CHAPTER 1

GENERAL INTRODUCTION

Pteridophytes, the seedless vascular plants constitute the dominant vegetation of the earth’s surface next to flowering plants. They possess a simple organisation [when compared to other tracheophyta] and are unique in being characterised by cryptogamic mode of reproduction and independent gametophytic and sporophytic generations and hence hold the key to a better understanding of different aspects of all vascular plants. Pteridophytes to which the ferns and fern allies belong constitute an important component of the flora. There are about 12,000 living species of ferns and 1000 species of fern allies in the world.

Ferns are found growing luxuriantly in the tropical regions where a humid tropical climate prevails [Holttum, 1954]. The most fern rich part of the old world tropics is Malaysia and Mainland South East Asia. The Indian subcontinent with a great variety of climates ranging from tropical to cold temperate supports a very rich flora of vascular plants. These number about 15,000 species of monocotyledons and dicotyledons [Santapau & Henry, 1973] and about 1000 species of ferns and 100 species of fern allies [Bir, 1991] with many of these being endemic in the country.

The Indian subcontinent constitutes one of the most valuable regions of the world as far as plant wealth in terms of species diversity is concerned. It is one of the richest tropical regions abounding in the pteridophytic flora, particularly fern flora [Fraser Jenkins, 1984]. Most of them inhabit a variety of niches in the mountainous regions which include central and western Himalayas, north eastern India and the Western Ghats [Nayar and Gee Varghese, 1993]. The Western Ghats are one of the important centres of plant diversity and richness [Heywood, 1995]. It is evident from the fact that about 233 fern taxa and 23 fern allies are estimated to occur in the region south of Palghat gap. There are about 137.
species of ferns endemic to India [Chandra, 1982; Chandra and Kaur, 1984 and Kaur, 1989] and 26 species of ferns confined to Sri Lanka and South India [Sledge, 1982]. Pascal (1988) is of the opinion that the highest percentage of endemism is found south of Palghat gap i.e. in a region with the shortest dry season. Being a vast country and one exceptionally rich in pteridophytes, it is best and more practical if detailed studies are undertaken of selected groups / families of particular regions.

The Western Ghats lie between 8° 20' - 20' 40" N and 73° 77' E and cover a distance of 1600 km from Tapti valley in Gujarat to Kannyakumari in Tamil Nadu. These series of hill ranges run north-south along the west coast. The more or less continuous hill ranges have a major discontinuity in the Palghat gap separating the Nilgiri ranges from the Anamalais. The Ghats descend steeply in the west facing the Arabian Sea whereas they merge gradually through a series of hills with the Deccan plateau in the east. Anamudi rising to 2695 m is the highest peak south of the Himalayas. The Western Ghats after the interruption by the 30 km wide Palghat gap, reappear abruptly as the Anamalai - Palni block. This block is a composite range made up of the Nelliampathi plateau [drained by Chalakudi] to the west, the Anamalai plateau in the centre and Palni horst overlooking the pediplain of Tamil Nadu from a height of almost 2000 m.

To the south of this West - East oriented block, the Ghats display further changes. Here they form an elevated plateau slanting towards the west - the Periyar plateau. The eastern part of this plateau forms the Elamalai range [Cardamom Hills]. This central range attains its peak, Devar Malai (1922 m) and terminates in the east by a sheer cliff about 1000 m high. From this, the SW - NE oriented Varushanad massif is detached and continued by the Andipatti which together with the Palni hills embraces the Kambum valley.
South of Devar Malai, at about 9° N the Ghats are once again interrupted by the narrow Shencottah pass (160 m). From here they continue as a narrow ridge with steep slopes to the west as well as to the east, until about 20 km before Cape Comorin [Kanyakumari]. This last bit is very rugged and its highest peak is Agasthiyamalai (1869 m). Here three regions may be distinguished: Agasthiyamalai proper, Mahendragiri to the south and the Tirunelveli hills on the eastern slopes. The coastal zone (20-50 km wide) constituting Travancore is made up of convex-shaped hills with rounded summits [Fig. 1].

By virtue of its geographical location, topography and rainfall from both the North-East and South-West monsoons, the Western Ghats shelter half of the wet tropical evergreen forests stretching from Maharashtra to Kerala. The tropical moist evergreen forests occur at an altitude of 200 - 1500 m, generally along the windward side where the rainfall ranges from 2500 - 5000 mm. The moist deciduous forests occur between 500 - 900 m depending upon the rainfall ranging from 2500 - 3500 mm. The dry deciduous forests occur between 300 - 900 m where the rainfall ranges from 300 - 900 mm. A characteristic feature of the Western Ghats is the occurrence of sholas above 1500 m. They are found in the Anamalais, the Nilgiris and the Palnis and the high ranges of Kerala and Karnataka.

The climate in Peninsular India is in general uniformly megathermal [Subramanian et al. 1965 and Rao et al. 1972]. South India falls under four homoclimate types such as semi-arid, sub-humid, humid and superhumid regimes [Chowdhury and Sarwade, 1982].

The Western Ghats of South India is one of the hot spots of the world as far as fern floras are concerned [Nayar, 1996]. More than 300 species of ferns and fern allies have been recorded from this region [Manickam and Irudayaraj, 1992 and Nayar and Gee Varghese 1993]. There is nearly no information on the current and possible utilization of ferns, though they are known to be in use as drug and food since long. Over 400 types of medicines prepared out of pteridophytes are currently in use in the indigenous Chinese medicine. Recent investigations have proved that many of the Indian pteridophytes are
Fig. 1 Western Ghats of South India.
having curative values. They also include some of the most sought after ornamentals, but lack of information makes the Indian ferns horticulturally least explored and exploited. Every plant has a role to play in maintaining a healthy environment and so ferns which form the dominant ground flora in tropical high altitude forests, have a vital role to play in the biogeocycles. The value of ferns for man, unknown as it may appear now, will definitely become apparent in the studies to be undertaken in the future [Manickam and Irudayaraj, 1992].

Fern and fern allies are of minor economic significance to mankind today. However, the great benefits from past eons when ferns and their allies dominated the world’s vegetation and contributed much to the world’s coal reserves will always be important. Their contribution has been of inestimable value and is highly significant today in an energy conscious world. In U.S.A. the large fronds of the Ostrich fern *Matteuccia struthiopteris* are highly regarded as a delicacy and are exploited commercially. Another fern which is used for food in the U.S.A. is *Onoclea sensibilis*. In Asia and the Pacific region, the developing croziers and young fronds of the fern, *Diplazium esculentum* are eaten as a cooked vegetable or raw in salads [Jones, 1987]. Young leaves of the fern are cooked as vegetables by the tribals of Uttar Pradesh in India [Singh et al. 1989]. The decoction prepared from rhizome and young leaves is used for haemoptysis and cough in Philippines. Similarly, the fronds of *Diplazium cordifolium* are cooked and eaten in New Guinea [Jones, 1987]. The extract of the fern *Diplazium dilatatum* is diuretic [Asolkar et al. 1992]. Ferns like *Athyrium filix-femina, Diplazium tomentosum, Deparia petersenii, Diplazium dilatatum* and *Athyrium niponicum var pictum* are of ornamental value [Jones, 1987].

Unfortunately the study of pteridophytes has been sorely neglected in India until recently and we do not have even today a reliable checklist of Indian pteridophytes nor have much idea about their ecology, the role they play in ecosystems [functional niche] and
possibilities of their economic exploitations as brought out by Nair and Bhargavan (1981). Hamburger et al., (1991) are of the opinion that ferns now receive more attention, because of the search for new biological compounds from all the available life forms in each and every part of the globe.

A number of compounds have been isolated from different taxa of some fern genera considered in the present investigation. Some of these genera are: Acystopteris [Murakami et al. 1986], Cystopteris [Murakami and Tanaka, 1988], Athyrium [Hikino and Hikino, 1970], Deparia [Hiraoka, 1978], Gymnocarpium [Murakami et al. 1986], Hypodematum [Murakami et al. 1986], Matteuccia [Mohri et al. 1982], Onoclea [Hiraoka, 1978] and Woodsia [Richardson, 1984].

The South Indian hills are rich in ferns with a number of endemic species. The Athyrioid ferns constitute one of the phylogenetic groups of plants. No critical study of these ferns has been undertaken since Beddome’s time. Minor changes in nomenclature and arrangement since then have been due to the publication of general taxonomic works on these ferns. Hence in the present investigation detailed micromorphology, ecology and distribution and phytochemistry of the following 12 Athyrioid taxa collected from different hills in South India have been studied:

1. Athyrium solenopteris (Kunze) T. Moore
2. Athyrium puncticaule (Bl.) T. Moore
3. Athyrium lanceum (Kunze) T. Moore
4. Deparia petersenii (Kunze) M. Kato
5. Dryoathyrium boryanum (Willd.) Ching
6. Diplazium esculentum (Retz.) Sw.
7. Diplazium polymodioides Blume
8. Diplazium brachylobum (Sledge) Manickam et Irudayaraj
9. Diplazium muricatum (Mett.) Aldrew. van Rosenb
10. *Diplazium dilatatum* Blume
11. *Diplazium travancoricum* Beddome
12. *Diplazium sylvaticum* (Bory) Sw.

Mature and healthy ferns were collected during winter season from the Western Ghats of South India and were shade-dried at room temperature for about three weeks. All vouchers of the collection have been deposited in the herbarium of St. Xavier’s College [XCH], Palayamkottai, India [Table 1]. The Athyrioid ferns were identified with authentic specimens by Dr. V.S. Manickam, Department of Botany, St. Xavier’s College, Palayamkottai, India.

Alston (1956) established the family Athyriaceae [Pichi-Sermolli, 1977]. There are about 24 Athyrioid genera throughout the world. In India about 39 species of *Athyrium* and 29 species of *Diplazium* are present [Bir, 1989]. In South India about 5 genera are recognized under this family namely *Athyrium, Diplazium, Anisocampium, Deparia* and *Dryoathyrium* [Manickam and Irudayaraj, 1992]. In Western Ghats, 22 species of *Athyrium* and 10 species of *Diplazium* are present. The Athyrioid group has been variously classified by the fern taxonomists according to their own conceptions.

Much ecological work on Indian Pteridophytes has not been done. Nearly no information is available on the ecology and distribution of Indian pteridophytes. The ecological study on the fern flora of Palni hills by Manickam and Ninan (1984) is the first of its kind in South India. In the present investigation, the distribution and ecology of the Athyrioid ferns have been studied for the first time. The distribution of the Athyrioid ferns on different hills of South India, their altitudinal range, light and moisture condition, vegetation type and frequency on the field have been studied in detail and presented. Some chemical characteristics [pH, total alkalinity, lime status, total N, P, K, Mg, organic matter and water holding capacity] of the soils from where the Athyrioid ferns were collected have been studied. These parameters are compared with the foliar mineral contents of the ferns in order to find out whether there is any correlation between the soil and the ferns.
### Table 1 Athyrioid taxa of the Western Ghats of South India

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the species</th>
<th>Locality</th>
<th>Voucher</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Athyrium solenopteris (Kunze) T. Moore</td>
<td>Berijam (Palni hills)</td>
<td>RHT 32829</td>
<td>2200</td>
</tr>
<tr>
<td>2.</td>
<td>Athyrium puncticaule (Bl.) T. Moore</td>
<td>Rottikadai (Anamalais)</td>
<td>XCH 2148</td>
<td>1300</td>
</tr>
<tr>
<td>3.</td>
<td>Athyrium lanceum (Kunze) T. Moore</td>
<td>Naduvattam (Nilgiris)</td>
<td>RHT 34478</td>
<td>2300</td>
</tr>
<tr>
<td>4.</td>
<td>Deparia petersenii (Kunze) M. Kato</td>
<td>Valparai (Anamalais)</td>
<td>XCH 2150</td>
<td>1300</td>
</tr>
<tr>
<td>5.</td>
<td>Dryoa thyrium boryanum (Wild.) Ching</td>
<td>Akkamalai (Anamalais)</td>
<td>XCH 1896</td>
<td>1800</td>
</tr>
<tr>
<td>6.</td>
<td>Diplazium esculentum (Retz.) Sw.</td>
<td>Sholayar dam forest (Anamalais)</td>
<td>RHT 31586</td>
<td>1050</td>
</tr>
<tr>
<td>7.</td>
<td>Diplazium polypodioides Blume</td>
<td>Perumalmalai (Palni hills)</td>
<td>RHT 31191</td>
<td>1700</td>
</tr>
<tr>
<td>8.</td>
<td>Diplazium brachylobum (Sledge) Manickam et Irudayaraj</td>
<td>Kakachi stream (Tirunelveli hills)</td>
<td>RHT 35322</td>
<td>1150</td>
</tr>
<tr>
<td>9.</td>
<td>Diplazium muricatum (Mett.) Aldrew. van Rosenb</td>
<td>Upper Kothayar (Tirunelveli hills)</td>
<td>RHT 35303</td>
<td>1300</td>
</tr>
<tr>
<td>10.</td>
<td>Diplazium dilatatum Blume</td>
<td>Kakachi (Tirunelveli hills)</td>
<td>RHT 32080</td>
<td>1100</td>
</tr>
<tr>
<td>11.</td>
<td>Diplazium travancoricum Beddome</td>
<td>Upper Kothayar (Tirunelveli hills)</td>
<td>RHT 32067</td>
<td>1200</td>
</tr>
<tr>
<td>12.</td>
<td>Diplazium sylvaticum (Bory) Sw.</td>
<td>Upper Kothayar (Tirunelveli hills)</td>
<td>RHT 32130</td>
<td>1200</td>
</tr>
</tbody>
</table>
Many morphological characters have been used for the taxonomic study of ferns. These include architecture and dissection of fronds, soral shape and distribution, venation, spore morphology, stomata, epidermal appendages and rhizome scales. All the characters are not equally applicable to all the ferns. Each group of ferns may need more attention for a particular character together with other characters [Manickam and Irudayaraj, 1992]. In most of the ferns macromorphological characters have been studied well but micromorphological characters are given least attention. Except *Deparia* and *Dryoathyrium* all other Athyrioid ferns lack epidermal appendages which can be used as criteria for the taxonomic study of ferns. Hence, other characters such as the venation pattern, stomatal types and spore morphology of 12 Athyrioid taxa are studied in detail in the present investigation for the delimitation of South Indian Athyrioid ferns.

Sledge (1956) is of the opinion that over-emphasis of one or more characteristics results in the creation of spurious species. In such situation these characters certainly exceed their reliability. Also, these characters vary according to their environment. The venation character has been used by many workers for the delimitation of fern taxa. So far, no detailed study has been made in the venation pattern of South Indian Athyrioid ferns. Hence the present study aims at knowing the role of the venation characteristic in Athyrioid ferns taxonomy.

Stomata occur on all aerial parts of land plants being most abundant on the leaf lamina except the veins [Sen and De, 1992]. As an organ a stoma is clearly of great importance to the physiology of land plants, being the site of gaseous exchange during respiration, photosynthesis and transpiration [Pandey and Sinha, 1995]. Besides, the structure and mode of arrangement of stomata provide very important clues to identify many of fossil or extant tracheophyta. In recent years, the structure and ontogeny of stomata in ferns have generated renewed interest in phylogenetic relationships among members of the Filicopsida [Sen and De, 1992]. However, no attempt has so far been made to determine the detailed structure of the stomata in all the South Indian Athyrioid ferns.
The only study on stomata of Athyrioid ferns in India is by Bir et al., (1980). About 33 Athyrioid taxa were studied by them. Manickam and Irudayaraj (1992) estimated that about 17 species of Athyrioid ferns are distributed in South India. Among these 17 species, stomatal studies were carried out on 10 species. However, except 4 species which were collected from South India, all other species were collected from the Himalayas. Stomatal studies on Diplazium travancoricum, Diplazium sylvaticum and Diplazium brachylobum which are mostly confined to South India and Sri Lanka have not been carried out so far. Hence, the above three species are studied in the present work in addition to 9 other species from South India. The additional nine species are studied in order to ascertain whether there is any intraspecific variation between the Himalayan and South Indian species or within the South Indian species since the Himalayan species are usually diploid while the South Indian species are tetraploid as seen in Diplazium muricatum [Manickam and Irudayaraj, 1992].

The role of spores in fern taxonomy was stressed by Brown (1960). The catholicity of the spores and their specific characteristics are important criteria in taxonomic and phyletic studies. Of late, both in India and elsewhere the significance of spores in taxonomy of ferns is more and more appreciated. In almost all the taxonomic and morphological papers published from India during the last 40 years, Light Microscopic (LM) spore characters of the taxa which were studied are invariably given [Bir, 1987]. Scanning Electron Microscopy (SEM) has helped in getting a more magnified and closer look at the surface of the spores with an added depth of vision [Devi, 1977]. With a view to finding out additional information on laesura, ornamentation and shape of the spores, SEM study has been carried out on 12 South Indian Athyrioid ferns in the present investigation. Such attempt is the first of its kind on South Indian Athyrioid ferns.
The phytochemical analysis and biochemistry are found to be of great use in the systematics and evolutionary relationship [Heywood, 1980]. Ferns are one of the largest groups of plants that have received little attention [Mabry et al. 1970]. Phytochemistry of Indian pteridophytes has largely been ignored as compared to morphology, anatomy and cytology. So far much work has been done on the pteridophytes of Rajasthan and the Western Ghats. However, no detailed study has been carried out on the South-Indian Athyrioid taxa. Hence, preliminary phytochemical study has been performed on the 12 Athyrioid fern taxa. Such studies would enable to find out the ferns that are rich in nutrients and minerals. For the 12 taxa under consideration Paired Affinity Indices (PAI) and Group Affinity Indices (GAI) with regard to the type of amino acids present in them were calculated. This study would enable to ascertain whether the species are related. To find out new biological compounds, systematic phytochemical study has been carried out on *Athyrium solenopteris* as it is confined to only South India and Sri Lanka. Five flavonoid glycosides have been isolated for the first time from this fern. The structural elucidation of these compounds are determined using U.V. shift reagent studies, Co-chromatographic studies with authentic specimens and hydrolysis followed by identification of the aglycones and sugar moieties with authentic specimens.
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