SUMMARY AND CONCLUSION

Pteridophytes were the dominant land plants in the Jurassic and Lower Cretaceous periods. Ferns and fern allies are the constituents of pteridophytic flora and they come next to flowering plants in dominance and representation in the extant vegetation, particularly in the tropics. They possess both a vascular system and a cryptogamous mode of reproduction. Now, 12000 species of ferns and 1000 species of fern allies are known to exist throughout the world. They grow richly in the temperate and cool tropical regions of the world.

Indian sub-continent with its striking varieties of ecological conditions provides a congenial environment for the luxuriant growth of ferns mainly in the peninsula to the south of the tropic of cancer with fairly high hill ranges i.e. The Western Ghats. These ranges lie between 8° 22' - 20° 40' North and 73° - 77° East and run for a distance of about 1600 km along the western border of Deccan from the mouth of river Tapti in Gujarat to Cape Comarin in the state of Tamil Nadu. The otherwise more or less continuous hill ranges have a major discontinuity at Palghat Gap (30 km wide), separating Nilgiri hills from Anamallays and a narrow Shenkottah pass at about 9° North. The average elevation is 1200 m with the highest Anamudi peak (2695 m) south of the Himalayas. The Western Ghats receive heavy rainfall both from the south-west and north-east monsoons. The annual rainfall varies from 1000 - 5000 mm depending on altitude. The climate of this region is tropical-warm and humid to sub-humid due to the alteration of monsoon seasons. The Western Ghats is one of the fern rich areas of the world because of high rainfall, moderate climate and complex topography, all favouring the formation of different habitats. It is evidenced by the fact that this region consists of about 300 species which constitutes about one forth of the fern flora of India, approximately 1000 species.
The family Dryopteridaceae Ching includes fourteen genera and about 1200 species, distributed widely in the temperate zone and at higher elevations in tropical parts. Twenty three taxa under eight genera have survived in South Indian hills because of an equable climate and the presence of mountain refugia.

The genera of Dryopteridaceae are the most complex and difficult to study not only on account of their larger size but also because they contain groups of closely related species with polyploids and apomicts resulting as one of the most controversial groups. There is diversity of opinion as to the composition of the group and its position in taxonomic schemes. The present study related to diverse aspects of the species has thrown light on this problem. Moreover the Western Ghats is identified as one of the species rich area and declared as an important mega biodiversity centre. Highly variable polymorphic species complex like Polystichum and Dryopteris are represented in the high mountains of South Indian tropics.

When compared to other countries of the world, ferns are the least exploited group of plants in India. Obviously, studies of these plants is equally important while evaluating the plant wealth of any region. It is also not possible to determine the source of any economically useful materials without any detailed phytochemical study.

A remarkable feature of fern distribution in this area is the high percentage of endemism due to diverse and localised conditions. Most fern species, being shade and moisture loving, grow in the interior of forests and sholas. Today most of the sholas on the high plateau of the Western Ghats have been cleared for cultivation leading to the destruction of ferns. These ferns have to be conserved in ex situ for which detailed ecological notes are essential.

Hence in the present investigation, a detailed ecological and micromorphological studies have been performed for the first time on the following 23 taxa of the family Dryopteridaceae collected from different parts of the Western Ghats of South India. However preliminary phytochemical studies have been undertaken only on 16 taxa of the family for want of materials:
In Chapter 1, the origin of the problem and the importance of the present study of the family Dryopteridaceae have been discussed in detail.

Chapter 2 deals with the area of the study. Detailed notes on physiography, rivers and drainage pattern, the climatic conditions with reference to rainfall, temperature, dry
periods and monsoons, soil types of the selected area, vegetational types of the area and fern flora of the Western Ghats of South India have been presented.

Chapter 3 provides a brief survey of significant treatments given to this group of ferns in different systems of classifications till the recent past. This chapter also pinpoints the broad consensus that has been arrived at regarding systematic position and phylogeny of Dryopteridaceae.

A close collaboration between laboratory and field studies is essential for any meaningful analytical work on systematics and taxonomy. The essential part is the understanding of the fern species right in its conditions of growth and throughout its distribution range. Detailed account on ecology and distribution of 23 taxa of Dryopteridaceae has been studied and presented in Chapter 4. The observations related to ecology viz., altitudinal range, main habitats, frequency and abundance, distribution in different hills, soil humidity, light conditions and vegetational types have been presented for the respective hills. The distribution maps are presented for every species based on the collection spots. The members of Dryopteridaceae grow in a variety of ecological habitats and have a wide range of specific distribution pattern. On account of the presence of overflowing streams, availability of deep shades, extremely damp soil with more humus on the surface and cool climatic conditions, the ravines of the Western Ghats provide the most congenial conditions for the luxuriant growth of the Dryopteridaceous ferns. Based on the total number of species represented by this family, Nilgris with 18 taxa is the richest area for Dryopteridaceous members and it is due to the complex topography with varied climatic conditions, the heavy rainfall and high altitude. Nilgris favours the growth of high altitude ferns like species of Polystichum and Dryopsis. The ecological conditions of Palnis favour the growth of many Dryopteris species. Very interesting about Kerala Ghats is that some of the high altitude species of Polystichum are growing at a lower altitudes from 900 m onwards because of heavy rainfall and a higher percentage of humidity. Generally, species of Polystichum grow at an altitude of 2000 m or above and members of Dryopteris grow between 1800 - 2100 m. A few species of Dryopteris and Arachniodes grow in a wider altitudinal range.
Phytogeographical analysis has shown that *Tectaria paradoxa*, *Polystichum harphophyllum*, *Polystichum subinermae* and *Dryopteris approximata* are endemic to Sri Lanka and South India. It is due to the reason that the topography is so complex and the peninsula is sufficiently away from the landmass due to the sea waters on three sides, the two main hill ranges with higher elevations on the coasts do avoid the opportunities for migration and extinction.

The correlation between the soil characteristics and plant elemental analysis have been performed for the first time to find out the relationships between the soil characteristics and the species. The chemical parameters such as pH, alkalinity, organic matter content, water holding capacity and mineral contents (total N, P, K, Ca and Mg) have been quantitatively determined and presented. Similarly, the mineral content of the 16 species have also been discussed. The results are compared and correlated with those of the soils.

Morphological work pays much dividends in the proper understanding of relationships between the taxa and in terms of classifications at family, generic and species levels. The micromorphological characteristics like venation pattern, stomata and spore morphology of the 23 taxa have been studied and presented in Chapter 5.

The evaluation of venation patterns in modern ferns is quite interesting. The venation pattern in ferns has provided valuable information to taxonomists but this character has been much neglected for quite a long period. The venation pattern of the ferns are photographed and presented. The complex venation pattern in certain taxa of this family has been discussed.

Ferns with an open type of venation pattern have been considered as primitive and ferns with anastamosing venation as advanced. In the present study, it has been observed that all except the species *Tectaria* and the varieties of *Phanerophlebia*, and all other Dryopteridaceous ferns are with free venation. *Tectaria paradoxa* is a much confused species with different names and synonyms due to the variation in anastamosing of veins. South Indian specimens have been identified as *Tectaria paradoxa* based mainly on venation pattern. Based on the comparative gross morphology of the venation of
Dryopteroid ferns two distinct groups of venation have been found. The first group with open and free veins usually with three orders ultimately forked once or twice, usually considered as a primitive group. The other group comprising *Tectaria* species and two varieties of *Phanerophlebia* have a tendency to increase in regularity and complexity.

Stomatal characteristics, such as the size of the guard cells, their arrangements, stomatal frequency and stomatal index have been studied in the epidermal peelings of the fronds. The epidermal peelings showing the stomata have been drawn using Camera lucida. The morphological and the ontogenetic stomatal types provide diagnostic character and valuable taxonomic and phylogenetic clues. Stomatal type is an important character that gives complementary systematic evidence.

In the present investigation 23 taxa belonging to Dryopteridaceae are investigated. Most of the leaves under present investigation are hypostomatic except *Hypodematium crenatum* in which it is amphistomatic. Broadly speaking, three types of stomata namely polocytic, staurocytic and hemiparacytic stomata are present in this family. Out of 23 species studied 18 species showed polocytic type. The largest stomata is found in *Arachniodes amabilis* and the smallest in the *Polystichum tanticopterum* stomal frequency is maximum in *Dryopteris juxtoposita* (92/mm$^2$) and minimum in *Phanerophlebia caryotidea var micropteris* (25/mm$^2$). The stomatal pattern of Dryopteridaceous members explain that they are relatively advanced and the members are much related and grouping of these plants is very natural.

The usefulness and applicability of spore characteristics have been stressed by several taxonomists. With a view to finding out additional information on spore surface ornamentation Scanning Electron Microscopic (SEM) and light microscopic studies have been done and a general account of spore morphology has been presented.

Spores are characterised by thick wall bearing incredible morphological features particularly in their exine. The wall structure is characteristic of particular species which helps in the recognition and identification of plants. The present study reveals that the Dryopteridaceous spores are monolete, plano convex to concavo-convex, reniform to spherical with or without a perine. Generally, the spores are light brown to dark brown in
colour and the size varies from 24 x 18 μm to 50 x 40 μm. The spore morphology of the Dryopteroid ferns will be a repository of information on the variety of sculptural patterns of spore walls and can be used in recognition and identification of the species.

Chemical characters assume much importance besides the usual characters in the recent years. They have been utilized for improving upon the classification. Secondary metabolite are the most useful in systematic and evolutionary studies. Hence, qualitative and quantitative analysis of various chemical compounds of 16 ferns of Dryopteridaceae have been performed and presented in chapter 6.

Preliminary phytochemical screening has been performed in petroleum ether (40°-60°C), benzene, chloroform and ethanol extracts of the sixteen taxa for the presence of steroids, triterpenoids, sugars, alkaloids, phenolic compounds, flavonoids, catechins, saponins, tannins, anthraquinones and aminoacids. Among the solvents used for extraction, ethanol is found to possess more number of compounds than the other solvents. Sugars and tannins are found in the benzene extracts of all the taxa. Steroids and flavanoids are found in benzene extracts of all the taxa.

The pigments such as chlorophylls carotenoids, anthocyanins and flavanoids have been quantitatively estimated. The pigments content have been correlated with light, altitude and morphology of the leaves. In the present investigation, it has been observed that the shade and medium altitude ferns possess more photosynthetic pigments than the Sun and high altitude ferns. It is also found that moderate and quite significant differences found in the pigment contents are due to the lamina size and texture of these ferns. In general, it has been observed in the present investigation that the contents of flavanoids and anthocyanins are found to be increased in high altitude ferns which could act as a protective screen against the intense UV radiation in high altitude ferns. Primary metabolites such as sugars, starch, free aminoacids, proline, total lipids and total phenolic compounds have been quantitatively estimated. The present investigation reveals that the amount of total and reducing sugars are maximum in the fronds and minimum in the rhizomes. On the other hand starch is in the reverse order.
Wide and significant differences are observed in free aminoacid, proline, total lipids and total phenolic contents of the species studied. The existence of differences in the content of metabolites are attributed to many factors which affect photosynthesis and ultimately the synthesis of other metabolites.

Separation and identification of aminoacids and sugars are effected by ascending and descending types of paper chromatographic techniques respectively. A wide variation is found in the distribution of aminoacids in the present investigation. Among the aminoacids taken for study L. leucine, L. proline and DL. serine are consistently present in all the taxa. It is also observed that 12 different aminoacids are present in Tectaria coahuana, Arachniodes amabilis and Dryopteris cochleata, eleven different aminoacids in five taxa and a minimum of eight aminoacids in Dryopteris hirtipes. The aminoacid profile is a consistent character because it is influenced by genes and hence genetical. So indentification of the aminoacids can be used to differentiate the species. Based on the group affinity indices it is observed that Dryopteris cochleata has the highest group affinity index indicating that it is closely related to all other species. Dryopteris hirtipes is distantly related to other species as it is evident from group affinity index. The paired affinity indices help us to understand the systematic decisions of the taxonomists regarding the status of the taxon.

Chromatography of sugar also revealed a specific pattern of distribution of the sugars in the different taxa. Differences are seen in the distribution of D. Mannose, D. lactose and D. galactose which could be used as identification marks.

Among the 16 species studied in the present investigation Tectaria paradoxa (Fee) Sledge has been chosen for a thorough phytochemical investigation of flavonoid constituents as it is confined to south India and Srilanka only. It is the most common species of Tectaria usually growing in rainforests as big colonies but a much confused species with different names and synonyms. The methanolic extract of the aerial parts of the fern has been subjected to paper and coloumn chromatography and four flavonoids which are already known have been isolated for the first time from this fern. The structural elucidation of the compounds are done mainly by 2 dPC with authentic rutin
standard and also by UV shift reagent studies. The O-glucoside sugar moieties are cleaved by refluxing with 2N Hydrochloric acid and the isomerised products are analysed by TLC. The structures of the four compounds are elucidated as Orientin, Isoorientin, Vitexin and Isovitexin.

The present interdisciplinary approach to the study of Dryopteridaceous ferns of the Western Ghats of South India would help towards better understanding of this group regarding their taxonomic relationships and evolutionary tendencies. The phytochemical study, just beginning in India is expected to stimulate interest among the fern researchers to extend similar study to other Indian ferns. While evaluating the plant wealth of this region, for exploiting the ferns, for use as raw material, the present study will be of great use in giving information about this group of ferns. The information on ecology and distribution will be of great help in conservation programmes. The future study of ferns should include this kind of investigation for a greater understanding of the diversity of ferns.