Discussion

CHAPTER - VI

Pteridophytes are primary land dwellers and furthermost primitive group of vascular plants that originated on planet in mid-Palaeozoic era (*i.e*. nearly 438 million years ago) during the Silurian period (Chaloner & Sheerin 1979; Banks 1995; Kenrick & Crane 1997; Dudani *et al.* 2011, 2014). The evolution of specialized tissues for the mechanical support, translocation of water and photosynthate played a vital role in greater colonization and successful adaptation to terrestrial habitats to this group of plant. Development of the transportation of water and food tissue *i.e*. vascular tissue played a pivotal role by providing mechanical support to stand erect. Thus, several of them (like *Cyathea* and *Wilsonia* also known as tree ferns) could attain great heights like trees. Therefore, they are essential components of the forest flora due to their species diversity and richness. They are the pioneers in the evolution of land plants and play a crucial role in the ecology of every biogeographic zone (Rothfels *et al*. 2015; Rajput *et al*. 2016a). Pteridophytes flourish well in moist tropical and temperate forest. Besides this, they also found in various eco- and biogeographical zones of the world where conditions are unfavourable for proper growth (Dixit 2000). Most of them prosper well in shady and moist places while, a few of them survive in rock crevices and dry places whereas a few of them like *Salvinia* and *Azolla* occur in aquatic habitats (Bower 1923, 1963).

Nearly 11,916 species of pteridophytes have been projected to occur worldwide (PPG-I 2016), of which *ca*. 1138 species have been documented from different biogeographic regions of India (Fraser-Jenkins *et al*. 2016-2020). However, comprehensive work on pteridophytes diversity of Gujarat state was lacking due to a dearth of enumeration/excursion studies in the state (Rajput *et al*. 2016a, b). In the available literature, a relatively minor level of species diversity was reported by GEC (1996).

Gymnosperms are the most ancient seed plants, which are ascended during the late Paleozoic era *i.e*. *ca*. 265 million years ago (Uniyal & Awasthi 2000). Over time, most of them were shivering. They are considered as an integral group of the plant kingdom and placed between pteridophytes and angiosperms. They receive a varying degree of focus when dealing at hands of botanists. They are the most preferred plants for gardeners and plant lovers due to their expressive look, attractive foliage, simple cultivation, heavy trunks and typical reproductive apparatus (*i.e*. cones) and are the chief ornamental plants. The wood is straight-grained, lightweight and strength makes them easily workable. The wood of gymnosperms is often called softwood and can easily

discriminate from the hardwood angiosperms (Chamberlain 1935; Dogra 1964; Dutta 1973; Sahni 1986). They have their ovules without the ovary wall unlike, angiosperms, and are exposed before and after the fertilization. Naturally, these taxa are very common in the Himalayas and the mountains ranges of southern and northern India (Tripathi *et al*. 2009). In contrast to other plant groups, extant gymnosperms are less in number; they comprise *ca*. 1,106 species worldwide. In India, extant gymnosperms diversity is estimated *ca*. 157 taxa (149 species and 8 varieties including indigenous/introduced) belonging to 46 genera belonging to 12 families (Singh & Srivastava 2013; Sharma & Singh 2015; Akhtar *et al*. 2019).

Gujarat is the westernmost state of India, and biogeographically it is divided into five regions, *viz*., North, Central, South, Saurashtra and Kachchh. There are four National parks, twenty-three sanctuaries, and one conserved reserve forest, covering a 14,857.33 km^2 geographical area declared as forest and representing about 7.57% of the total land of the state (Anonymous 2021d). Climatic and geomorphological zonation of the state divides it into the largest zone, the coastline of the country, followed by the saline deserts of Rann (Little and Great Rann), Grasslands, Wetlands and moist deciduous to arid and semiarid areas. The state of Gujarat has four main highland ranges, *viz*., the Aravalli Range, Vindhya Range, Satpura (also referred to as Satpuda) Range and the Western Ghats.

The two important biogeographical areas, the Western Ghats (one of the important hot spots of biodiversity of the country, which lies along with the western coast of Peninsular India and reaches into southern Gujarat) and Kachchh (the northwestern part of the state). The state is geographically divided into dissected hills (Deccan traps and Mesozoic), Piedmont zones, Pediplains, Banni Plains (fluvio-marine), Alluvial plains and alluvial fans, Salt flats and encrustations and Mudflats). Such a wide array of climatic and geographical regions has resulted in varied and unique ecosystems.

Various pteridologists have attempted to work on pteridophytes in the past; from them, the most prominent and pioneer work was carried out by a field worker R. H. Beddome. He started his work in the field of ferns and their allies on the present-day Indian subcontinents and published several books and supplements (Beddome 1863-1892). Later, Nayar & Kaur (1974) and Chandra & Kaur (1987, 1994) compiled his work and included nomenclatural novelties to the fern's flora of the country. Subsequently, various field researchers worked on different bio-geographical zones of India and enriched the diversity of ferns and fern-allies of the country.

In Gujarat, Saxton & Sedgwick (1918) documented the first report on the pteridophyte (*i.e*. *Ceratopteris thalictroides*) in the Flora of North Gujarat. Subsequent studies on the diversity of pteridophyte of Gujarat were done by contemporary investigators like Phatak *et al.* (1953), Chavan & Mehta (1956), Gaekwad & Deshmukh (1956), Chavan & Sabnis (1961), Chavan & Padate (1962, 1963), Mahabale (1948, 1963), Shah & Vaidya (1964), Nayar & Devi (1964), Padate (1969), Inamdar & Shah (1967) and Inamdar (1970). Based on secondary data already available, Gujarat Ecological Commission (1996) compiled 16 species of ferns and fern-allies from different regions of the state including forest areas. Subsequently, this group of plants was completely ignored and research on them trailed behind. In the last decade, few sporadic reports appeared on the distribution of pteridophyte that was already reported by earlier researchers (Patel *et al*. 2010; Dabgar 2012; Modi & Dudani 2013). Nevertheless, these records lack location-specific data of the species reported from state and such studies were mostly concentrated on water ponds or open areas in and around the urban areas, whereas, dense forest and other areas are already known as rich and potential areas of angiosperms diversity are completely neglected. This gave realisation for the necessity of in-depth studies on documentation of the pteridophyte diversity.

6.1 Reports on pteridophytes of Gujarat state:

Pteridophyte of Gujarat state has received very little attention in terms of diversity and distribution and there has been no substantial previous work on this group of plants in this region. They are inadequately represented in the past literature (GEC 1996). As mentioned above, the first report of fern *i.e. Ceratopteris thalictroides* was reported by Saxton & Sedgwik (1918) from the riverbank of Watrak. Thereafter, Phatak *et al*. (1953) and Chavan & Mehta (1956) reported five species of *Ophioglossum*; Gaekwad & Deshmukh (1956) and Chavan & Sabnis (1961) recorded *Isoetes coromandeliana* from Harni pond, Baroda (Vadodara), but due to anthropogenic activities like, road widening and building construction, habitat was lost. Later, Chavan & Padate (1960, 1962) surveyed Savli and reported a common occurrence of *Marsilea minuta* (*M. quadrifolia*), *Azolla pinnata* and *Ceratopteris thalictroides*. Moreover, Chavan *et al*. (1961) enumerated the frequent occurrence of *O. costatum* (*O. fibrosum*), *O. vulgatum* (*O. nudicaule*), *Adiantum philippense* and *M. minuta* from Devgadh hills of Devgadh Baria. Further, Chavan & Padate (1962) and Padate (1969) enlisted *Equisetum debile* from Savali Taluka. In the present study, we could not locate the same due to

habitat destruction. Chavan & Padate (1963) provided distribution of *Ceratopteris thalictroides* from Savali, Rajpipla, Ratanmahal, Khedbramha and Junagadh. In the present investigation, besides other locations, we have successfully collected from Rajpipala and Junagadh. Moreover, Shah & Vaidya (1964) enumerated the common occurrence of *Ophioglossum reticulatum* from Dangs forest. Nayar & Devi (1964) carried out spore morphology of *Tectaria cicutaria* and *Athyrium solenopteris* collected from Girnar hills, Junagadh (Saurashtra). Later, American species whose name had used widely misapplied in India to *T. coadunata* and was similarly reported erroneously from Girnar forest. A few individuals of *Tectaria*, were collected near Ambaji temple in the Girnar hills were found to be *T. coadunata*. Available literature indicates that *A. solenopteris* is endemic to south India and its occurrence is reported only at higher altitudes (*i.e.* above 1500 m) while the Girnar hills have a maximum height of 1000 m. The report of *A. solenopteris* from Girnar; therefore, appears to be erroneous and *A. parasnathense* is common in the upper part of the hill. Inamdar & Shah (1967) reported *Ophioglossum nudicaule* and *O. nudicaule* var. *macrorrhizum* synonym of *O. parvifolium* from Dharampur forest and we have collected both the species from the same studied area. Thereafter, Thaker *et al*. (1971) misreported *Actiniopteris radiata*, *Adiantum philippense*, *Marsilea minuta*, *Ophioglossum costatum* and *Selaginella ciliaris* on the name of *A. austrialis*, *A. lunulantum*, *M. quadrifolia*, *O. fibrosum* and *Selaginella* sp. from Chhota Udaipur ranges. Gandhi *et al*. (1976) reported common occurrence of *Ophioglossum costatum* on the name of *O. fibrosum* from Girnar hills, Junagadh. During present investigation, we surveyed throughout the state including the same locality where few studies have already been carried out by earlier researchers.

The Gujarat Ecological Commission (GEC 1996) compiled a list of pteridophytes along with other flora (algae, bryophytes, gymnosperms and angiosperms) occurring in Gujarat, which included some erroneously reported species *viz*., *Ophioglossum fibrosum*, *Marsilea quadrifolia*, *Actiniopteris australis*, *Adiantum lunulatum* and *Aleuritopteris favinosa*. Later, Parmar (2008) reported *Actiniopteris radiata* and *Adiantum lunulantum* from Taranga Hills and Taranmata of Mehsana respectively. Parmar (2012) listed *Azolla africana* from Vijaynagar in the error of *A. pinnata* subsp. *asiatica*, which we have collected from the same location. Dudani & Gavali (2016) overlooked the report of Kachhiyapatel *et al*. (2016) and recorded *Thelypteris prolifera* as a new distribution record from Gujarat. Recently, Fraser-Jenkins *et al*. (2018a) reported *Diplazium esculentum* from Gujarat state; however, our frequent field visits to the relevant forest

areas in the state, we could not locate this species in the wild. It might be extinct from the state may be due to habitat loss or due to secondary data available in Blatter Herbarium, which has records including before separation of both the states.

A new species of *Ophioglossum i.e. O. malviae* M. Patel & M.N. Reddy, described from Dangs district was based on the size of the plant, spore morphology and molecular identification (Patel & Reddy 2018a). The external morphology of the plant and spore ornamentation showed significant similarity with *O. parvifolium*. Further, Patel & Reddy (2018b) added some mistaken identification of previously reported pteridophytes from the state. Moreover, Patel & Reddy (2018c) wrongly identified *Equisetum ramosissimum* Desf. subsp. *debile* instead of *Equisetum ramosissimum* Desf., from Dangs district and was collected from the same locality of our collection. Patel & Reddy (2018d) recorded *Cheilanthes tenuifolia* from Zand Hanuman. Similarly in the present study, we collected the same species from the Narukot, Jambughoda. On a similar line, one more unauthenticated species, *Ophioglossum aletum* M. Patel, M.N. Reddy & H.K. Goswami was described based on alete spore morphology by accepting the fact that strobilus of this species has an infrequent distribution of alete spores. This feature has been reported to be an irregularity in some related African species of the genus and individuals of this species growing in a small patch and are few in numbers (Patel *et al*. 2018). Another species, *O. hitkishorei* M. Patel & M.N. Reddy, was described from Dangs district, when compared with their description and photographic shreds of evidence they provided in the manuscript appears to be juvenile individuals of *O. costatum* R. Br.

In our earlier report, Kachhiyapatel *et al*. (2019) recorded *Athyrium micropterum* Fraser-Jenk., and *A. schimperi* Moug. ex Fee subsp. *biserrulatum* (Christ) Fraser-Jenk., from Dangs district Gujarat, which are corrected in Rajput *et al*. (2021) as re-identification and confirmation by Fraser-Jenkins, as belonging to *A. falcatum* Beddome and *A. parasnathense* Ching Ex. Mehra & Bir respectively. Recently, Patil *et al*. (2021a, 2021) added *Selaginella reticulata* (Hook. & Grev.) Spring, and *O. jaykrishnae* S.M. Patil, S.K. Patel, Raole & K.S. Rajput [a new species described by Patil *et al*. (2020)] to the pteridophyte flora of Gujarat state which escaped from the observations; though, the herbarium specimens are already available in BARO herbarium. Similarly, *Ophioglossum rubellum* Welw. ex A. Braun, a small, red coloured, annual fern was added to the flora of Gujarat by Patil *et al*. (2021b).

6.2 Reports on the gymnosperms of Gujarat state:

An immense work on wild-growing and exotic taxa of gymnosperms was done by various field workers from all the biogeographical zones of the state. In the present study, all the exotic and wild species that were reported from the state was successfully collected from gardens/arboretum and forests of the state respectively. The first and foremost report of *Thuja occidentalis*, an exotic species was recorded by Bharti (1959) from Visnagar. Subsequently, Joshi *et al*. (2006), Joshua *et al*. (2008), Joshi (2009), Patel *et al*. (2012) and Joshi *et al*. (2013) recorded rare and endangered plant species (*i.e*. *Ephedra foliata*) from Bhuj and its surroundings, Kachchh. During the present study, all the nearby areas of the Bhuj were surveyed and collected *Ephedra foliata* from various localities *viz*., Kala Dungar, Navinal, Mundra, Dhinodhar etc. Afterwards, Pandey *et al*. (2009) studied the phytodiversity of *E. foliata* from Narayan Sarovar Wildlife Sanctuary, Kachchh. Patel *et al*. (2010) recorded three ornamental gymnosperms from the campus of Arts, Commerce & Science College, Borsad. Modi *et al*. (2013) enlisted two ornamental gymnosperms from the campus of Gujarat University, Ahmedabad. Subsequently, Khokhariya *et al*. (2014) collected *E. foliata* from the island of Bet Dwarka. During the present survey study, we recorded few individuals of *Ephedra foliata* from the same localities. Meena (2014) listed one species of gymnosperm from Bhavnagar.

During the field survey in different biogeographic zones of Gujarat, unique population of *Ephedra* was collected from Ramsan (North Gujarat, arid region), which was under observation in the field since 2014. After critical observations and molecular evidence, it was found to be new and described as *E. karumanchiana* S.K. Patel, S.M. Patil, R.N. Kachhiyapatel, Raole & K.S. Rajput. Meanwhile, a similar population is also reported from several other locations (*i.e*. Dhroba, Dhakha, Vasan; Rajasthan state: Jalor Dt., Panseri, Pooran, up to Sunadha Mata temple). Recently, Meena *et al*. (2019) analysed the genetic diversity of *Ephedra foliata* occurring in Gujarat and Rajasthan and concluded that the population of *Ephedra* from Gujarat is genetically distinct from Rajasthan. Dendrogram provided by Meena *et al*. (2019) also depicting that samples from north Gujarat formed separate clade which is a piece of indirect evidence that samples collected from the northern part of Gujarat state also supporting to raise status as a new species.