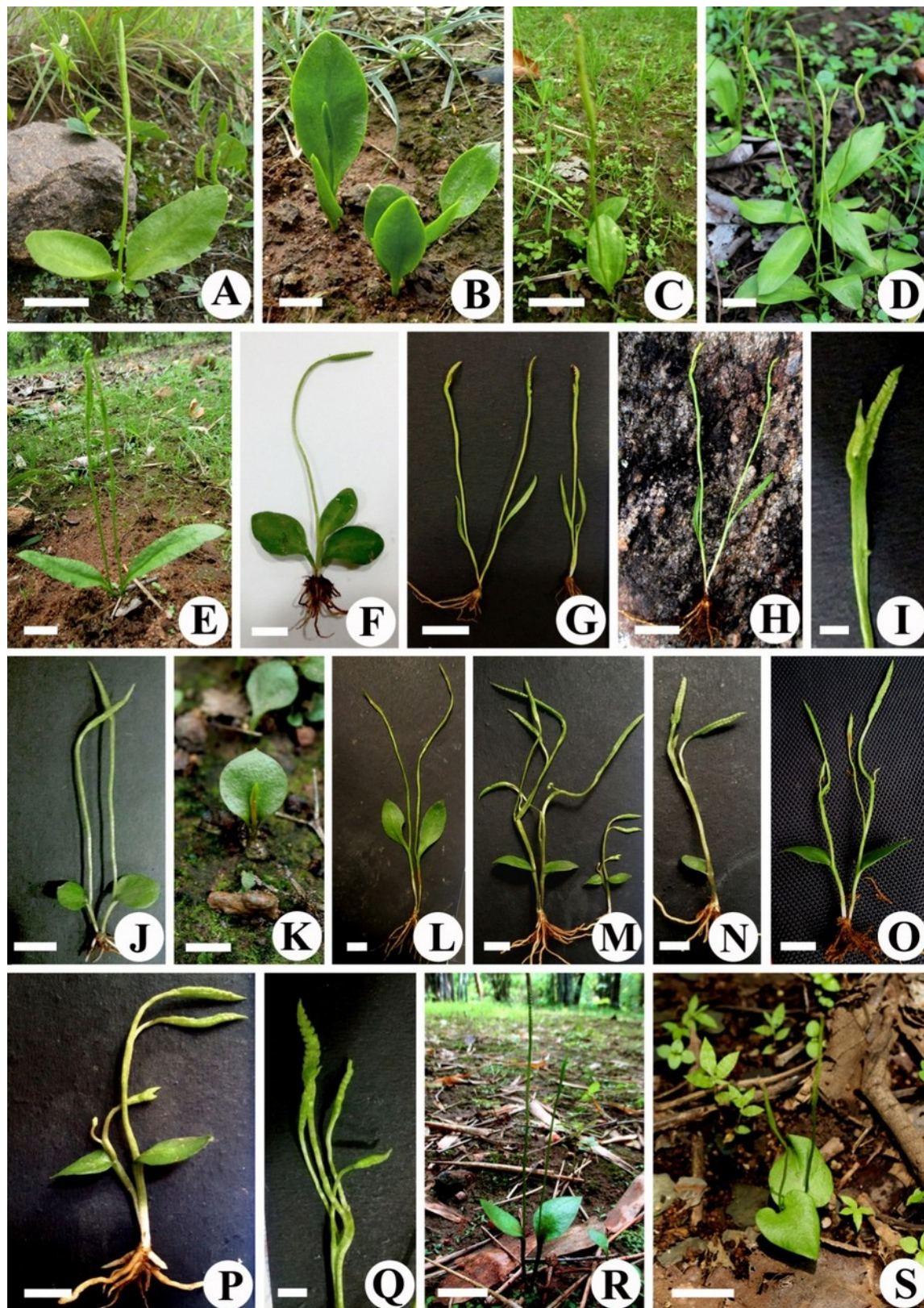


Fig. 5. Biotypes and anomalies in external morphology of *Ophioglossum* species (A-F *Ophioglossum costatum*, G-I *O. gramineum*, J-Q *O. nudicaule*, R and S *O. reticulatum*). A. *Ophioglossum costatum* (normal); B. *O. costatum* (feebly developed spike); C. *O. costatum* (normal, single tropophyll); D. *O. costatum* (normal, four elliptic lanceolate tropophyll); E. *O. costatum* (normal, two elliptic lanceolate tropophyll); F. *O. costatum* (normal, orbicular tropophyll); G, H and I. *O. gramineum* (bifurcated spike); J. *O. nudicaule* (normal, orbicular tropophyll); K. *O. nudicaule* (feebly developed spike and orbicular tropophyll); L. *O. nudicaule* (ovate tropophyll); M, N, O, P and Q. *O. nudicaule* (Branched and forked spike); R. *O. reticulatum* (normal); S. *O. reticulatum* (cordate tropophyll). Scale bar: A, G, H, J, K, M = 15 mm, B = 5 mm, C, D, E, R = 20 mm, F, L, N, O, P, Q = 10 mm, I = 3 mm, S = 25 mm

their conservation in natural habitat, there is an urgent need of *in situ* conservation by protecting

the natural habitat by developing action plans. For this purpose help is also needed from government

side particularly from the forest department to formulate necessary action plan to conserve these species by legal protection to protect the species falling in RET category. On this line, we have started *ex situ* conservation of these species by multiplying them using conventional method and cultivating them in the university arboretum. We are also trying to conserve them by providing the saplings to individuals who are interested to cultivate ferns in their home garden or as an indoor plant.

Competing Interest

The authors declare that they have no competing interests.

Authors' contributions

KSR and VMR designed and coordinated the study. RNK, SKP and KSR carried out fieldwork. Data analysis, identification and manuscript preparation is done by RNK and KSR.

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