FLORISTIC DIVERSITY AND CONSERVATION STRATEGIES IN INDIA

VOL. I: CRYPTOGAMS AND GYMNOSPERMS

BOTANICAL SURVEY OF INDIA
Ministry of Environment and Forests

50

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Volume - I

CRYPTOGAMS AND GYMNOSPERMS

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BOTANICAL SURVEY OF INDIA

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प्रो० सैफुद्दीन सोज़
PROF. SAIFUDDIN SOZ

मंत्री
पर्यावरण एवं वन
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MESSAGE

Biodiversity-variety of life forms is essential for the survival of the planet. It is fundamental to fulfilment of human needs and ecologically sustainable development. India is one of the 12 megabiodiversity countries of the world. About 81,000 species of animals and 49,000 species of plants have so far been recorded in the country. Identification of the biological resources of the country and development of a sound database on them are prerequisites for effective conservation, management and sustainable use of these resources.

Botanical Survey of India (BSI) as the premier survey organisation of the country for floral resources is doing the basic work of inventorisation of plant resources. It is regularly bringing out publications on the flora of India at national, state and district levels. The present publication entitled 'Floristic Diversity and Conservation Strategies in India' is the first in a series of six volumes of State of the Art report on the occurrence and strategies and measures for conservation of floristic diversity in various States and Union Territories. The series of publications would provide a much needed understanding of the rich floristic diversity of the country, and would also help in formulating strategies for their conservation and sustainable utilisation.

The present publication in this series (Volume I) is devoted to the lower groups of plants namely the cryptogams and the gymnosperms. Publication of this volume this year is a befitting tribute of the BSI to India's 50 Years of Independence.

SAIFUDDIN SOZ

FOREWORD

These days, we hear and read a lot about biodiversity, and not unoften, from people who are not, or are very marginally, aware about its 'what', 'where', 'how', 'why', and 'when', etc.

To fill this gap, the Botanical Survey of India published in 1995, a volume on Indian floristic diversity in Hindi. It served two objectives. It was the first work in India's national language on the subject of biodiversity, and it soon placed a demand, and, shall we say a sincere obligation, on the Botanical Survey of India, to produce for the larger and global readership in English, a more comprehensive work in English language. The Survey has not failed the scientific community in this expectation.

The current book in six volumes has now been put forth by the Botanical Survey of India. This is probably the world's most voluminous and exhaustive account of floristic diversity published on any area of the world of the size of India.

Its publication is very opportune in another respect; it appears in the golden jubilee year of India's independence. It covers several aspects of floristic diversity, its utility and conservation. The various chapters are authored by well known taxonomists and economic botanists of Botanical Survey of India, and some other organisations. Some chapters have been contributed by very experienced superannuated scientists of Botanical Survey of India.

The book has fairly detailed account of the floristic diversity of the country, and is unique in the sense that it deals with varied facets. For example, the first volume contains chapters on different recognised plant groups of nonflowering plants and gymnosperms. The account of lower plants will inform many readers for the first time, the unique diversity in structure and life of these rather less known members of plant kingdom.

The second and third volumes deal with different states in various phytogeographic regions of India. The account provides an very interesting and informative.broad spectrum, as well as a comparative picture of the large diversity.

Among flowering plants, greater details are provided for certain economically or botanically more important or unique groups or genera;

for example, grasses (and bamboos) and legumes are specially treated in separate chapters in the fourth volume.

Fourth volume also deals with economic aspects. Separate chapters are provided for some groups like agriculture, medicinal plants, and ethnobotany. Genetic Diversity in crops or crop relatives is of great value. This aspect has also been dealt.

Conservational aspects have been dealt with in fifth volume. Proper conservation is the ultimate objective of such studies, and the editors and authors have given close attention to this by providing descriptions of *in-situ* and *ex-situ* methods and status in variety of habitat conditions, terrestrial or aquatic in fifth volume.

Some modern approaches and topics like questions of IPR or methods of biotechnology have not escaped the attention of authors.

The book has several useful appendices and indices. Readers will find them handy, for ready reference to contents of these volumes as also to certain related matters.

These volumes are also a good example of interdisciplinary approach and cooperative effort in handling a topical but also very vast subject like Biodiversity and its conservation. These volumes will serve as very useful guides to naturalists, biologists, and environmentalists.

The data in the book are based on life-time work and experience of the authors. The contents of the book can, therefore, be taken to be quite authentic and exhaustive, if not the last word for today's situation.

The contents cover various groups of the plant kingdom, and the information should be useful for utilisation and conservation of these bioresources, and also for further critical research.

The book is illustrated with numerous colour pictures; several of them are of unique habitats, plants or plant products.

The book will also help in the assessment of major gaps in our knowledge in any groups of the plant kingdom or in geographic regions of the country.

The book will serve as a very useful reference work for some decades and it should be welcomed by researchers in all departments related to plant resources like agriculture, forestry, indigenous systems of medicine, university botany departments, and even for development planners.

S.K. Jain

PREFACE

Bharat Ki Vanaspati Vividhita (Plant Diversity of India, in Hindi) was released by Shri N.R. Krishnan, Secretary to the Govt. of India, Ministry of Environment and Forests on April 4, 1996 at Central National Herbarium, Botanical Survey of India, Howrah Dr. T.N. Khoshoo, Distinguished Fellow, Tata Energy Research Institute, New Delhi wrote on August 24, 1996, "I have just received a copy of *Bharat Ki Vanaspati Vividhita*. I am indeed happy to glance over and it has given me some inkling of the facts and figures. I would appreciate the English version of it at your earliest end."

Besides, Dr. T.N. Khoshoo, several eminent scientists including heads of premier institutions of Botany, Wildlife and Environment, have suggested for the English version of the above endeavour.

Bharat Ki Vanaspati Vividhita contains articles on Floristic Diversity in regional context i.e. Eastern Himalaya, Western Himalaya, Eastern Ghats, Western Ghats, Deserts, etc., besides separate articles on different groups of flowering and non-flowering plants, economic aspects, conservation, prospects and possibilities. As, the vegetation in the context of phytogeographical regions, has already been dealt by Botanists through various publications, including the first introductory volume of Flora of India published recently by Botanical Survey of India so, it was thought to deal with the Floristic Diversity in the context of States and Union Territories in the present book.

Dr. K.P. Singh, Scientist SE, Botanical Survey of India, Eastern Circle, sent a detailed note containing guidelines and contents for bringing out the English version of Floristic Diversity. Dr. M.N. Aziz, Dr. P. Venu and Dr. M. Sanjappa also helped in enriching the contents.

The contents of *Bharat Ki Vanaspati Vividhita*, though proved to be more useful and attractive for scientists, were actually addressed to the limited readership, mainly the common people. Considering the global readership in English language, the author's contributions increased not only in coverage of the allotted chapters but also contained pioneering efforts of providing first ever analysis of Floristic Diversity in various contexts and thus increased several times in volume than that of *Bharat Ki Vanaspati Vividhita*. The tentative details of volumes and contents of "Floristic Diversity and Conservation Strategies in India" are as below:

Volume I : Cryptogams and Gymnosperms.

Volume II : Floristic Diversity in the context of States and Union Territories: Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chandigarh, Dadra and Nagar Haveli, Daman and Diu, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka Kerala.

Volume III : Floristic Diversity in the context of States and Union Territories: Lakshadweep , Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Pondicherry, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal.

Volume IV : Angiosperms (selected groups), Agricultural crops, Horticultural plants, Medicinal plants and Ethnobotany.

Volume V : *In-situ* and *Ex-situ* Conservation.

Volume VI : Prospects, Possibilities and Appendices.

The present work is the result of massive exercise done by more than 100 scientists mostly from Botanical Survey of India, during the last five years and the data pooled pertains to more than 100 years of its existence. It is hoped, that the publication would prove to be a treasure house of information on the diversified plant resources of our country and form basis for the subsequent works on plant diversity.

The present volume-I, contains a general review of floristic diversity and conservation strategies in India; diversity in non-flowering plants (algae, fungi, lichens, liverworts, mosses and ferns) and naked seeded plants i.e. the gymnosperms. More than 27,000 species out of the total 45,000 belong to these groups. The data on fungi, lichens liverworts, mosses, ferns and gymnosperms is based on actual counts of described species by the authors, while data pertaining to algae is based on published reports and estimates available. Diversity in woodrotting fungi (aphyllophorales) of the temperate-timberline zone of Himalayas, is based on the author's explorations and research work and brings into record very rare, interesting and incompletely known species. The material presented focusses on general diversity levels, diversity in specific groups, percentage of endemism and threatened species. Specific ecological issues that are further related to sustainability of species are also discussed. All such information provided, will not only be useful to the Botanists but also attract and enlighten the people from different walks of life. In order to conserve space and increase readibility, the author's citations have been omitted and will be given in appendices i.e. in the last volume of the series.

The editors are thankful to Ms. A.K. Ahuja, I.A.S., Joint Secretary, Ministry of Environment and Forests, New Delhi for her critical comments and helpful suggestions. The ungrudging help rendered by Dr. S. Babu and Dr. (Miss) S. Arora, of Ministry of Environment and Forests, is also acknowledged.

The preparation of this publication has been made possible by prompt cooperation and involvement of Dr. K.P. Singh, Botanical Survey of India, Eastern Circle; Dr. D.K. Singh, Dr. S. Kumar, Dr. J.R. Sharma, Shri B.P. Uniyal, Smt. Reshma Mathur, Shri R.C. Semwal, Shri S. Uniyal and other staff members of Botanical Survey of India, Northern Circle; Dr. P. Venu, Botanical Survey of India, Southern Circle; Dr. P.S.N. Rao and P.V. Sreekumar, Botanical Survey of India, Andaman & Nicobar Circle; Shri Utpal Chatterjee, R.G. Bhakta, S.K. Sur and S. Roy, Publication Unit; Dr. M. Sanjappa, Dr. G.V.S. Murty, Dr. G.S. Giri, Central National Herbarium; Dr. D.C. Pal, Shri R.N. Kayal, Dr. Subir Bandopadhyay, Dr. S.C. Srivastava, Dr. A.K. Sahoo, Shri M.K. Pathak, Shri M. Bhaumik, Shri Sabya Sachi Saha, Shri P.P. Ghosal, Km. B. Sutar, Shri D.D. Bahali, Shri M. Das, Shri S. Bandopadhyay, Shri S. Mitra and Shri R.P. Bhattacharya, Pharmacognosy Unit, Botanical Survey of India; and Shri I.J. Gupta of Zoological Survey of India. Shri Shital Adhikari of Botanical Survey of India has also helped in many ways.

The work involved a team work for months together by various persons of botanical background at the residences of Shrimati Archana Mudgal, Calcutta and Shrimati Vijay Sharma, Dehra Dun. Both of them had gladly accepted all the inconveniences and helped a lot.

V. Mudgal
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FLORISTIC DIVERSITY-REVIEW, SCOPE AND PERSPECTIVES

J.R. Sharma
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The realization that the earth's biological systems consisting of plants, animals and microorganisms are of fundamental importance for human society and that our influence on these systems is increasing exponentially has resulted in the increased interests being expressed in the environmental issues throughout the world. During the last decade, much of this interest and concern has been focussed on the issue of biodiversity. The scientific and social concepts and issues involved are highly complex and often poorly understood and badly explained.

The global biodiversity crisis has given rise to a growing concern at the prospect of a rapidly accelerating loss of species, populations, domesticated varieties and natural habitats such as tropical rain forests and wetlands. Recent estimates suggest that more than half the habitable surface of the planet has already been significantly altered by human activity (Hannah and Bowles 1995), and we are on the verge of mass extinction of species (Myers 1979, Wilson 1985). The woefully incomplete knowledge of the biodiversity and variability of plants, animals and microorganisms and the ecosystems in which they occur has further compounded the problem. It is this situation which emerged some fifteen years ago and led to the introduction of the notion of biological diversity meaning the total variability of life on earth (Wilson 1985, Wilson & Peters 1988, Reid and Miller 1989, Chauvet & Olivier 1993). The contracted form "biodiversity" was apparently coined by W.G. Rosen in 1985 for the first planning meeting of the "National Forum on Biodiversity" held in Washington during September, 1986. The multifaceted nature of biodiversity is reflected in the many definitions that have been put forward. But the definition adopted in article-2, of the convention on biological diversity is as : "Biological diversity means the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within species, between species and of eco-systems"

Biological resources are increasingly being eroded. There is a significant and growing scientific consensus that these resources are being lost at rates higher than ever witnessed before in the history of human evolution. Concern over this increasing loss of biological diversity has its roots in the evolution of interests in the environmental issues around 1940. The work of the World Conservation Union (IUCN) gave concern for biological diversity erosion. The efforts of United Nations in organising the UN Scientific Conference on conservation and utilization of resources in 1949 raised the global awareness of the problem. The conference also drew attention to the need to approach the problem through collective efforts. These issues were kept alive at various conferences, studies and publications in between 1960 and 1970.

The United Nations Conference on the Human Environment which was held at Stockholm in 1972 gave political and legal legitimacy to the issues of biological diversity. The conference underscored the link between development and environmental conservation. It formulated an action plan and also declared some environmental principles. The principle-II of the Stockholm declaration called upon the nations of the world to identify and institute the international programme on conservation of genetic resources. It stressed the concern that the natural resources of the earth including air, water, land, flora and fauna particularly the representative samples of natural ecosystems must be safeguarded for the benefit of present and future generations through careful planning and management as appropriate.

Although these issues were discussed during the Nairobi declaration of 1982, but the first significant and systematic effort to bring the attention of International community, the urgency of indentifying and instituting long-term measures to conserve biological diversity were made by the World Commission on Environment and Development (WCED) which was chaired by Gro Harlem Brundtland, the Norwegian Prime Minister. The commission was established in 1983 by the decision of United Nations General Assembly and was charged with the mandate of identifying long term strategies for achieving sustainable development through environmentally sound means. The commission particularly recommended that in order to ensure sustainable development, environmental concern should be integrated into economic programmes. This required a reorientation of the existing institution so that there is a greater coordination among conservation and economic institutions.

As part of the implementation of the recommendations of the Brundtland commission, the UN General Assembly convened the United Nations Conference on Environment and Development (UNCED). The UNCED agenda gave both North and South the opportunity to negotiate on such crucial issues as poverty alleviation and access to the genetic diversity. The UNCED, besides being a political venue for signatures on the two conventions i.e. climate change and biological diversity, also provided two nonbinding instruments i.e. Rio declaration and Agenda-21.

The biodiversity convention was one of the most significant and far reaching environmental treaties ever developed and signalled a move to a more proacting position that simultaneously seeks to meet people's needs from biological resources while ensuring the long-term sustainability of Earth's biological capital. The treaty was signed by heads of over 155 Governments in June 1992 and came into force on 29th Dec., 1993. India also ratified it on 18th Feb., 1994. At present 168 governments are the parties to the convention. This convention helped to articulate the growing global concern for saving and sharing the genetic wealth of our planet.

FLORISTIC DIVERSITY IN INDIA

Species and their populations vary widely in their abundance and geographical distribution because each region has unique phylogenetic, geographical and ecological conditions. McNeely *et al.* (1990) estimated that 70% of the world's total flowering plants occur in 12 countries and these have been called the megadiversity centres. Table-I shows the number of flowering plant species (Groombridge 1992) in some most species rich countries.

Table I
Twelve most species-diverse countries in the world for flowering plants

Country	No. of plant species (flowering)
Brazil	55,000
Columbia	35,000

Country	No. of plant species (flowering)
China	30,000
Mexico	25,000
South Africa	23,000
Former Soviet Union	22,000
Indonesia	20,000
Venezuela	20,000
United States	18,000
Equador	18,000
India	17,500
Australia	15,000

India, with geographical area of *ca* 329 million hectares and over 6,000 km of coastline, is the seventh largest country in the world and second largest in Asia. A great variety of climatic and altitudinal variations coupled with varied ecological habitats have contributed immensely to the rich vegetational wealth of India. There are almost rainless areas to the highest rainfall areas. The climate ranges from temperate to arctic in the Himalayas, to tropical and subtropical in its Indo-gangetic plains and the peninsular region. The altitude varies from the sea level to the highest mountain ranges of the world. The habitat types vary from the humid tropical Western Ghats to the hot deserts of Rajasthan, from cold deserts of Ladakh and icy mountains of the Himalayas to the long, warm coastline stretch of peninsular India. The extreme diversity of the habitats has resulted in such luxuriance and variety of flora that all types of forests ranging from scrub forests to the tropical evergreen rain forests, coastal mangrove to the temperate and alpine flora occur in the region. Out of the 16 major forest types (Champion & Seth 1968), the Tropical moist deciduous forests account for *ca* 37% while the Tropical dry deciduous forests form *ca* 28.6% of the forest cover in India. A significant feature of the Indian flora is the confluence of species from the surrounding countries like Malaya, Tibet, China, Japan, Europe and even from widely separated continents like America, Africa and Australia.

Though, the area of the country is only 2% of the world's total landmass, but India harbours *ca* 45,000 plant species (0.4 million known in the world), representing as much as 11% of the known world flora. Table-II. shows the number of species of major groups of plants described from India, World and their estimated number (Groombridge 1992).

Table II
Number of species of major groups of plants and microorganisms described and estimated.

Organisms	Species described		Estimated number
	India	World	World
Virus / Bacteria	850	8,050	9,00,000
Algae	6,500	40,000	3,50,000
Fungi	14,500	70,000	10,00,000
Lichens	2021	13,500	20,000
Liverworts	845	7,500	9,000
Mosses	1,980	7,000	9,000
Pteridophytes	1,200	10,000	12,000
Gymnosperms	48	650	650
Angiosperms	17,500	2,50,000	3,00,000

The flowering plants comprising *ca* 17,500 species under *ca* 4,000 genera and over 315 families (out of the total over 500 defined) occur in different ecosystems and represent roughly 7% of the described species of flowering plants in the world. As per the latest reports available family Poaceae is the largest, being represented by *ca* 260 genera and *ca* 1200 species followed by Fabaceae (*ca* 191/1152), Orchidaceae (*ca* 166/1141), Asteraceae (*ca* 167/950), Rubiaceae (*ca* 115/659), Cyperaceae (*ca* 38/545), Euphorbiaceae (*ca* 84/528), Acanthaceae (*ca* 92/510), Rosaceae (*ca* 40/492) and Lamiaceae (*ca* 72/454). *Impatiens, Carex, Dendrobium, Habenaria, Bulbophyllum, Rhododendron, Taraxum, Astragalus, Saussurea, Ficus, Primula, Cassia* are among the dominant genera of Indian flowering plants.

About 30 families have more than 100 species each, while over 60 families are represented only by one species. About 2560 species (15%) of the known species are trees, including highly valued timber species of the world, predominantly occurring in families like Euphorbiaceae, Lauraceae, Annonaceae, Rubiaceae, Moraceae, Fabaceae, Arecaceae, etc.

Indian flora also represents rich insectivorous plants belonging to families Lentibulariaceae (*ca* 36 spp.), Droseraceae (3 spp.), and Nepenthaceae (1 sp.), while the families Orobanchaceae (54 spp.), Loranthaceae (46 spp.), Santalaceae (10 spp.), Cuscutaceae (12 spp.), Balanophoraceae (6 spp.) and Rafflesiaceae (1 sp.) are known for parasitic plant species.

About 1000 species in 355 genera like *Arenaria, Thylacospermum, Acantholimon,* etc. are found growing in the cold deserts of Trans-Himalayan belt. These plants survive the adverse ecological conditions by special adaptations. Indian region is also known for many botanical curiosities like *Nepenthes khasiana,* species of *Utricularia, Drosera, Pinguicula* (insectivorous plants); species of *Galeola, Epipogium, Monotropa* (saprophytic plants); *Sapria himalayana* and *Mitrastemon yamamotoi* (flowers representing the whole plant); *Balanophora dioica, Boschiniaekia himalaica* and *Aeginetia indica* (parasitic plants). It is also worthwhile to appreciate the floristic diversity in some groups like Orchids, Bamboos, Rhododendrons, Citrus, Hedychiums, Impatiens, Pedicularis and Primulas (Rao 1994).

Out of *ca* 17,500 described species of flowering plants, over 5000 species (*ca* 33%) belonging to *ca* 140 genera and 47 families are endemic to present Indian boundaries. India harbours the maximum number of endemic species in the world after Australia. Areas rich in endemism are the North-eastern India (*ca* 3500 species out of 8000 known); Western Ghats (1600 species out of 5000 known); North-western Himalaya (1600 species out of 4500 known) and Andaman & Nicobar islands (195 species out of 2200 known). Because of the floristic richness, threats by environmental destructions and high proportion of endemic species, Eastern Himalaya and Western Ghats are recognised as two biodiversity "hot spots" among the 18 identified throughout the world (Myers 1990). Besides these two internationally recognised hot spots, different phytogeographic zones of India have over 40 sites (Nayar 1996) which are known for high endemism and genetic diversity.

Gymnosperms, though lesser in number as compared to other groups, but are equally important providing timber, wood, pulp, resins, tars, turpentines, etc. They are more gregarious and often dominate the Himalayan landscapes. They number about 60 taxa (including varieties) under 15 genera (*ca* 53 genera and 650 species in the world) and 8 families in the wild state. Apart from this, *ca* 26 species are exotics which are introduced in Indian Gardens/Parks and Avenues. Family Pinaceae (8 genera and 17 species) is the largest family followed by Cupressaceae (2/8), Ephedraceae (1/8) and Gnetaceae (1/5). Families Ginkgoaceae, Araucariaceae and Taxodiaceae include only exotic species. The dominant genera are *Ephedra* (8 spp.), *Pinus* (7 spp.), *Juniperus* and *Gnetum* (5 spp.). Five genera have only one species each in India. *Abies spectabilis*, *Cupressus torulosa*, *Taxus wallichiana*, *Pinus wallichiana* and *P. roxburghii* are widely distributed in the Himalayas while *Cedrus deodara*, *Picea smithiana*, *Abies pindrow* are confined to Western Himalaya and *Abies densa* and *Larix griffithiana* to the Eastern Himalaya. Many species like *Pinus gerardiana* (WH), *P. kesiya* (EH), *P. merkusii* (EH), *P. bhutanica* (EH), *Cephalotaxus manii* (EH) have very restricted and localized distribution in the respective Himalayan zones.

Most species of *Gnetum* are woody climbers/lianas and alongwith *Cycas* are mostly confined to North eastern India, Eastern & Western Ghats and Andaman islands. *Juniperus* species grow near timberline. *Abies spectabilis* has been found growing at an altitude of 5350 m in Kashmir, probably the highest limit for any tree species. *Pinus gerardiana* (seeds) and *Gnetum gnemon* (leaves and strobili) have edible value while *Ephedra* spp. (Ephedrine) and *Taxus wallichiana* (Taxol) are known for their medicinal value.

The Pteridophytes (fern and fern-allies) represented by over 1200 taxa under 204 genera (*ca* 10,000 species in the world), grow in all climatic zones of the country. Though still underexplored, the extent of richness and diversity in Indian Pteridophytes is further strengthened by the fact that they grow in a variety of habitats ranging from epiphytes like species of genera *Arthomeris, Belvisia, Microsorium, Lycopodium, Polypodium, Oleandra, Drynaria, Asplenium, Lepisorus, Vittaria,* etc; terrestrial like species of genera *Cyathea, Alsophila, Angiopteris, Osmunda, Equisetum, Lycopodium, Pteris, Pteridium, Polystichum, Athyrium,* etc. and aquatic like species of *Marsilea, Azolla* and *Salvinia.* Though, the pteridophytes in general prefer shady and moist places but a few species like. *Adiantum lunulatum, Psilotum nudum* love rocks covered with mosses and rock crevices and a few others like *Woodsia elongata, Actinopteris radiata* survive in dry places. *Acrostichum speciosum* and *A. aurexum* grow in mangrove forests. *Lygodium flexuosum* and *Microsorium normale* are climbers. Some species of *Vittaria, Lepisorus* and *Asplenium* prefer tree tops. Tree ferns like *Cyathea spinulosa* and *C. gigantea* adorn the tropical forests.

The North eastern India including Eastern Himalaya is the richest region representing 2/3rd of the known Pteridophytes i.e. *ca* 845 taxa under 179 genera followed by South India including Eastern and Western Ghats with 345 taxa under 117 genera and North India including Western Himalaya with 340 taxa under 101 genera. The families like Polypodiaceae (*ca* 137 spp.), Dryopteridaceae (*ca* 125 spp.), Athyraceae (*ca* 97 spp.), Thelypteridaceae (*ca* 83 spp.), Selaginellaceae (*ca* 62 spp.) and genera like *Selaginella* (*ca* 62 spp.), *Pteris* (*ca* 62), *Dryopteris* (*ca* 53 spp.) *Asplenium* (*ca* 45 spp.) and *Polystichum* (*ca* 45 spp.) are the dominant families and genera in the Indian Pteridophytic flora. About 17% of the species are endemic to India. Some species of genera *Diplazium, Dryopteris* and *Marsilea* are eaten. Similarly, *Adiantum capillus-veneris, Selaginella bryopteris* and species of *Lycopodium, Actinopteris, Polystichum* and *Marsilea* are well known for high medicinal properties in India.

The Mosses (Musci) constitute the major component of Indian bryophytes with *ca* 1,980 species occurring mostly in the hot and moist climate of Himalayas (*ca* 318 genera and 1,420 species) and Western Ghats (41 genera and 684 species). Eastern Himalaya harbours *ca* 1,030 species followed by Western Himalaya (*ca* 751 spp.) and Western Ghats (*ca* 684 spp.). Families like Pottiaceae (*ca* 190 spp.), Bryaceae (*ca* 150 spp.), Dycranaceae (*ca* 146 spp.) and genera like *Fissidens* (*ca* 67 spp.), *Bryum* (*ca* 59 spp.), *Campylopus* (*ca* 41) and *Brachythecium* (*ca* 39) are the largest families and genera of Indian mosses. Species of genera *Fissidens, Stereophyllum, Ditrichum,* etc. are common at lower altitudes while the species belonging to genera *Brachymenium, Philonotis, Campylopus, Pogonatum, Thuidium, Mnium,* etc., dominate in between 1500-3500 m altitudes. Another interesting aspect of Indian mosses is the presence of species of *Sphagnum, Calliergon, Pleuridium,* etc., above 5,000 m, indicating their adaptability to such conditions where other plants cannot even survive.

Indian Liverworts (Hepaticae) comprising *ca* 845 species, under 140 genera also contribute to the floral diversity. The vast areas in Himalayas and Peninsular India with abundant precipitation and high humidity are richer in liverworts as compared to the large plains stretching over greater part of the country. Eastern Himalaya representing with *ca* 548 species is the richest region followed by Western Ghats (*ca* 280 spp.) and Western Himalaya (*ca* 235 spp.). The rest of the country accounts for only *ca* 135 species. Families Legeuneaceae (*ca* 155 spp.) Plagiochilaceae (*ca* 119 spp.), Jungermanniaceae (*ca* 76 spp.) and Genera *Plagiochila* (*ca* 114 spp.), *Frullania* (*ca* 54 spp.), and *Jungermannia* (*ca* 38 spp.) are among the largest families and genera in India. The representation in certain genera like *Cyathodium* with 9 species out of 12 known and *Notothylus* with 8 species out of 18 known; presence of some phylogenetically significant genera like *Fossombronia, Sewardiella,* etc. together with the discovery of some fossil liverworts (*Hepaticites pantii*) are also indicative of the diversified and unique Liverwort flora of India.

The Lichens being represented by over 2000 species (*ca* 13,500 in the world) under 248 genera, also constitute an interesting component of Indian flora, growing from tropical to alpine zones of the country. The topographical and climatic conditions of India coupled with rich vegetation and diversified flora also point towards a rich Lichen flora. Based on the available data, Western Ghats are the richest with *ca* 800 species (39%) followed by Eastern Himalaya with *ca* 759 species (37%) and Western Himalaya with 550 species (27%). The families like Parmeliaceae Graphidaceae, Physciaceae, Usneaceae, Cladoniaceae, and genera like *Parmelia, Graphina, Usnea, Graphis* and *Lecanora* are among the dominant families and genera of Indian Lichens. Based on the data available, *ca* 20% of the species mainly belonging to genera like *Graphina,* *Trypethelium, Graphis, Porina,* etc. are endemic to India. As per the survey made till date, Andaman & Nicobar islands (24%), Western Ghats (20%) and Eastern Himalaya (18%) show high percentage of endemic species. Apart from their use as bio-indicators of air pollution, the Lichens in India are also known for a variety of diversified uses like spices and flavouring agents (species of *Usnea, Ramalina, Parmotrema, Heterodermia*); medicinal (species of *Heterodermia, Peltigera, Stereocaulon*) and edible (*Everniastrum cirrhatum*). Over 30 species of genera like *Usnea, Ramalina, Everniastrum,* etc. are used in industry (dye stuffs, antibiotics, smoking tobacco and cigar, perfumes) because of the presence of aromatic resinoids.

Though, only *ca* 14,500 species of fungi (including synonyms) have been recorded from India till date as against *ca* 70,000 described and *ca* 1.5 million estimated to occur (Hawksworth 1991), throughout the world. The number of described/recorded species from India appears to be an underestimate keeping in mind the vastness of the country and a great variety of substrate and environmental conditions present. The trends available for certain better known groups/genera like : the Earth's tongue fungi (Geoglossaceae) a small group of terricolous/lignicolous fungi is represented by 9 genera and 48 species (18 genera and 85 species known); family Diatrypaceae has 8 genera and 85 species (8 genera and 185 species known); more than 350 woodrotting aphyllophorales reported as occurring in the narrow belt between temperate-timberline zone of Himalayas; presence of over 100 species of coral fungi (Clavarias), *ca* 165 species of cup fungi (Pezizales) and *ca* 350 species of true slimemolds (Myxomycetes) mainly in the Western Himalaya, also point towards the richness and highly diversified Indian mycoflora. Similarly, the species richness in certain genera like 52 species of *Phellinus* (*ca* 155 known); 18 species of *Inonotus* (*ca* 50 known); over 700 species of *Cercospora* (*ca* 4000 known); 330 species of *Puccinia* (3000-4000 known) are also quite encouraging.

Even though, a reasonably correct number of endemic fungi for a mycologically less explored country like India is difficult to determine at present, but as per the data available, *ca* 3500 species (*ca* 24% are endemic to India. The relative high proportion of certain classes/groups of organisms like Fungi Imperfecti forming *ca* 40% of the total Indian mycoflora, coupled with the prevalence of some groups in certain parts of the country like the thick forests of Western Ghats abound in sooty moulds

(Meliolales); Northern forests of Himalayan range have more prevalence of Powdery mildews (Erysiphales) and the hills of Himalayas support a rich variety of coral fungi (Clavarias) and wood rotting fungi further give a distinctive stamp to the rich and diversified Indian mycoflora.

Another fascinating aspect of the Indian mycoflora which may arouse more than an average curiosity is the occurrence of certain fungi in and around the snow clad regions of Himalaya. For example, wood rotting fungi like *Phellinus laevigatus* and *P. acontextus* causing serious rots to *Betula* and *Rhododendron* respectively near the timberline and presence of "snow bank fungi" (species of *Hygrophorus, Paxina, Aleuria,* etc.) along the banks of melting snow.

Besides, the forest floor formation as a result of degradation of substrates by a vast majority of saprophytic/soil fungi, the Indian mycoflora also harbours a varied wealth of edible mushrooms (species of *Morchella, Agaricus, Termitomyces, Ramaria, Clavaria, Sparassis, Boletus, Tuber,* etc.) and poisonous/hellucinogenic fungi (*Amanita muscaria, A. phalloides, A. verna, Russula emetica, Gyromitra esculenta* and many others). There is a great variety of parasitic forms ranging from rusts (Uredinales), smuts (Ustilaginales), downy mildews (Peronosporaceae), damping off (Pythiaceae), white rusts (Albuginaceae), powdery mildews (Erisyphales), wilts (*Fusarium & Verticillium*) and woodrots (Aphyllophorales). The mycoflora also abounds in fungal curiosities like *Nyctalis parasitica* (on *Russula*); *Boletus parasiticus* (on *Scleroderma*); *Pilobolus* spp. (the hat thrower) and species of *Arthrobotrys, Harposporium* and *Dactylella* (friendly fungi catching nematodes) and so many others.

Algae are a highly diversified group of green plants standing near the lowest rung of the ladder of evolution of life with enormous economic implications, not only as primary producers and pollution indicators but also as a source of several natural products, biofertilizers and fine chemicals. Represented by over 6500 species and *ca* 666 genera, they grow in a variety of habitats ranging from fresh water, terrestrial, marine and soil, etc. The fresh water algae, dominated by Chlorophyceae (green algae), Bacillariophyceae (diatoms) and Cyanophyceae (blue green algae) represent the major portion of Indian algae. The genera *Spirogyra, Nitella, Volvox, Anacystis, Zygnema, Mougeotia,* etc. are dominant and well known. Over 70 species of the Indian stoneworts belong to genera *Chara, Tolypella,* *Nitellopsis*, etc. *Oscillatoria* (*ca* 65 spp.), *Lyngbya* (*ca* 60 spp.), *Phormidium* (*ca* 30 spp.) are dominant genera of blue green algae. Species of genera *Nostoc* and *Anabaena* are common in Indian rice fields.

The marine algae (seaweeds) known for their varied colours, are an attractive group of plants found growing on the ocean floors and the long stretches of Indian sea coasts. A total of *ca* 680 species described from Indian coasts is quite less a number keeping in view the long stretch of Indian coast line. Out of *ca* 680 species, so far recorded, *ca* 50% belong to Rhodophyceae (red algae), *ca* 25% to Chlorophyceae (green algae), *ca* 22% to Phaeophyceae (brown algae) and *ca* 3% to Cyanophyceae (blue green algae). The Gujarat coast, the islands stretches in Gulf of Mannar and Andaman and Nicobar group of islands are of special interest and excel other areas for luxuriance, variety and abundance of marine algae. In India, over 45 species of marine algae are useful mainly as source of Agar-Agar (species of *Gelidium, Gelidiella* and *Gracilaria*); and Algin (species of *Sargassum, Turbinaria, Dictyota, Padina*, etc.). Some species are also useful as food (species of *Ulva, Enteromorpha, Turbinaria, Gracilaria* and *Porphyra*); as fodder (species of *Dictyota, Padina, Sargassum*, etc.) and manure (all sea weeds in coastal areas).

Equally impressive is the range of domesticated biodiversity. The Indian subcontinent considered as one of the world's 12 centres of origin of cultivated plants is also known as the Hindustan centre of origin of cultivated plants, so termed by Russian Scientist N.I. Vavilov (1951). Atleast 166 species of crops and 320 species of wild relatives of crops are known to have originated here. Within each of these species, the diversity of varieties is astoning. For example, there were possibly an estimated 50,000 to 60,000 varieties of rice grown in India till not so long back. Other crops with rich diversity include Wheat, Sugarcane, Legumes, Sesame, Eggplant, Citrus, Banana, Mango, Jute, Ginger, Turmeric, Pepper, Cinnamon and Cardamom. There are several hundred species of wild crop relatives distributed all over the country, especially in the Eastern and Western Himalayas, in the Western peninsula and the Malabar coast, in North-eastern India, the Gangetic and the Indus plains and in the East peninsular Deccan plateau. A major centre for wild maize occurs in the humid and semihumid tracts of the East and West peninsular areas extending to North-eastern India. Wild millets are found in the North-eastern hills and the Tamil Nadu hills. Wild relatives of wheat and barely have been located in the Western Himalaya. India's rich germplasm resources include 51 species of cereals and millets, 104 species of fruits, 27 species of spices and condiments, 55 species of vegetables and pulses, 24 species of fibre crops, 12 species of oilseeds and various wild strains of tea, coffee, tobacco and sugarcane.

VALUE OF FLORAL DIVERSITY

Biodiversity or its physical manifestation-the biological resources are the basis of life on earth. It is an ecological imperative that we depend on them for our basic existence. Ecosystems and species provide an enormous range of goods, and other services-immediate as well as long-term, material as well as spiritual and psychological which are vital to our well-being.

The floral diversity of the world already supports human life in so many practical ways such as for food, clothing and shelter. One of the most fundamental contribution of the plant diversity for human survival is in the supply of world's food. Out of 511 plant families of flowering plants recognised (Brummit 1992) about 173 have domesticated representatives. Of these Poaceae has the largest number of domesticated species (379 species) followed by Leguminosae (337 species), Rosaceae (158 species), Solanaceae (115 species), Asteraceae (86 species), Cucurbitaceae (53 species), Lamiaceae (52 species), Rutaceae (44 species) Brassicaceae (43 species), Apiaceae (41 species), Chenopodiaceae (34 species), Zingiberaceae (31 species) and Arecaceae (30 species).

Out of the estimated 2,50,000 species of flowering plants in the world, nearly 3,000 are regularly exploited for food in some way. Though most of these (*ca* 2500) are domesticated yet only 15-20 have become the crops of major economic importance (Ford-Lloyd and Jackson 1986). At present only 103 species of plants supply 90% of our food and 50% of it is from the three crops i.e. wheat, maize and rice (Prescott-Allen 1990). These three crops account for about 60% of the calories and about 55% of the proteins that humans consume directly from plants.

Wild species have also provided many of our medicines. World Health Organisation has listed over 21,000 plant names which have medicinal uses around the world but only a few of them are grown as crops. The US National Cancer Institute has identified over 1400 tropical forest plants with potential to fight cancer. However, we use only a small proportion of plant species known or estimated to exist. Floristic diversity is still a largely untapped source of new food crops, new medicines, new fibres, new source of energy to substitute for petroleum, new flavours and scents and countless other products of commercial value.

Of the 17,500 plant species, known from India, more than 4,000 species, including some highly reputed species are known to be used in different medicine systems throughout the world. Nearly 3000 species have edible value; *ca* 700 species are traditionally used in social and various religious ceremonies, *ca* 500 species are fibre yielding, *ca* 400 species have fodder value, *ca* 40 species are insectivorous, *ca* 300 species yield gum and dyes and *ca* 100 species yield different types of scents and essential oils.

Besides the direct benefits, plant diversity also provides the essential ecological services of maintaining our atmosphere, creating and maintaining soils, sustaining hydrological cycles and controlling world climate patterns. Apart from the potential future crops, wild plants retain an exceptional importance for agriculture, as wild genetic resources are the key to the future production of existing crops. The high yielding and diseases resistant varieties of crops have come from the genepools of rich biodiversity. For example *Oryza nivara* a wild variety of rice was collected from eastern Uttar Pradesh in 1963. This variety is known to be resistant to the "Grassy stunt virus" which had caused an extensive damage to *ca* 1,16,000 hectares of paddy in India, Indonesia, Sri Lanka, Vietnam and Philippines in 1970. The resistant gene from this species has been introduced in the varieties which are now grown in over 30 million hectares of land in India, Nepal, Bangladesh, China and other South-East Asian countries. The sugarcane industry had been on the brink of complete collapse on several occasions because of the "mosaic virus" causing Red rot and gummosis until the problem was solved by introducing resistance to it from wild relative (*Saccharum spontaneum*). Wild coffee has been found which is resistant to the "rust" that had already devastated former coffee producing regions such as Sri Lanka, India, Java, Philippines, etc. and wild cacao have saved the industry from devastating "Witches broom" (Oldfield 1984). Table-III shows some more examples where wild relatives of crops have contributed to the productivity.

Table III
Genetic diversity and Agriculture : Some specific contributions made by wild relatives of crops.

Crop	Country/Place	Effect on Production
Wheat	Turkey	Genetic resistance to disease valued at US $ 50 million per year.
Rice	India	Wild strain proved resistant to "grassy stunt virus".
Barley	Ethiopia	Protects California's US $160 million per year crop from yellow dwarf virus.
Hops	N. Europe	Added US $ 15 million to British brewing industry in 1981 by improving bitterness.
Beans	Mexico	Genes from wild mexican bean used to improve resistance to the Mexican bean "Weevil" which destroys as much as 25% of stored beans in Africa and 15% in South America.
Grapes	Texas	Texas rootstock used to revitalise the European wine industry in the 1860s after a louse infection.
Watermelon	India	Wild strain proved resistant to mildew, saved crops in California.

The appropriation of new genetic material and biological resources from wild are also important in a number of other economic activities. For example, pharmaceutical companies are becoming increasingly interested in the potential biochemical properties of tropical species and varieties for developing new drugs. Based on data from Costa Rica, the net private returns to pharmaceutical prospecting of biological resources is around US$ 4.8 million per new drug developed (Aylward 1993). No one thus knows as to which species might prove itself extremely useful at what point of time. So, we need to conserve and save the genepool as well as species for our future prosperity. Many species have the potential to substitute and complement our food, medicinal and other needs in future. Their loss will render the human race helpless and uncared for.

Interest in microbial diversity in recent years fuelled by the increasing recognition that vast numbers of bacteria, fungi remain unknown, has focussed on the known and potential value of these organisms to humans particularly as sources of food and drugs. Todate, only a tiny proportion of the 70,000 or so described species of fungi have been traditionally used by humans. Of these, the most important are yeasts, moulds and mushrooms. Since the discovery of successful method for growing mushrooms in stable manure, their exploitation has now spread to most industrialized countries. In addition to *Agaricus bisporus* (*ca* 1.42 million tonnes per annum) several other species like *Lentinus edodes*, species of *Pleurotus, Volvariella, Auricularia, Flammulina* and *Tremella* have been commercially exploited. Microorganisms are also used in the processing of dairy products such as cheese, fermented milk and butter and manufacture of alcoholic beverages. An additional role for microorganisms is the production of Pharmaceuticals in the form of metabolites e.g. Penicillin, Cephalosporin, etc. Such metabolites are now known to be produced by about 5000 (*ca* 7%) of described fungi. Microorganisms also play a role in sustainable agriculture as some are employed as biological control agents, some as biopesticides and others for increasing soil fertility (Hawksworth 1991, Jones 1993). The maintenance of microorganismal diversity in the wild is thus vital for future prospecting.

LOSS OF FLORAL DIVERSITY

The earth and its diversity are dynamic and everchanging. As such extinction of species is a natural phenomenon and over the geological time scale, it is likely that more species have become extinct than are living today. Fossil records reveal that all species have a finite lifespan and at a rough estimate, would be just a fraction of the existing species in hundreds of years. It is often remarked that no species will survive for ever and that every species is a unique potential ancestor of new species. Hence accelerated extinction has profound consequences for the evolution of life on earth. In the history of life, disappearance of species and higher taxa has been compensated by the evolution of new forms from the existing ones. The rates of extinction and speciation have varied greatly. Our current concern about biodiversity stems largely from the judgement that the present rate of species extinction is extremely high in comparison to the natural average rate, and this is happening largely through man-made alterations in and destruction of environment rather than in the process of evolution. Despite the long history of human impact, human activities are placing significantly more species at risk of extinction today than at any time in the past as a result of environmental changes affecting current population size, environmental carrying capacity, population density, the mean and variance in population growth rates, the genetic structure of populations and the size, number and distances of suitable habitat patches and local populations.

Rate of forest loss in the tropics is currently increasing by an estimated 4 to 9% annually (Houghton 1994). It is likely that tropical rainforests of the world will be reduced to 10% of their original size during the next 30 years. Over the next half century, tropical deforestation will be the single largest cause for species extinction. At the current rate of deforestation, about 5-10% species of closed tropical forests will become extinct per decade. i.e. an unimaginable rate of about 100 species a day. An extremely worrying aspect of this situation is that even if all human activities were to cease immediately, species extinction due to the impacts, that have already taken place would continue for decades and added to this tragedy, is our limited knowledge of the earth's floral wealth, as an ever increasing number of plant species are being lost without even being discovered and studied. While one lot of species is dying, a whole many lots are threatened with extinction in the forseeable future.

In fact, no one can say for sure how many species we have already lost. We always talk about a few conspicuous ones but there must be hundreds, perhaps thousands of species which have gone forever, unsung and unrecorded either because they were not glamorous enough or simply, we did not know about their existence. As just one example, an evergreen tree *Madhuca insignis* identified in the last century has not been relocated for over a hundred years now. Its type locality in South-West India was once covered by dense evergreen vegetation, but severe deforestation of the area, and selective felling of this tree seems to have driven it to extinction (Nayar & Sastry 1990). The process continues for thousands of other species as habitats which have scarcely been explored continue to be destroyed. The Silent Valley rainforests in the south Indian state of Kerala revealed several species new to India, even some species never recorded before in the world, after plans to build a hydroelectricity dam there, were shelved following strong public protests.

A tragic fate has also hit India's domesticated flora. Thousands of crop varieties have disappeared from the field and not all of them remain even in gene banks, since the advent of a handful of miracle varieties. The broad genetic base of many crops like wheat & rice provided insurance against pests, diseases and drought and a bank for desired characteristics like productivity, nutritional value and residue fodder potential. Perhaps equally important, these varieties were culturally valuable, thus there were rice varieties which would be grown for their scent, others for their taste, yet others for their colour and so on. How can a single hybrid variety which is only high yielding possibly fulfill all these vital functions. Thus loss in nutritive, cultural and other values of agriculture is a striking phenomenon of the Green Revolution.

There are both natural and man-made causes which have posed a serious threat to floral diversity. The natural causes responsible for the threat to flora include fluctuations in the abiotic parameters of the environment such as cyclones, long dry spells of weather, onset or withdrawls of ice ages, earthquakes, landslides and biotic parameters such as natural competition between species, biology of species (lack of pollinator, etc.) and natural regeneration, diseases and spread of alien weedy species. Among the man-made causes are the population explosion, rapid expansion of industry and agriculture, urbanization and large scale development projects like dams, highways, mining, increased expansion and intensification of human activities. These activities have led to the destruction or modification of habitats, pollution and overutilization of biological resources.

Habitat destruction is widely considered the most pervasive anthropogenic cause of the loss of biodiversity (Brown 1985, Myers 1988). It is concluded that 73% of the world's land surface other than the rock, ice and barren land is either human dominated (36.3%) or partially disturbed or modified (36.7%). Land use for human food production now occupies over 1/3 of the total land area. In 1991, cropland covered 11% and permanent pasture 26% of the world's land area and were the leading causes of habitat conversion on global basis (WRI 1994).

Destruction of habitats and unsustainable harvest in wild flora and its products have severely threatened many of our wild species. Since 1600, *ca* 654 plant species (mostly flowering plants) are recorded as having gone extinct according to data compiled by the World Conservation Monitoring Centre (1992) although, this is certainly an underestimate of the true total, particularly with regard to tropical species. The estimate for the minimum number of globally threatened plant species in 1994 is 26106 plants. This figure, however is mainly for the flowering plants, while for the vast majority of the described species and many millions of undescribed species, no assessment of status has been made due to lack of information. In India, atleast 1500-1700 species (*ca* 10%) of the recorded flowering plants are considered threatened and endangered. About 20 species are characterized as possibly extinct as these species have not been sighted during past many decades. This is not surprising for in the last few decades, India has lost atleast 50% of the forests, polluted over 70% of its waterbodies, built or cultivated over much of its grasslands and degraded most of its coasts. To this habitat destruction have been added hunting, over-exploitation, poisoning by pesticides, displacements by exotics and a host of other activities which have taken a heavy toll of biodiversity.

Unsustainable and selective harvest of wild resources motivated by cultural traditions, survival needs, for cash income to supplement earnings from other resources, have also endangered certain groups of plants particularly medicinal and orchids. For example, survey conducted by International Trade Centre in 1982, noticed that out of 80,750 tonnes of medicinal plants, India accounted for 10,555 tonnes. India remains the single largest exporter of medicinal plants to European countries. During 1989, 65.8 tonnes of Kuth (*Saussurea costus*) - a CITES Appendix-I plant was exported. Similarly, many of our beautiful orchids like *Renanthera imschootiana, Vanda coerulea, Paphiopedilum* spp.

(Lady's slipper orchids) and *Cymbidium* spp. have become endangered mostly due to overexploitation for trade. Unfortunately, overexploitation for illegal trade still continues in certain plant species having highly threatened status.

The current dominance of intensive agricultural production in much of the world, which relies on lower levels of varietal diversity, has led to a significant reduction in genetic diversity of crops. Thousands of varieties of rice, millets, oil seeds, vegetables and legumes have been lost. In India, until recently, an estimated 60,000 local varieties of rice existed mainly in the paddy diversity rich areas like North- eastern India and tribal areas of Bihar, Andhra Pradesh, Orissa and Madhya Pradesh. Today, a small number of varieties (6000-7000) is grown over 70% of the paddy land. Similarly, a handful of high yielding varieties of wheat are grown over 95% of the land allocated to wheat. In Godawari district of Andhra Pradesh an estimated 95% of traditional rice varieties have been lost.

Commercial agriculture has led to considerable marginalization of the landscape and has had an adverse impact on physical environment through the degradation of land, the depletion of water resources and the loss of genetic diversity (Biswas 1994). Between 1952-1989, the area of cereal harvested increased by 14% while the yield increased by 114% largely due to the use of irrigation, fertilizers and pesticides (FAO 1990). Surface irrigation, the largest consumer of fresh water accounting for 63% of water withdrawl globally (WRI 1990), has transformed the complete mosaic of microclimates into a uniform agricultural mosaic, favouring a few crop species and varieties while displacing numerous microclimates such as hedgerows, fallow fields, treegroves and so forth. The inception of canal irrigation in the last century has led to the increasing trends towards water logging, salinity and desertification, which for example have now pushed natural Tropical thorn forest communities in arid zones of western India to the verge of extinction (Khan 1994). The use of artificial fertilizers and pesticides has also caused widespread poisoning of land, water, wildlife and ultimately of the humans.

Developing countries including India, account for a greater share of the World's population and it is expected that by 2030 this share will increase from 78% to 86% of the world's population. Human population of India which is 17% or 1/6th of the total humanity of the world (estimated 5.29 billion in 1991) is highly disproportionate keeping in view the land area of the country and the available resources. Moreover, the population has risen at an alarming rate i.e. it has jumped from 238 million in 1901 to around 840 million in 1981. If it goes at this pace, perhaps the billion mark will be crossed by the turn of the century or even earlier. The human population explosion as is already well known has its problems which are of a very serious magnitude, particularly for a developing country like India. For example, in India, almost 10 million entrants a year are projected in the coming decade. Since 73% of the Indian population is currently in rural areas, so it is possible that agricultural lands and forests will need to absorb *ca* 7 million new workers each year placing additional pressure on already degraded resources (Bose 1991).

As the individuals compete for basic necessities of life like food and shelter so this directly or indirectly puts pressure on natural resources and the ecosystems (Brown and Wyckoff-Baird 1992). The population level due to breeding and/or cultivation of those species of animals and plants which are directly consumed, utilized or associated with man would also tend to increase. It would increase the extent of pressure on our natural ecosystems to meet their needs of fodder. Grazing in forest land has also led to the excessive removal of undergrowth in the forests. It is estimated that currently more than 90 million animals graze in the forests and as much as 83% of forest land is subject to grazing. This pastoralism has catalysed the conversion of much natural vegetation into grassland all over the world (Stewart 1956). Most of the grasslands of India dominated by a small number of grass species and exotic weeds like *Parthenium* have been created from much more species rich tropical deciduous forests (Gadgil & Meher-Homji 1985).

Further, in order to cater to the requirements of human populations, more and more virgin land has been used for housing, building industries, dams, roads, schools, hospitals, etc. The requirement of land for food production and eventually the demand of timber for fuel and for other purposes (India needs 235 million tonnes of fuel wood per annum, while can sustain only 40 m. t.) has become important motive for tree felling, thus disturbing the physical structure and microclimatic conditions of the ecosystems. Similarly, removal of old, dead and decaying trees for timber and fuel wood has led to the disappearance of many specialist species of microorganisms including fungi. As the world population increases on many different habitats of biodiversity, many species of all groups of organisms in the world are likely to disappear over the next 30 years.

Pollutants stress ecosystems and may reduce or eliminate populations of sensitive species (Carson 1962) and may directly affect the crops and vegetation including forests (Hutchinson & Meema 1987). The air is polluted mainly from the combustion of fossil fuels in power plants, industry, cars, houses, ships, etc. The main pollutants are carbon dioxide, sulphur dioxide, nitrogen oxides, ammonia, ozone, heavy metals and organic micropollutants. Aquatic life and soil microbes are also threatened by organic, chlororganic and other micropollutants from polluted rains, pesticides from agriculture, drainage from dumps and fillings, industry outlets, etc.

The recent development of an unscientific perception that biodiversity management is primarily an issue of isolating biodiversity from the humanity, has also led to the loss of biodiversity by diluting our conservation efforts. Such an approach adopted in India and many other countries has succeeded in protecting habitats and species only in the short-run, but has done an incalculable harm in the long-run by alienating local people. In many instance, the areas have been closed off to local communities, only to be opened up to a massive tourist traffic. It is not surprising that the local people have often turned hostile to wildlife conservation attempts or at the very best become passive onlookers while officials struggle to conserve the area. It has been realized that though this "Gun and Guard" policy should continue to play an important role in biodiversity management, but even more important will be steps to reintroduce or restore local and regional management practices that successfully integrate sound management of biological resources.

Another complex manifestation is the human induced global change of the earth and climate like ozone depletion and airborne particulates (producing a cooling influence) and green house gases (producing a warming influence). Many climatologists believe that the green house effect caused by the observed accumulation of carbon dioxide, methane, nitrous oxide and chloroflorocarbons in the atmosphere is likely to raise mean world temperatures by about 2°C by 2030 and mean sea level by around 30-50 cm (Warrick *et al.* 1988). In coming decades, a massive side effect of change of earth climate could play havoc with the world's living organisms.

Several anthropogenic changes have had broad impacts on micro-organisms. Excess nutrient input from sewage, fertilizers and soil erosion has drastically changed nutrient availability in many coastal systems. (Norse 1993). Increased UV irradiation from a thinning ozone layer probably has a detrimental effect on phytoplankton over vast areas (Hebling *et al.* 1992, Smith *et al.* 1992). Warming from climate change reduces available oxygen and probably favours some species over others (Epstein *et al.* 1993), or causes evolutionary change in organisms that experience these environmental impacts as a form of directional selection (Lynch and Lande 1993). Both processes are likely to change the structure of microbial communities with unpredictable impacts on ecosystem functioning.

CONVENTION ON BIOLOGICAL DIVERSITY AND ITS FOLLOW-UP

India is a Party to the International Conventional on Biological Diversity (CBD) which entered into force on 29 December, 1993. The Convention has three main objectives the conservation of biological diversity, the sustainable use of its components, and fair and equitable sharing of benefits arising out of the utilisation of genetic resources. The Convention reaffirms the sovereign rights of the states over their own biological resources, and recognises the desirability of sharing equitably benefits arising out from the use of traditional knowledge, innovations and practices relevant to the conservation of biological diversity and sustainable use of its components with the creators and holders of such knowledge systems, innovations and practices. Further, the Convention obliges the Parties to meet their commitments for conservation and sustainable use of biological diversity and facilitate access to biological resources. Such access is to be facilitated between the providers and receivers of these resources, ensuring equitable sharing of benefits with local people and communities arising out of utilisation of their traditional knowledge systems, innovations and practices.

The Ministry of Environment and Forests, is the nodal point in the Central Government to deal with the CBD and its follow-up action.

Following the ratification of CBD by India in 1994, the Ministry of Environment and Forests had initiated action for preparation of a

National Action Plan on Biodiversity and working out the elements of a legislation on biodiversity. A Core Group of experts was set up to work out issues and a series of consultations were held with representatives of concerned Ministries/Departments, government and non-government organisations and agencies, universities and experts. Based on these consultations, a draft of the National Action Plan and a broad outline of legislation on biodiversity were prepared. Further, work for finalising the Action Plan and developing the legislation is underway.

In addition, the Ministry has initiated action on the following issues:

Biodiversity information network

Biosafety

Access to genetic resources

Indigenous knowledge and benefit sharing

Coastal and marine biodiversity

Capacity building in taxonomy

Revalidation of endangered species and development of their conservation strategies

Conservation and management of sacred groves.

FLORAL DIVERSITY AND CONSERVATION STRATEGIES

Approaches and actions initiated for conservation and sustainable utilisation of natural resourecs in India are briefly discussed below.

I. Planning and coordination of conservation efforts

Recognising the complexity and uncertainty associated with biodiversity and its sustainable use and conservation, a comprehensive and integrated framework is vital to the complex task of managing biodiversity for conservation, sustainable use and benefit sharing objectives. The goal of biodiversity management is to strike the optimal balance between conserving the diversity of nature and advancing human sustainable living. Rather, biodiversity management includes the steps required to incorporate conservation and sustainable use practices within all components of overall landscape, supported by policies, agreements and institutional arrangements that foster cooperation. Management has to be a social goal and a large component of Strategies and National action plans for sustainability (Holdgate 1991).

National biodiversity strategies, actions or programmes under the article-6 of convention on biodiversity and agenda 21 are intended to identify appropriate conservation and sustainable use measures and specifiy how they will be implemented. The National Conservation Strategy (1992) in India outlines the policy actions required to give greater attention to biodiversity conservation. The National Forest Policy as amended in 1988 stresses the sustainable use of forests. The National Wildlife Action Plan (1973) lays down the priorities in the area of wildlife conservation. National Afforestation and Eco-Development Board of the Ministry undertakes the large scale rehabilitation of degraded forest lands in the country through state governments. One of the major considerations in the environment impact analysis carried out by the Ministry of Environment and Forests is the protection of habitats and valuable ecosystems.

2. Defining priorities for conservation

Inventorying and monitoring biodiversity is in itself an immense task and to ensure its conservation in the face of multifarious pressures is mindboggling. National and local capacities for the conservation and sustainable use of biological diversity are limited everywhere, especially in developing countries. Given these constraints, setting priorities and assigning conservation values at the national and local levels will have greatest effect and will also help strengthen the conservation strategies (Daniels *et al.* 1991). At the local and community level, rapid rural appraisal and other techniques can be used to identify the most effective or urgently needed actions but at the national and international level, the requirements of the convention on Biological diversity are to be used to analyse priorities in terms of what needs to be done and like a variety of countries, these priorities have to be incorporated while developing National biodiversity strategies and other National action plans as also suggested by Miller & Lanou (1995). Development of National strategies and action plans will require choices to be made about resource allocation in order to maximize the long-term benefits that biodiversity can provide. Investments in conservation and sustainable use of biodiversity have to be made in a systematic, analytical and transparent manner. Though, deciding which species and habitats have precedence in the allocation of limited financial, human and institutional resources is likely to remain a difficult yet inevitable task for the foreseeable future.

Given the complexity of biodiversity and range of values, perspectives and goals, though there is no generally accepted universal scheme for establishing biodiversity priorities (Forey *et al.* 1994, Johnson 1995), but in order to distinguish between almost infinite variety of genes, species and ecosystems, priority values on both biological and non-biological criteria may be assigned to the elements of biodiversity at all levels.

Ecosystem or habitat approaches to setting biodiversity conservation priorities generally should seek to protect most species in conservation area, that are representative of a region's natural habitats. It can be elaborated with few examples like: more unique elements such as mangrove forests should get priority and should be sampled more intensively; sampling should give higher weightage to the more important elements such as coral reefs; rarer habitats such as the few surviving patches of Deccan Thorn forests may be sampled at higher rates; emphasis should be laid on the more critically threatened habitats such as wetlands of Brahmputra valley; emphasis should be on elements that could be managed more effectively to maintain or enhance their diversity levels or contributions to quality of human life, for instance high altitude pastures of Himalayas.

Since species are the units or elements of the biodiversity spectrum, so most approaches to setting biodiversity-conservation priorities have relied heavily on the species as the basic unit for analysis. A species based approach should emphasise the conservation priorities depending upon the value attached to individual species. Such values might be assigned on one or more of the following kinds of criteria.

(i) **Taxonomic distinctiveness** : *Gnetum ula* a climber of Western Ghats which is one of the two gymnosperm species on Western Ghats may be valued more on taxonomic distinctiveness than a vine of *Piper nigrum*.

(ii) **Endemicity** : *Berberis huegeliana*, restricted to Kashmir only may be valued more than the *B. lycium* which occurs widely and also in neighbouring countries.

(iii) **Rarity** : The relatively rare *Bentickia* palm from southern Western Ghats may be valued more than the widespread palm species *Phoenix sylvestris*.

(iv) **Threatened status** : *Pinus gerardiana* threatened by the fragmentation of its habitats may be valued more than the widespread and more adaptable *Pinus wallichiana* in Western Himalaya.

(v) **Economic potential** : *Artocarpus hirsutus* - a wild relative of Jackfruit may be valued more than another tree species say *Holigarna arnottiana* of evergreen rain forests.

(vi) **Cultural value** : *Ficus* species may be specially valued because of their widespread sacred status.

(v) **Taxa with special attributes** : like keystone species, indicator species, etc, need conservation priority.

Genetically based approaches to identifying conservation priorities are needed in conserving genetic diversity within populations, because of their potential for future utility or for avoiding the loss of evolutionary potential. Efforts to characterize and conserve genetic diversity have been dominated by an emphasis on domesticated plants, particularly a few dozens of agriculturally important species. A growing number of agricultural research institutions have sought ways to limit genetic vulnerability by preserving the range of genetic diversity found in crop species and their wild relatives both under *in-situ* and *ex-situ* facilities. Genetically based approaches to identifying conservation priorities are pivotal in circumstances like setting-priorities for small isolated populations of genetically vulnerable species having high economic and other value and also for identifying species which have no conservation alternative to *ex-situ* conservation.

It is also urgent to focus our attention on sites which are of special importance for biodiversity both in the National and International perspectives. Such sites will include the proposed World Heritage sites, RAMSAR sites, Biosphere/protected sites and biodiversity Hot-spots sites. Similarly, over 40 major centres (Nayar 1996) like Nandadevi, Namdapha, Agastyamalai hills, Nallamalai hills, etc. having exceptional degree of plant species richness and endemism require strongest efforts on priority basis to conserve their floral diversity.

3. Sustainable use of biodiversity

Human uses of biodiversity lead to the simplification of ecological systems and reduced biodiversity. Humans manipulate about 70% of the world's temperate and tropical ecosystems to produce 98% of their food and all their food products (Pimentel *et al.* 1992) and only 5% of the temperate and tropical land area is totally uninhabited and unmanaged. Most terrestrial species therefore, are found in the land area that is managed for agriculture, forestry and human settlements. Coastal and marine diversity is likewise predominantly found in areas where fishing and other human activities take place. Therefore, maintaining biodiversity depends on measures to use its components sustainably and to manage natural resources in ways that minimize adverse impacts on biodiversity.

Our ability to maintain and make the most beneficial use of biodiversity depends on using and managing biodiversity sustainably in agriculture, forestry, fisheries, tourism and other activities where the production of goods and services for human consumption is the principle objective. The traditional agricultural management systems provide opportunities for the conservation and sustainable use of biodiversity. For example small scale farmers using traditional agricultural practices have long been effective creators of varietal diversity and stewards of genetic diversity. Traditional farms of agriculture, particularly in developing countries are the world's largest repositories of crop genetic diversity. Similarly, traditional approaches to forests have also contributed to the maintenance of biodiversity. To meet the demands of a growing Indian population and simultaneously maintain biodiversity requires measures that (1) conserve genetic diversity in existing domesticated plant varieties (2) identify and conserve wild species that can improve agricultural productivity and adaptability in the face of environmental change and (3) minimize the adverse impacts of agricultural practices on other ecosystems.

4. Protection and restoration of ecosystems

Hand in hand with measures to use biodiversity sustainably are measures to protect ecosystems, species and generic diversity either in place (*in-situ* meaures can be used at all biological levels) or in specially designed facilities outside natural habitats (*ex-situ* measures can be used for species and genetic diversity). These are the measures by which we can protect biodiversity against the failure of the sustainable use measures. Both *in-situ* and *ex-situ* conservation measures display a wide diversity of approaches, spanning from ancient traditions for the protection of wild habitats, medicinal plants and domesticated crops.

India has a long history of *in-situ* conservation of flora and fauna through protected areas. With the establishment of the Indian Board for Wildlife in 1952 and the enactment of the Wild Life (Protection Act) 1972, the protected area network has been strengthened. Today, we have 85 National parks and 445 sanctuaries, covering about 1,48,532.3 sq. km. area (*ca* 4.2% of the total geographical area). In order to ensure the unhindered evolution of microorganisms, plants and animals in their totality as part of the natural ecosystems, Govt. of India has designated eight biosphere reserves out of the total 14 proposed by UNESCO'S. Man and Biosphere programme initiated in 1971. To reduce the gaps in the different biogeographic units and biomes, there are further reommendations to increase the protected area network. A national committee on Wetlands, Mangroves and Coral reefs has identified 21 wetlands, 15 mangroves and 4 coral reef areas for conservation and scientific management. Six internationally significant wetlands of India have been declared as "RAMSAR sites" under the Ramsar Convention (1981). Under the World Heritage Convention, five natural sites have been declared as "World Heritage sites".

To complement the efforts made for *in-situ* conservation, attention has also been paid to *ex-situ* conservation. There are *ca* 66 Botanic Gardens and more than 205 areas for *ex-situ* wild life preservation. Some of these gardens have made significant contributions in captive breeding of endangered species. Recently a special scheme has been launched to support *ex-situ* conservation of rare, threatened and endemic orchid species in Botanic Gardens. Collection and preservation of genetic resources is done through the National Bureau of Plant Genetic Resources, (NBPGR), New Delhi for the wild relatives of crop plants. The department of Biotechnology established in 1986 has also developed some important facilities like National facility for Microbial type culture collection, Chandigarh; Blue green algae at IARI, New Delhi; Marine Cyanobacteria, Tiruchirapalli and Plant tissue culture at NBPGR, New Delhi and three National gene banks for Medicinal and Aromatic plants at Lucknow, New Delhi and Trivandrum. Besides these, tissue culture pilot plant units for multiplication of forest trees have been established at National Chemical Laboratory, Pune and Tata Energy Research Institute, New Delhi. In addition, plant tissue culture laboratories have also been set up by several organisations like BSI, ICFRE and G.B. Pant Institute of Himalayan Environment and Development. In addition, an international centre for Genetic Engineering has also been established. Recently, a project on the technological development and demonstration of Biofertilizers has been launched and technological packages for blue green algae and *Rhizobium* have also been developed.

5. Socio-economic strategies and sharing of the benefits

Social and economic strategies have become increasingly prominent in biodiversity planning and conservation. Some of the most effective tools for enhancing the sustainable use and conservation of biodiversity, however are strategies to strengthen social involvement and participation in biodiversity management. The different cultural dimensions in a vast and varied country like India have played a major role in the ways in which biodiversity is perceived, maintained, preserved, used and appreciated. This high level of cultural diversity and high level of biodiversity, should be interdependent and be recognized again in the traditional resource management systems (Gadgil & Berkes 1991). Without local participation and support, many conservation and sustainable use efforts have failed. Indigenous people with a historical continuity of resource use practices often possess valuable knowledge about the behaviour of complex ecological systems in their own localities. This knowledge has accumulated through a series of observations that stretch over many generations. Conserving this knowledge might best be accomplished through promoting the community based resource management systems of indigenous peoples (Gadgil *et al.* 1993). One such example is the Sal-coppice forests in West Bengal once a major economic resource was linked to local community participation in forest managment and benefit sharing. Local communities were invited by the state to become partners in protecting natural forest land and aiding natural regeneration for which they would receive harvesting rights to fuelwood and non timber forest products (e.g. fruits, nuts, medicinal plants) and a 25% share of timber sale profit (SPWD 1992). Convinced by the success of joint forest managment projects in West Bengal and elsewhere, the Ministry of Environment and Forests issued policy instructions in 1990 to encourage all states to adopt joint forest management procedures. There are now nearly 10,000 forest protection committees, responsible for the management of about 2 million hectare forests in ten Indian states. Local people can participate in projects and can contribute in information gathering, consultations, decision making, initiating actions and evaluations (Paul 1987, Salmen 1987).

6. Legal measures for sustainable use and protection

Most nations are parties to one or more international treaties of relevance to biodiversity. All are required to take actions at the national level to implement their obligations. Legal measures considered in the context of traditional legal systems and modern legal systems used at national and international level, are critical tools for countries seeking to maintain their diversity, regardless of their status as parties or nonparties to international agreements (de Klemm & Shine 1994). Biodiversity managment efforts will however work most effectively with a legal framework that provides regulatory and incentive tools needed to implement conservation and sustainable use activities.

Long before the modern legislations and regulations concerning biodiversity, traditional communities around the world already possessed a varied and complex store of customary law dealing with the same issues. Survival of these communities depended upon effective systems of husbanding biological resources. Traditional knowledge therefore, provides valuable information ranging from effective managemnt techniques to pharmaceutical or agricultural application of particular species. In Orissa and other tribal parts of India, a variety of customary restrictions in the past have ensured that the forests were not over-exploited. Such customary restrictions included exploitations in certain seasons, ban of cutting certain sacred species, restriction based on certain stages of a species life cycle, limits on quantities to be exploited and complete ban on harvesting from certain areas. Though such traditions have however been substantially eroded (Fernandes 1988) but in some cases traditional legal systems, used to manage biological resources in agriculture, forestry and hunting are still effective. In India, for the past 20 years, the state forestry authorities and local communities have collaborated successfully on the development of Joint Forest Managmenet projects to meet demands on forest resources.

Nearly, all countries have legislation, policies and legal procedures that govern the protection, use and management of natural living resources. Both regulatory and non-regulatory measures are required to be strengthened to support the sustainable use and protection of biodiversity. The regulatory measures include like species oriented legal measures, regulating use of protected areas. area based legal conservation actions, land use planning, legislation, legal protection of representative habitats, regulating processes and activities detrimental to biodiversity and regulating access to genetic material. The non-regulatory measures include like Financial incentives, covenants, easements, management agreements, combining regulatory and voluntary measures, environment impact assessments and other legal institutions for conserving biodiversity. In India, on the legal side there are about 24 existing central laws relevant to biological diversity, a few of them are: the Forest Act 1927, the Wild Life (Protection) Act 1972, the Forest (Conservation) Act 1980, the Environment (Protection) Act 1986, Import & Export (Control) Act 1947, Tea Act 1953, Seed Act 1966 and Spices Board Act 1986. These are supported by a number of state laws and statues to sustainably manage and protect biodiversity and to develop regulatory and voluntary approaches. Based on the assessment of 40 or so National acts/laws, Kothari and Singh (1992) have analysed the legal coverage of eleven aspects of floral diversity in India for wild flora/domesticated flora (crops and cultivated plants) and genetic material (seeds, germplasm, etc.) as shown in Table IV.

Table IV
Coverage of some aspects of floral diversity by the existing National laws in India.

Type of Activity	Wild Flora	Domesticated Flora	Genetic Material
1. Identification	N	N	N
2. Protection *in-situ*	W	N	N
3. Protection *ex-situ*	P	N	N

Type of Activity	Wild Flora	Domesticated Flora	Genetic Material
4. Access/extraction	P	N	N
5. Use	P	N	N
6. Trade	W	W	P
7. Breeding/ Cultivation/ Multiplication	P	P	P
8. Introduction/ Augmentation/ Reintroduction	P	P	P
9. Release	N	N	P
10. Movement	P	P	P
11. Intellectual Property Rights	N	N	N

N= Not covered P= Partially covered W= Well covered.

7. Building capacity for biodiversity management

The development and implementation of successful biodiversity policies depend on the capacity of the people to carry out a number of related intellectual and practical tasks. To achieve an integrated and comprehensive biodiversity management programme, India will need to provide opportunities for its citizens to develop the relevant scientific, technical and administrative knowledge. A set of institutions, physical facilities and financial resources will also be required to support their work. More specifically, the success of biodiversity management programmes will depend greatly on how India encourages its human capacity to design and carry out intellectual and practical tasks ranging from survey and inventorization to exploiting biotechnology. Various types of physical facilities and infrastructures are needed to house collections and training establishments, transport scientists and practitioner, foster research in sustainable technologies and so on. Finally, there is a need for financial capacity. Continuing research can be expected to provide policy makers with a growing sense of certainty, even as new mysteries of nature are uncovered.

Survey of floral resources in the country is mainly undertaken by the Botanical Survey of India (established 1890). The Forest Survey of India (established 1981) uses satellite imagery, aerial photography and ground truth verification to assess the forest and tree cover with a view to develop an accurate data base for planning and monitoring purposes. These reports are published in Floras at National, State and District level. Red Data Books on threatened, endangered/endemic plants species are also published from time to time for planning suitable conservation measures. The Ministry of Environment and Forests provides financial assistance to several research projects in identified priority areas of research on environment conservation and specific ecosystems such as Wetlands, Mangroves and Biosphere reserves in many universities and research institutes. In addition, the Wildlife Institute of India, Botanical Survey of India, Forest Survey of India, Indian Council of Forestry Research and Education, G.B. Pant Institute of Himalayan Environment and Development and other National Institutes are also conducting research and impart training on varied subjects concerning biodiversity.

FLORAL DIVERSITY AND ROLE OF BOTANICAL SURVEY OF INDIA

According to the recent international agreements and strategies, all member countries are committed to undertake identification and monitoring of the components of biological diversity important for its conservation and sustainable use. Article 7 of the United Nations Convention on Environment and Development and chapter 15.5 of Agenda-21 require signatory parties to identify components of biodiversity important for conservation and sustainable use and monitor through sampling and other techniques, the components of biological resources identified. It also calls for signatories to identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological resources and monitor their effects and to maintain and organise data derived from identification and monitoring activities. This involves a combination of existing data, generation of new data and its organisation to ensure that the resulting information is both usable and accessible (Johnson 1993, Glowka *et al.* 1994). Chapter 15.6 of Agenda-21 calls for a systematic sampling and evaluation on a national basis and also stresses for initiation or continuation of work on survey at appropriate level and establish baseline information on biological and genetic resources.

An understanding of the magnitude of plant diverstiy at all levels is crucial to its conservation, management and utilization. The scale of plant diversity is immense and while estimates of its magnitude are being improved, investment is required to bridge crucial knowledge gaps and synthesize existing information. For a nation like India, knowing the identity and geographical distribution of its plant species is perhaps the most important information available in its attempts to preserve and use its biodiversity. This information comes primarily from floral inventories of various kinds, prepared by Botanical Survey of India, and it provides the basic knowledge for day-today managament decisions regarding natural resources. Species inventories across the region/state level are important for establishing patterns of diversity and identifying areas of endemism which are the two primary components in evaluating areas for protected status. Further, the species inventories at local levels are also required for meeting management objectives for protected areas (UNEP 1993) including maintenance of ecosystems and biological diversity, conserving genetic resources, monitoring change, providing for sustainable economic uses such as hunting and facilitating education and research. Botanical Survey of India provides the necessary feedback to adaptive management programmes by way of preparing inventories and monitoring of floral components of biodiversity.

Till date, most of the efforts to assess geographical patterns in diversity have considered species as the currency of biodiversity. Total organismal diversity that is the sum of all species of all organisms has not been tabulated for any area of land or water at any scale. While there are good estimates of total richness for some of the better known taxonomic groups (vascular plants), little is known about large scale spatial biodiversity pattern for many of the most diverse groups of organisms on earth e.g. Eubacteria, microfungi and various group of protozoa, algae, etc. Even in better known groups such as vascular plants, perceived variation in diversity at the spatial scales that are most useful for determining conservation priorities, sometimes reflects sampling effort rather than true pattern. These many biases reflect the fact that we are still at the stage of learning about what species are present on earth a stage that necessarily implies a sound taxonomic approach and many short cuts when it comes to exploration.

The study of different kinds of plants, the variation among and between them, how they are distinguished from one another and their patterns or relationship as revealed by the taxonomic studies conducted by Botanical Survey of Indiafor the last 100 years, are fundamental in providing the units and the patterns to humankind's notion of species diversity. Indeed, the first estimates of global biodiversity were only those made by taxonomists. Taxonomy and taxonomic classification based on examining all available specimens supplemented by local and specialist collections made after intensive field surveys provide the core reference system and knowledge base, on which all discussions of biodiversity hinge; thus forming the framework within which biodiversity is recognised and in which species diversity characterization occurs (Janzen 1993). This reference system is made available by Botanical Survey of India through the range of taxonomic products such as Floras (National, State, Local), Monographs, Hand books and Guides which disseminate the basic information about organisms and tend to contain four basic elements i.e. Classification, Nomenclaure, Description and Identifying keys.

The role of Botanical Survey of India is quite challenging, after the realization of the fact that Taxonomic characterization of all the known plant species is a mammoth but essential infrastructure task with which only limited progress has been made. Just, about 45,000 plant species (excluding microorganisms) out of *ca* 0.4 million described/reported to occur in the world, have so far been described. The task becomes more challenging when this reported number of plant species from India is considered in comparison to 1.6-2 million total plant species estimated (Groombridge 1992) to be occurring in the world i.e. just *ca* 2% of the plant species have been reported from India. Most of the reported species are still poorly known in biological terms and there is not even a comprehensive catalogue of these 45000 species.

The taxonomic work done by the Botanical Survey of India provides considerably more than the bare-bones factual information system, described above. It also provides a summary of the pattern of diversity and of the pattern of evolution in a group of plants by placing them in taxonomic hierarchies. For example, the taxonomical hierarchy for Gymnosperms will show that *Ginkgo biloba* is the only living representative of the order Ginkgoales and it is thus very isolated and distinct in terms of diversity from the nearest other group, the Coniferales (conifers). Conversely, the Coniferales is made up of seven families, each of which contains several genera and many species, amounting to 610 species. Further, the family Pinaceae contains 10 genera of which *Pinus* has about 120 species worldwide and *Abies* 55. *Pinus* and *Abies* species are thus nowhere near being so isolated as *Ginkgo biloba* and each species has a number of other species so close or similar genera exist in the same family and in the six related familes. This, then is the pattern of species diversity. The same taxonomic hierarchy will also show the elements of evolutionary pattern like that the *Ginkgo biloba* was separated from the evolutionary line of conifers at an early date and secondly that the members of coniferales had a common ancestor and all the decendants of that common ancestor are included in the coniferales group.

Collection, storage and maintenance of biological specimens including the type specimens in the main and the regional herbaria of Botanical Survey, serve several distinct fundamental functions in the characterization of biodiversity. All taxonomic research is based on the comparison of a large number of specimens. The minimum parameters like location, altitude, date of collection, identifying characters, collector's name, field number and substrata noted on each specimen provide the raw data for biological recording, which ultimately forms the fundamental source for biodiversity survey, inventory and assessment.

The studies carried out by the Botanical Survey of India on the species richness and species diversity at National/State/Local levels is also required for characterization of floral diversity on different measures like Alpha diversity, Beta diversity and Gamma diversity. (Whittaker 1960, 1972). Both, Alpha diversity (species richness within area of a given size; Huston 1994) and Gamma diversity (overall diversity within large region/landscape level; Cornell 1985) represent the "with in-area diversity" of species, while the Beta diversity is the measure of " between area diversity" generally used to estimate average changes in species among discrete sites or habitat units.

FUTURE TASKS

A much greater unity of efforts for conservation of floral diversity is needed if we are to slow the current rate of species and habitat loss.

The approximately 0.4 million plants that have been described todate represent only a small percentage of the total plant species diversity on earth. Assuming that there are 1.6 to 2 million plants, only 20-25% have so far been described and if higher estimates of species turnout to be true, it could be as little as 10-12%. Biodiversity cannot be properly conserved, used or managed if it is still so poorly known. So the first and the foremost task is to greatly increase the taxonomic effort to identify the species of plants in the country. It is a tragedy that at a time when we are realizing the importance of biodiversity and when it is under more threat, the number of systematists is decreasing rather than increasing. If biodiversity is really important, we need to mobilize an adequate task force of systematists to cope with the problem.

So far, the major focus of floral diversity inventorising effort was on preparing lists of species of a few well known groups of organisms such as flowering plants at the level of regions such as states and districts and less frequently smaller localities like Biosphere reserves, National parks and sanctuaries. There are atleast tens of thousands of species of lower sexual and asexual organisms each of whose members, is probably unique in its genetic constitution and role in the ecosystems. Furthermore, many more taxa of lower groups of plants, which we know so little, are likely to have far more restricted distribution and be endemic in comparison to better known higher plants. Thus, the effort must now widen its focus from concern primarily with flowering plants and cultivated crops to a whole range of lesser known lower groups of plants and wild relatives of crop plants.

Another step required is that the focus in space should now shift to sampling of more carefully selected landscape elements like the unique habitats, rich habitats, rare and threatened habitats, feasible habitats, etc. and in time the sampling should be repeated at some defined interval to monitor changes. Strongest efforts may be laid immediately, on the areas like "World Heritage sites, RAMSAR sites, the Hot-Spot areas known for their diversity richness and clusters of endemic species and Biosphere sites, having significance at the National and International level.

Another immediate task for a more certain future is that we must use a greater diversity of species for food and preserve as much genetic diversity of each crop as possible. Besides, better cooperation and understanding among the concerned National institutes, better use of human resources and traditional and modern technologies, serious efforts are also required to streamline the mechanism for sustainable use of genetic resources. A central mechanism may be created immediately to deal with administrative, policy and strict regulatory measures for sustainable use of both domesticated and wild diversity. To sustain a viable future, we must achieve a better balance between the maintenance of human welfare and the retention of floral diversity in the widest sense.

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FRESH WATER ALGAE

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Algae are a group of heterogeneous assemblage of photosynthetic plants comprising highly diverse forms ranging from prokaryotic and microscopic blue-green algae to giant kelps but stand at the lowest rung of the ladder of evolution of life and have enormous economic implications. With growing realisation of the importance of algae not only as primary producers in the aquatic ecosystem but also as a source of several natural products, biofertilisers and fine chemicals, phycological studies have got a fillip globally in the last few decades. Among the cryptogamic flora, algae seem to be ubiquitous owing to their greater adaptability to extremes of climatic conditions and diverse habitats. The minuteness of many algal forms and the great difficulty experienced in identification of fresh water algae in a dried state have been the principal cause of their having been almost neglected while the angiospermic flora which forms the conspicuous vegetation cover attracted the attention of many plant taxonomists. Nevertheless, the studies on Indian algae which started in the latter part of the 18th century have yielded some systematic accounts of algae.

Out of *ca* 45,000 plant species that are estimated to be occurring in India, over 25,500 species belong to non-vascular plants. Among the later, approximately 6,500 belong to Algae (*ca* 40,000 known in the world) representing *ca* 14% of the known Indian flora and thus contributing significantly to the floral diversity of India. While nearly 5820 species are from fresh water bodies and allied habitats, the remaining 680 species are recorded from marine environment.

ALGAL FLORISTICS IN INDIA

The dawn of studies on Indian algae was heralded in 1768 when John Gerald Koenig, who came to India as a member of Morivian Mission to Tranquebar, South India collected, studied and described some algae. This was followed in the 19th century by a galaxy of famous algologists Agardh (1824), Turner (1892), Kuetzing (1849), Ehrenberg (1854) and Rabenhorst 1861). During this period, all the workers were Europeans except K.R. Kirtikar who was the first Indian phycologist to publish a paper as early as 1886. During the 19th century, a number of expeditions were undertaken for study of the marine algal flora of India, the details of which are given in another article in this volume. The 20th century saw a mighty spurt in Indian Phycology. During the initial 35 years of this century, we mostly had British and European workers like Allen (1925), Prain (1905), Carter (1926) and Groves (1924) to name a few. While Boergesen, a Europen marine algologist was exploring the Arabian sea shore for marine algae during this period, S.L. Ghose was contributing to our knowledge of fresh water algae from Lahore.

However, during the thirties, a new era dawned and Indian algologists came into the lead. Prof. Y. Bharadwaja and Prof. M.O.P. Iyengar specialised in blue-green algae (BGA) and green algae respectively, established schools of phycological research at Banaras and Madras respectively and their students. R.N. Singh and T.V. Desikachary respectively carried the torch onward. Even today, these two places are like Mecca and Madina for algologists in India. Several other centers of active research came up later but, many of them originated or are academically sustained by one of these centers. In the early thirties of this century, the Sea Lark Expedition (1932) to Ladakh and John Murray expedition (1933) to Maldives were notable efforts of interests outside Banaras and Madras. While most of the studies during this period are confined to relatively small geographic areas, they have added up considerably to our present knowledge on Indian algae. Even though a larger part of the country still remains unexplored, but based on the fewer reports from small geographical areas by various workers, the habitat-wise algal diversity alongwith some dominant genera as occurring in India, presently stands as shown in Table -I. Some genera are common to more than one habitats.

Table I
Habitat-wise richness of algae in India.

Algal habitats	Families and diversity	Important genera
Fresh water algae (rivers, ponds, lakes)	390 genera, 4500 species; all familes except brown and red algae	*Anacystis, Microcystis, Spirogyra, Chara, Nitella, Volvox, Vaucheria, Chlamydomonas.*

Algal habitats	Families and diversity	Important genera
Terrestrial algae	125 genera, 615 species; Chlorophyceae, Bacillariophyceae, Xanthophyceae and Cyanophyceae	*Aphanothece Oscillatoria, Nostoc*
Soil algae	80 genera, 1500 species; Cyanophyceae and Chlorophyceae	*Anabaena , Anabaenopsis, Aulosira, Calothrix, Phormidium, Navicula, Nostoc, Scytonema, Scenedesmus, Pinnularia*
Marine algae	169 genera, 680 species; almost all the divisions	*Ulva, Halimeda, Sargassum, Padina, Gelidium, Gracilaria, Hypnea*
'Usar' soil algae	15 species; Cyanophyceae	*Aulosira, Nostoc, Tolypothrix*
Pollution indicator algae	Cyanophyceae, Chlorophyceae and Bacillariophyceae	*Microcystis, Spirulina, Oscillatoria, Nitella*
Alpine algae	Chlorophyceae	*Chlamydomonas, Micorocoleus, Scizothrix*
Thermal algae	Cyanophyceae	*Mastigocladus, Scytonema*
Parasitic algae	Chlorophyceae	*Chlamydomonas, Chlorella, Cephaleuros, Zoochlorella*
Symbiotic algae	Chlorophyceae, Cyanophyceae	*Zoochlorella, Anabaena, Nostoc*

DIVERSITY

Taking an overall view, we find that, out of a world total of over 2500 genera and *ca* 40,000 species of algae, *ca* 666 genera and *ca* 6500 species are represented in India which include nearly 700 marine species This amounts to a proportion of 27 per cent of global generic representation and 16 per cent of world species. Thus a great variety in the flora is found at the generic level than at the level of species in India. If the proportion of representation of different classes of algae at the generic level is compared with that in the world, we find that the families Cyanophyceae, Dinophyceae, Chlorophyceae and Bacillariophyceae are better represented in India as they constitute greater percentages of the flora here than in the world as a whole. On the other hand, the families Xanthophyceae, Chrysophyceae, Rhodophyceae and Phaeophyceae are distinctly poorer in the Indian flora. The causes for disparity must be many and may be difficult to decipher but the inadequecy of explorations is one of the reasons. The greater representation of Cyanophyceae and Chlorophyceae may be simple due to Bharadwaja and Iyengar having given a boost to the study of these groups. Conversely, the lower representation of Rhodophyceae and Phaeophyceae may be due to the fact that climate in temperate and arctic regions is more favourable for many members of these groups, where they find greater scope for development and diversification. Yet, some more species beloning to these two classes may be added to the inventory if extensive and intensive studies are undertaken in the areas hitherto not explored. Coming to the level of species, on comparing the world flora with the Indian flora, we again find that the Chlorophyceae, Cyanophyceae, Bacillariophyceae and Dinophyceae show a better representation in the Indian flora than in the world. On the other hand the Rhodophyceae, Phaeophyceae, Chrysophyceae and Xanthophyceae exhibit a poorer representation. The causes for these disparities are again difficult to elucidate. Thus the representation of different groups of algae in India shows similar pattern at the generic and species levels.

The fresh water algae growing in rivers, streams, tanks, ponds, etc. constitute the major portion of Indian algae and are being represented by *ca* 300 genera and *ca* 4500 species in India as compared to *ca* 1120 genera and 14,400 species so far reported from the fresh water habitats in the world. They were the subject of serious work at many regional centres by different workers and some notable contributions mainly on the fresh water algae under Volvocales, Chlorococcales, Ulothricales, Cladophorales, Oedogoniales, Chaetophorales, Zygnemataceae, Desmidiaceae and Cyanophyceae have been made from India. The

Chlorophyceae, Bacillariophyceae and Cyanophyceae dominate in the species representation of fresh water habitats, while the Rhodophyceae (Red algae) and Phaeophyceae (Brown algae) have only very few species growing in fresh waters. The diversity in Indian fresh water algae is discussed below under these major families:

CHLOROPHYCEAE (Green Algae)

The green algae are common in soils, fresh water and marine environments. Most of the green algae are small, unicellular or filamentous. Since green algae have the same pigments and reserve foods as higher plants, they are usually considered to be the progenitors of land plants. It being the largest of the eight divisions of the algae, chlorophycean members inhabit wide range of habitats. They differ with blue-green algae in possessing nucleus, both chlorophyll a and b in the chloroplast and in having one or more pyrenoids. The green algae are mostly aquatic and terrestrial. Some fresh water forms viz. *Volvox, Chlamydomonas, Spirogyra and Cosmarium* form scum on the water surface in the stagnant pools while the forms such as *Oedogonium, Cladophora, Coleochaete and Chaetophora* grow firmly attached to the submerged rocks and similar substrata in the streams. The terrestrial forms grow on damp soil and tree bark. A species of *Scotiella* is reported to be occurring in snow. There are species which lose colour and become parasites on tea and pepper plants *(Cephaleuros)* while some act as space parasites *(Chlorochytrium lemnae)* growing inside the tissues of *Lemna*. Some epizoic forms *(Chlorogonium)* grow on small crustaceans. Epiphytic and symboitic forms are also known to occur.

The order Volvocales comprises of motile vegetative cells arranged in definite numbers so as to form colonies called 'coenobia' which are covered with common mucilagenous sheath. Some of the genera of this category are *Gonium, Pandorina, Eudorina, Pledorina* and *Volvox*. Non - motile forms are seen in the order Chlorococcales *(Pediastrum* and *Hydrodictyon)*. The beautiful alga *Hydrodictyon* commonly known as 'water-net' occurs mostly in the ponds and lakes of Punjab. *H. reticulatum* and *H. indicum* are common in India and are composed of 5-6 cells arranged in pentagons or hexagons. Many fresh water forms of *Pediastrum* are reported from Gujarat. Some of them are *P. boryanum, P. constrictum, P. notatum* and *P. biradiatum*. The simple *Chlorella* is known by 4 species viz. *C. vulgaris, C. parasitica, C. ellipsoidea* and *C. conglomerata* whereas *Scenedesmus* is represented by 6 species in

India. Thread like *Ulothrix* occurs mostly in cold water streams. *U. zonata* is dominant fresh water form usually seen. The order Oedogoniales is represented by 3 genera in India *(Oedocladium, Oedogonium* and *Bulbochaete)* and hold an isolated position in Chlorophyceae due to which they are considered to have neither known ancestor nor descendents. Among the above genera, *Oedocladium* is mainly terrestrial while other two are aquatic. *Oedogonium* is the only one with an unbranched filament and is well represented from Karnataka. Two genera of the order Ulvales viz. *Ulva* and *Enteromorpha* are mostly marine forms. In the order Cladophorales, elongate coenocytic cells are arranged in the form of branched filaments. About 8 species of *Cladophora* are reported from fresh waters and marine habitats. Among them *C. glomerata* is dominant whereas *C. bengalensis* and *C. callicoma* are endemic to Bengal and Varanasi respectively. Other Indian species include *C. crispata, C. furcata, C. incurvata* and *C. rottleri*. This group is characterised by the presence of ball like body 'Aegagrophila' which floats freely and under the influence of wave action transform into fine young branched filament. *C. glomerata* is epiphytic on submerged water plants but *C. crispata* is epizoic on the shells of snails.

The order Chaetophorales is characterised by ismorphic alternation of generation. Among the representative genera *Draparnaldiopsis* is aquatic represented by *D. indica* whereas *Fritschiella* is terrestrial represented by *F. tuberosa* in India.

The members of the family Trentipohliaceae (order: Chaetophorales) are exclusively aerial growing in damp tropical and sub-tropical part attached to rocks, flower pots etc. Out of 50 species found in the world, 18 species are reported form India mostly endemic to north-eastern region. Some species occur as an algal component of many lichen thalli. *Cephaleuros virescens* of this family causes 'red rust of tea' in north-eastern India and also said to be damaging piper plants.

The genus *Coleochaete* represented by about 4 species is known to grow epiphytically on the leaves and stems of fresh water aquatic plants. *C. nitellerum* is an exception growing endophytically beneath the cuticle of the thallus of another green alga *Nitella*.

In terms of number of species, the family Zygnemaceae forms the largest group of Chlorophyta. Randhawa (1959) reported about 580 species under 17 genera from India of which *Mougeotia* with about 18 species, *Zygnema* with about 23 species and *Spirogyra* with nearly 94 species are the most predominant genera. The most distinguishing feature of the family Zygnemaceae is the 'conjugation' type of sexual reproduction. Among this group again, *Spirogyra* is the most common genus found in fresh water bodies. It is also commonly known as 'pond scum' or 'water silk'. *S. maxima, S. neglecta* and *S. nitida* are the dominant Indian species. All the species of *Zygnema* are aquatic except *Z. terrestre* Randh.

Desmids are unicellular green algae made up of one young and another old semi-cell. They are represented by about 2500 species under 27 genera in the world and are of two types: unconstricted desmids e.g. *Closterium* (c. 200) and constricted desmids e.g. *Cosmarium* (c. 800). Some of the Indian species are *C. connatum, C. distichum* and *C. monaliforme.* They mostly occur in association with other algae in the fresh water bodies.

Characean green algae, best known as stoneworts are represented in India by the genera *Chara, Tolypella, Nitellopsis* and *Lychnothamnus* with a total of about 69 species out of 294 species grouped under seven genera in the world. Except *Chara baltica* almost all the species of *Chara* grow in the water rich in calcareous materials and become encrusted with calcium carbonate. The dominant Indian species are *C. wallichii, C. zeylanica, C. corallina.* In *Nitella* and *Tolypella*, the oogonium has 10 coronal cells whereas in the rest there are five cells. Except *Nitella terrestris* which is terrestrial, all other species of the genus are either aquatic or semi-aquatic found in shallow water along the edges of fresh water pools, lakes etc. attached to the substratum. Sundaralingam (1962) has described the structure and life history of *Nitella terrestris* which is a dominant Indian species besides *N. acuminata* and *N. furcata.* Other Indian species are *N. flagellifera, N. hyalina, N. mucronata,* and *N. oligospira.* The Charales are best known as food for aquatic animals especially water fowl. They are also a cheap source of calcium in acidic conditions.

The family Xanthophyceae is mostly represented in India by *Botrydium* (ca. 6) and *Vaucheria* (ca. 11) out of 376 species grouped under 76 genera reported from the world. The unicellular, coenocytic filaments have carotenoids more than chlorophyll a hence yellow in colour along with oil, lipid and a glucose polymer 'leucosin' as a normal reserve food. Iyengar (1925) reported *Botrydium tuberosum* for the first time in

India. A new species *B. divisum* was also reported from India by him which differs from all other species in having a branched aerial vesicle not covered with lime. Most of the species are terrestrial frequently intermingled with superficially similar green alga *Protosiphon* but differ in having branched rhizoid, inability to divide vegetatively, and in food reserve, pigmentation and flagellar morphology. *B. granulatum* is a dominant species in India.

Most of the species of *Vaucheria* (ca. 9) are terrestrial, abundant in temperate region but few are fresh water forms. Of these, *V. vessilis* and *V. geminata* are common in north India during winter months. *V. uncinnata* is aquatic whereas *V. sessilis* and *V. amphibious* occur both on land and in the water. Other common Indian species are *V. versa, V. clavata, V. globulifera, V. orientalis, V. piloboloides* and *V. polysperma.* Altogether, 11 species of *Vaucheria* are reported from India out of the total 40 species found in the world.

BACILLARIOPHYCEAE (Diatoms)

Diatoms are beautiful, unicellular, microscopic and variously coloured organisms represented by about 20,000 species in the world. They are believed to be ubiquitous plants found everywhere where the life exists. Their number is infinite even in a small quanitity of water. They are both terrerstrial and aquatic. They also occur as epiphytes on algae and few as epizoic on animals. They are reported even from the hot springs where the extremes of climatic conditions prevail. Both planktonic and benthic forms are found among the diatoms variously shaped like tiny boats, half moon, triangles, rectangles and circles. They are found in different colours viz. golden yellow, yellow brown, or olive green which may be due to the presence of large amounts of colouring material in the form of chlorophyll a and chlorophyll c besides brown coloured 'fucoxanthin' known as 'diatomin'. The thallus is diploid with characteristic silicified cell wall called as 'frustule' or shell which in turn consists of two overlapping halves known as 'girdles'. All kinds of ornamentation such as ridges, pits and fine pores are arranged in beautiful geomatric patterns in the valve portion of the cell wall giving beautiful appearance.

In India, the diatoms belonging to family Bacillariophyceae are mostly represented by *Cymbella menenghiniana, Gomphonema, Eutonia pectinalis, Unnotia pectinalis, Navicula halophylla, Nitzschia sp, Neidium gracile, Pinnularia viridis, Melosira sp.* etc. Although diatoms are autotrophic they can utilize organic substances. However, a colourless species *Nitzschia putida* is a saprophyte. All the forms are known to be a part of the food chain and constitute a good source of primary food for a variety of aquatic animals.

PHAEOPHYCEAE (Brown Algae)

Although there are 1500 species under 250 genera, they are mostly from marine habitats growing in the intertidal zone along the coastal belt of littoral countries. However, there are some forms like *Heribandiella, Pleurocladia lacustris, Sphacelaria pseudobondenella* and *Lithoderma sp.* which inhabit the streams that directly drain into the sea.

RHODOPHYCEAE (Red Algae)

The red algae are predominantly marine and widely distributed. About 4000 species of red algae are grouped under 400 genera in the world. Except a few fresh water forms belonging to the genus *Batrachospermum* (ca.40) all others are marine forms.

Another important genus *Compsopogon* occuring in bunches is reported from fresh water streams of tropical and sub tropical regions. The blue-green coloured filaments are found attached to submerged aquatic plants but remain unattached when growing in the stagnant water. Some of the dominant Indian species include *C. indica, C. hookeri, C. iyengari* and *C. coerulens*.

CYANOPHYCEAE (Blue-green Algae)

The blue-green algae also known as Cyanobacteria are most primitive and simplest among the photosynthetic plants characterised by procaryotic cells and marked by their widespread occurence, abundance and mophological diversity. About 2500 species under 150 genera ranging from subspherical cells less than 1 um in diameter to trichome well over 100 um in diameter are known to occur in the world. Out of this, about 1500 species under 100 genera are found in India.

The order Oscillatoriales is most dominant order among the Cyanophyceae followed by Nostocales and Chrococcales. In Oscillatoriales, *Oscillatoria* (ca.65), *Lyngbya* (ca.60) and *Phormidium* (ca.30) are dominant genera in India. *Microcystis aeruginosa* is widely distributed through out the country and in association with a filamentous form *Phormidium mucicola* cause 'water bloom' in the lakes, reservoirs and ponds. Out of 250 planktonic species under 44 genera in India, about 40 species are known to form water blooms. The genera *Microcystis, Aphanizomenon* and *Anabaena* sometimes cover the entire water surface in the temple ponds etc. and float due to the presence of gas vacuoles. They are responsible for deoxygenation, unpleasant odour and for release of toxins. The genus *Trichodesmium* is however known to form blooms in Indian ocean, Bay of Bengal and Arabian sea. Some of the important planktonic genera are *Coelosphaerium, Arthrospira, Nodularia, Aphanizomenon, Gleotrichia, Lyngbya, Nostoc, Spirulina, Gleotrichia, Oscillatoria, Microcystis* and *Anabaena.*

The colonial forms of cyanobacteria are enclosed in a gelatinous sheath and are of filamentous and non-filamentous forms. The non-filamentous colonies are of various forms-cubical *(Eucapsis)*, square or spherical *(Coleosphaerium, Gomphophaera)*, irregular *(Microcystis)* depending on the planes and directions in which the cells divide. In case of *Aphanothece,* non-motile cells are limited by common mucilage secreted either by cells or originates due to gelatinization of the cell walls. Such a transitory phase is known as palmelloid stage.

The unicellular *Gleocapsa* with four dominant species viz. *G. atrata, G. calcarea, G. decorticans, G. gelatinosa* and *G. punctata* is abundantly found in India. The cells are held in mucilaginous sheath formed of masses of jelly.

The filamentous forms prominant in Oscillatoriales and Notocales are the result of repeated cell division in a single plane and in a single direction forming 'trichome' which may be straight *(Oscillatoria)* or coiled *(Lyngbya, Spirulina)*. The trichome may be branched *(Schizothrix)* or unbranched *(Oscillatoria, Lyngbya)* having single trichome or many trichomes *(Hydrocoleus, Microcoleus)*.

Among the species of *Phormidium, P. purpurascens* is dominant in the eastern and northern regions of the country where it forms brownish violet stratum on green alga *Mougeotia* in Yamuna river near Allahabad while two species viz. *P. africanum* and *P. orientale* are dominant in the western parts. Other common species are *P. ambiguum, P. foveolarum,* *P. mucicola* and *P. retzii* in many of which numerous trichomes are embedded in an emorphous mucus.

About 15 species of *Lyngbya* show affinity with species found in Myanmar and Sri Lanka but in India most species occur on the bark of trees, prominant among them being *L. conectens* and *L. palmarum* etc. Besides, three species are also reported from the Chilka lake in Orissa. Other coiled forms include 6 species of *Spirulina* some of which are well known to be the source of single cell protein and as a feed for chicken. Among the filamentous forms some are heterocystous while others are non-heterocystous. Presence of homogonia is also a characteristic feature of many heterocystous species. Some of the heterocystous forms are viz. *Anabaena, Aulosira, Nostoc* and *Scytonema*. Hormogonia are also present in few non-heterocystous forms like *Oscillatoria*, the differentiation and liberation of which appear to be a timed process associated with the environmental conditions such as light and phosphorus repletion.

The *Nostoc* balls, an aggregation of numerous filaments with common gelatinous boundary, are common features in Indian rice fields. Out of 19 species represented in India, most of them are found in northern and western parts and six species show affinity with Myanmar species. Some of the dominant species in India are *N. muscorum, N. paludosum, N. commune* etc. The closely related genus *Anabaena* differs from *Nostoc* in that no firm colony is formed. Some dominant species of *Anabaena* are *A. ambigua, A. fritschii, A. flos-aque* and *A. variabilis*. Some species such as *A. azollae* and *A. cycadearum* are well known symbiotic algae.

Tolypothrix and *Scytonema* belonging to order Scytonematales also exhibit ball like structure 'aegagrophilous' and 'pseudobranching' (filaments not connected by cytoplasmic connections) in contrast to true branching as observed in other members like *Stigonema* and *Hapalosiphon*. *Scytonema* (ca.25) shows great degree of adaptability to diverse habitats from colder regions of Sikkim *(S. substile)*, the Bajreswari hot spring in Maharashtra whereas *S. crustatum* and *S. zellerianum* are restricted to Assam. *S. symplex* is aquatic while *S. oscillatum* is terrestrial but absorbs moisture from the air and becomes cushion like on the tree bark and sometimes imparts green tinge to the ground. Other species of the genus represented in India are *S. guyanense, S. iyengari, S. javanicum, S. mirabilis, S. simplex, S. stuposum* etc. exhibiting affinity to Srilankan species. *Tolypothrix* (ca.12) is mostly confined to northern region while *Calothrix* (ca.22) to southern parts of the country. *Calothrix indica* is worth mentioning here as it is the first algal species reported from India by Montagne in the year 1845. The genus *Gloeotrichia* is represented by the species like *G. ghosei, G. indica, G. natans, G. pilgeri, G. pisum.* Unlike *Gloeotrichia, Rivularia* does not form akinetes and is represented by *R. beccariana, R. globiceps* and *R. manginii.* Likewise, *Cylindrospermum* (ca.4) is represented by *C. gorakhpurensis, C. licheniforme, C. majus* and *C. spherica.* Many blue green algal species are also found, some dominant, in marine environments. For example *Trichodesmium erythraeum* with large amounts of phycoerythrin imparts red colour to the Red sea. Several species of blue-green algae such as *Anabaenopsis, Phormidium, Anabaena* etc. are reported from salt lake of Sambhar in Rajasthan. Altogether about 35 species are reported from different salt water lakes in India.

Recent studies at IARI have indicated that about 5 strains of nitrogen fixing cyanobacteria are able to solubilize Mussorie rock phosphate, a raw matirial for the fertilizer industry. The accumulation of phosphate per unit of biomass is highest in *Calothrix braunii* followed by *Hapalosiphon fontinalis, Scytonema cincinnatum, Tolypothrix ceylonica* and *Westiellopsis prolifica.* Deposition of iron in *Aphanothece, Lyngbya* and *Microcoleus* and sulphur in *Oscillatoria sp* growing in the water rich in sulphur as seen in Sahastradhara at Dehradun have come to light.

Very few fossil forms of cyanobacteria are reported from India. Rao (1944) was the first to report *Symploca jurassica,* from the Cullygoody lime stones of Trichinopoly of upper Jurassic period while Mehta (1954) and A.R. Rao (1957) have reported *Aphanocapa* from Permocarboniferous beds of south Rewa and *Synechocystis* fossil from tertiary lignites of Bikaner respectively.

ECONOMIC IMPORTANCE

The uses of various types of algae are many fold. The algae offer at present a greater variety in the processes of development than any other class of plants. As we make further progress in algal research, we are sure to end up with many prospects out of them. The role of ubiquitous blue-green algae in the augmentation of the nitrogen status of rice-field soils by fixing atmospheric nitrogen and their use as biofertilisers both in lieu of and in combination with chemical fertilizer conservation has been considered a boon for many small and marginal farmers in India. Several unicellular green algae and some filamentous blue-green algae are very much in use as a source of single cell protein. To mention a few, *Chlorella, Synechococcus, Spirulina* etc. are being made use of for this purpose. *Chlorella, Ankistrodesmus* and *Chlamydomonas* are known to be a good source of food for crustaceans while *Spirulina* grown in seawage treatment plants for yellowing the yolk of eggs by feeding chicken. Some of the species belonging to order Charales of Chlorophyceae are recommended for indoor aquaria as they support abundant growth of epiphytes and small herbivorous animals grown in such aquaria. The algae viz. *Euglena, Chlorella, Chlamydomonas* and *Scenedesmus* are grown in seawage treatment plants for purification by utilizing phosphorus and nitrogen through bacterial decomposition in their metabolism liberating oxygen. Many diatoms are directly consumed by aquatic animals and zooplankton and the oil rich in vitamin A and D so formed as a result of diatom photosynthesis passed through the food chain to be finally stored in the fish liver. Diatom *Nitzschia* is extremely rich in vitamin A. Diatoms perform a unique service in the economy of nature as they trap and conserve the life giving nutrient materials washed from the land into the sea and keep them in circulation. The indestructible siliceous frustules of past diatoms have formed oceanic sediment 'diatomaceous earth' which is like a rock like deposit extending hundreds and thousands of feet in depth in many localities. They are mined in many parts of the world to obtain a whitish powder called 'DIATOMITE'. This powder is fire proof and is highly absorbent and is being used as filters in sugar refinery, brewing industries, in packing corrosive chemical liquids, insulation of refrigerators, in making sound proof rooms, houses and more importantly in making dynamite. A significant percentage of the world's oil reserve is considered to be of diatomic origin.

The importance of fresh water as well as marine algae in global primary production has been highlighted by many workers. Many algae absorb large quantities of heavy metals present in industrial affluents and thus help in ameliorating water pollution as zinc, cadmium, mercury, lead, copper and uranium are concentrated many times more in the algal cells than in aquatic environment. It is sometimes attempted to reutilise these algal forms after harvesting for biogas production and in some cases as a fodder. However, the putrefying algal masses in the lakes and water reservoirs are disturbing and economically aggravating. The 'water blooms' involving *Microcystis, Phormidium, Oscillatoria, Anabaena circinalis, A. flos-aquae etc.* secret toxins and kill the fishes by causing liver lesions, and lung haemorrage in some animals. Antagonistic effects of extracellular product 'Chlorellin' released by *Chlorella* inhibits the growth of other beneficial algae and phytoplankton.

CONSERVATION

It is preposterous, if not impossible, to designate algal flora as a rare, threatened and endangered genera or species due to impending changes in the composition depending on seasonal variation. An attempt may, however, be made for their conservation as we can not afford neglecting their role as nitrogen fixers, food, fodder, fertiliser, in soil fertility conservation, sewage, purification and in many industries whether they are fresh water or marine, aquatic or terrestrial and autotrophic or epiphytic. The need of the hour, therefore, is to explore and survey all the unexplored and underexplored aquatic and terrestrial habitats of their occurrence in our country so that the inventory or flora that takes shape will give us an exhaustive information regarding algal wealth and diversity for sustainable use.

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MARINE ALGAE

P.S.N. Rao
V. Mudgal

India has a coast line of over 6000 km. The Arabian sea washes the shores of the Gujarat on the west while on the east, the Bay of Bengal washes the coasts of Sundarbans, portion of West Bengal, Orissa, Andhra Pradesh and Tamilnadu States, and the southern promontory of Indian Peninsula is bathed by the Gulf of Mannar and Indian Ocean, along the coasts of southern portions of Tamilnadu state. The Gulf of Kutch and the Gulf of Cambay are the more important gulfs on the Arabian sea side. On the Bay of Bengal coast, the Chilka lake in Orissa and the creeks and inlets of Sundarbans are the more important features of the coastal strip. The geology of Indian coast, however, is very varied.

The more important places of Algal interest along the Indian coast are the Okha Port, Dwaraka, and several places along the Gujarat coast, Bombay, Karwar, Travancore, Kanyakumari, the various islands in the Gulf of Mannar, Tuticorin, Mahabalipuram, Waltair, Chilka Lake and Sundribans. The Andaman & Nicobar islands, the Lakshadweep and the Minicoy are of great interest for marine algae. The Gujarat coast and the island stretches in the Gulf of Mannar are of special interest, the former perhaps excelling all other areas in India for the luxuriance, variety, abundance and occurence of several species not usually to be found in the tropical seas. Especially, the Kanyakumari has a distinctive algal flora which also for its variety and luxuriance, is noteworthy.

Tidal effects and the nature of substratum in the littoral belts have great influence on the luxuriance of the algal vegetation. The rocky nature of the coast due to the naturally occurring rocks, huge boulders and stones or extensive formations of coralline beds and reefs is most ideal for supporting quite an innumerable variety of algal vegetation. A purely sandy beach harbour practically no alga. However, broadly speaking the more important factors influencing the growth of sea weeds are: the nature of substratum, effect of tides, surf or wave action, clearness of sea water and biotic and seasonal changes.

Late Prof. M.O.P. Iyengar realised as early as the thirties of the present century the importance of marine algae and the wealth of knowledge that still remained to be unravelled in the field of Algology and particularly in the marine algae of the Indian coasts. His profound knowledge and deep insight into the mysteries of these fascinating groups of plants and his passion for algae had an abiding influence on his pupils, benefiting considerably by his discourses, practical demonstrations on the life activities of the various groups of seaweeds, their methods of propagation, reproduction, structure, ecological and morphological peculiarities etc., - lessons which have left an indlible impression. That being so, the seaweeds of Indian coasts continued to attract the attention of his students and others even after their leaving him.

Although Iyengar was the first Indian algologist to work on the marine algae of the south Indian coast whose works are being posthumously published even now, our current knowledge of the Indian marine algae stems from the publications of Boergesen who carried out the poineering work on the marine algae of the South Indian, Bombay and Gujarat coasts. However, there are available in literature various records of Indian marine algae dating back to even pre-Linnean years. The first record of any algae from the Indian ocean is perhaps that of a specimen of *Amphiroa* collected by Herman as early as 1672 from the cape of Good Hope. Subsequently and prior to 1703 several pioneers have recorded many marine algae which would be the 17th and 18th century records of marine algae of the Indian Ocean region. In the 19th century, collections of marine algae were made during a number of expeditions. Although these expeditions did not touch the mainland coasts of India, they nevertheless collected marine algae from the Bay of Bengal and Arabian Sea Islands.

Collections of marine algae from the Indian Ocean region, especially from the shores of India, were made by a number of workers, of which the collections of James Murray and W.J.S. Pullen have proved invaluable. Marine algae of this region are found in the herbaria of W.J. Hooker, Bertol, Rudolph, Coleman, Areschoug and Hauck. However, seagrasses were collected and studied by Klein, Rottler, Thunberg and Campbell and are deposited in various herbaria such as those of the Indian Botanic Gardens, Calcutta, the British Museum of Natural History, London and New York Botanical Gardens, while some specimens collected from India are found in the Agardh Herbarium, Lund and in the Rijksherbarium, Leiden. Several references are also found in the early treatises of various algologists viz. Turner, Agardh and others up to early twentieth century . In early twentieth century, writers on Indian marine algae included Barton, Svedelius, Reinbold, Grunow and Iyengar. It was Boergsen who published extensively on Indian marine algae, having personally collected them from South Indian, Bombay and Gujarat coasts. Anand (1943) gave an account of the algae of Karachi coast. Biswas (1945) published lists of Indian marine algae from the west coast and later Biswas and Sharma (1950) on the Indian *Sargassam.*

Some of the later workers who reported on Indian marine algae are Srinivasan, Chauhan, Thivy, Desikachary, Balakrishnan , Krishnamurty, Joshi, Umamaheswara Rao and Dixit. Subsequently, Krishnamurthy and Joshi (1970) published a detailed check-list in which 520 species of Indian marine algae were included. Most recent check list enumerating about 624 species is by Untawale *et al* (1983). Out of these 159 species belong to Chlorophyta, 141 to Phaeophyta, 307 to Rhodophyta and 17 to Cyanophyta.

STATUS OF INDIAN MARINE ALGAL SURVEY

A consideration of all the published records shows that collections of marine algae made have been either stray and fortuitous or have been made during one short visit to the coast. Certain areas of the Indian coast have been worked out thoroughly while a large part of the shore has not been surveyed. Moreover, the data collected so far indicates a moment-picture of the algal flora in any given locality and do not include collections round the year. For example, very little is known of the marine algae of the Andaman & Nicobar islands while the only accounts of the algae of the Laccadives are those of Barton (1901, 1903). However, a recent survey by Subbaramaiah and his colleagues has netted about 80 species from Laccadives. Though in recent years various organisations have undertaken surveys of marine algae, the recorded results are not exhaustive as there is no detailed information on the species listed and no evidence as to the correct identity of the seaweeds is recorded.

Notable lacunae in our knowledge of the Indian marine algae include lack of exploration and therefore information on the genera and species of such regions as the Kerala, Karnataka, Andhra Pradesh and Maharashtra coasts as well as the Andaman & Nicobar islands. This is the scenario even with little known coastal areas of the Gulf of Kutch, some places on the Tamilnadu coast, not to mention the chain of islands from Ramesh- waram to Tuticorin.

Extensive and intensive explorations of unexplored and underexplored areas as mentioned above is a prerequisite in compiling a marine algal flora of the Indian coasts. Perhaps the most important areas for exploration is that comprising the Andaman and Nicobar group of islands which together have a coastline of about 1962 km which is one fourth of Indian coastal stretch.

TAXONOMY OF INDIAN SEAWEEDS (Marine Algae)

Studies made on the Indian marine algae have been reviewed from time to time by various authors like Agharkar, Biswas, Joshi, Iyengar, Randhawa, and Srinivasan. Based on the collections of M.O.P. Iyengar and on his own collections, Boergesen has published a series of papers on the green (Chlorophyceae), brown (Phaeophyceae) and red (Rhodophyceae) algae of the northern parts of the west coast, and brown and red algae of south India. After this valuable contribution of Boergesen, much work has been done on the morphology and taxonomy of Indian marine algae during the last five decades, especially with reference to different places along the coastline of India which information would be of much help for writing Marine Algal Flora of India (Table I).

Table I
Some contributions to the Marine Algal Flora of different regions of the India-Coast

Author and Year	Contribution and area
Biswas (1945)	Marine algae of west coast
Srinivasan (1946)	Marine algal flora of Mahabalipuram
Chacko *et al.* (1955)	Algal flora of Krusadai island
Varma (1960)	Seaweeds of pearl and chank beds off Tuticoron
Dixit (1964 and 1968)	Checklist of Indian marine algae
Srinivasan (1965)	Checklist of Indian marine algae
Misra (1966)	Monograph of Indian brown algae
Srinivasan (1966)	Indian species of *Sargassum*
Gopalakrishnan (1969)	Marine algae of Gulf of Kutch
Krishnamurthy and Joshi (1969)	Species of *Ulva* from Indian waters

Author and Year	Contribution and area
Krishnamurthy and Joshi (1969)	Checklist of 520 species of Indian marine algae
Umamaheswara Rao (1972)	Coralreef flora of the Gulf of Mannar and Palk Bay
Untawale *et al* (1983)	Enumerated 624 species of marine algae and their distribution along the maritime states of India

Stray marine algal collections have also been reported by various workers from different localities of Indian coast. However, some additions to the list of Untawale (1983) are also made after 1983 and the total number could be put around 680.

DIVERSITY

A floristic analysis of marine algal flora in India shows that maximum diversity both at generic and species level is noticed among Rhodophyceae with 99 genera and over 350 species followed by Chlorophyceae with 36 genera and over 159 species and Phaeophyceae with 33 genera and a little over 150 species. The Xanthophyceae is represented by only 1 genus and 3 species while Cyanophyceae is represented by 3 genera and 17 species.

CHLOROPHYCEAE

Among the green algae only 4 genera viz. *Caulerpa* (*ca* 19), *Cladophora* (*ca* 12), *Enteromorpha* (*ca* 10) and *Chaetomorpha* (*ca* 10) are represented by 10 or more number of species while *Ulva* (*ca* 7), *Bryopsis* (*ca* 7), *Codium* (*ca* 7) and *Halimeda* (*ca* 6) are represented by less than 10 species each. The remaining 28 genera are found representing less than five species each. The above analysis clearly shows that *Caulerpa* is the dominant genus with maximum number of species represented.

XANTHOPHYCEAE

Vaucheria is the only genus representing 3 species viz. *V. clavata, V. mayyanadensis* and *V. piloboloides* on the Indian coast especially along the southern coast and Andaman sea coast.

PHAEOPHYCEAE

Although, the brown algae are less represented in terms of number of genera and species as compared to other two dominant groups viz. green algae and red algae, they are quite predominant on the Indian coast in terms of biomass resource. Interestingly, the genus *Sargassum* which is represented by more that 45 species in India is most predominant with regard to species diversity among all the marine algae occuring in the Indian waters. The other phaeophyceaen genera which are represented by 5 or more number of species are *Ectocarpus* (*ca* 9), *Dictyota* (*ca* 8) and *Turbinaria* (*ca* 5) followed by other genera with less number of species represented.

RHODOPHYCEAE

The red algae, mostly inhabiting the marine environment in the world, are richest on the Indian coast with regard to generic and species diversity with a tally of over 100 genera and 307 species but with less biomass as compared to brown seaweeds. There are only 4 genera viz. *Acrochaetium* (*ca* 17), *Gracilaria* (*ca* 12), *Laurencia* (*ca* 10) and *Halymenia* (*ca* 10) representing 10 or more number of species. However, there are about 11 genera viz. *Polysiphonia* (*ca* 9), *Ceramium* (*ca* 8), *Champia* (*ca* 6), *Hypnea* (*ca* 8), *Liagora* (*ca* 6), *Gelidium* (*ca* 6), *Galaxaura* (*ca* 5), *Scinaia* (*ca* 5), *Chondria* (*ca* 6), *Acanthophora* (*ca* 5) and *Grateloupia* (*ca* 6), represented by 5 or more species but less than 10 while the remaining genera are represented by less than 5 species each.

CYANOPHYCEAE

Despite several studies undertaken on the blue-green algae (BGA) of freshwater habitats, there are very few workers who have dealt with marine forms of BGA. The studies, hitherto, made indicate that only 3 genera viz. *Phormidium, Nostoc* and *Oscillartoria* are recorded with a total number of 17 species from the Indian coasts. More studies are required to be made with an emphasis on the hitherto unexplored coastline.

From the above floristic analysis it is evident that the long coast line of India harbours a rich marine algal flora with a total of about 624 (680) species under 169 genera against a total of more than 1368 genera and 10, 350 species from oceans of the World. The lower representation of marine algae seaweeds on the Indian coasts as compared to the World number is perhaps due to the fact that the climate in temperate and arctic regions is more favourable for many members of these groups, where they find greater scope for development and diversification. Or else species belonging to these groups are still awaiting the attention of phycologists for their discovery.

Although marine algae of the Indian coasts have been studied by a number of phycologists over the last two centuries, little attention seems to have been paid to the crustose coralline algae which are generally found attached to reefs, coral stones, large boulders, shells or seen growing epiphytically on many marine angiosperms and macroalgae. Jayagopal (1985) has recently given a list of crustose coralline algae known from the Indian region on the basis of previous studies by other workers and his own (Table II).

To-date there are as many as 60 species belonging to 13 genera recorded from the mainland coast of India. However, there is much more to be achieved to fill up the existing lacunae in our knowledge of the marine algae of India.

Table II
Crustose coralline algae from Indian region (Genera)

Sporolithon	*Hydrolithon*
Lithothamnion	*Lithoporella*
Melobesia	*Fosliella*
Lithophyllum	*Tenarea*
Neogoniolithon	*Heteroderma*
Porolithon	*Pseudolithophyllum*
Titanoderam	

SEAWEED RESOURCES OF INDIA

The assessment of available seaweed resource in India has been necessitated with particular reference to agarophytes and alginophytes as more and more algin and agar industries started coming up in the recent years. It has been estimated that the seaweed resources of the world comprise about 1460 million tonnes wet weight brown algae and 261 million tonnes wet weight red algae. The total seaweed production may be about 1721×10^4 tonnes wet weight annually. The major sources of seaweeds are in the north east, western-central and south west Atlantic and the eastern-central and northwest Pacific areas. There is not much information regarding the Antarctic and Arctic regions.

India, with a long coast line extending upto 6000 km has a vast resource of seaweeds along her many open coasts and estuarine areas. The Lakshadweep and Andaman-Nicobar islands are thought to have considerable seaweed resource. Resource surveys have been conducted by Central Salt & Marine Chemicals Research Institute and Central Marine Fisheries Research Institute in India to assess the occurrence and distribution of seaweeds along our coasts, and it has been estimated that about 73,000 t of this resource is available along the areas explored so far.

MAIN CENTRES OF SEAWEED DISTRIBUTION

Along the coast line of India, the littoral and sublittoral rocky areas support a good luxuriant growth of different seaweeds (agarophytes, alginophytes and other edible seaweeds). There is extensive growth of seaweeds along the south-east coast of Tamilnadu, from Mandapam to Kanyakumari; Gujarat coast especially at Okha and Dwaraka; Lakshadweep islands and the Andaman-Nicobar islands. Fairly rich seaweed beds are present in the vicinity of Mumbai, Ratnagiri, Goa, Karwar, Varkala, Kovalam, Vizhinjam, Visakhapatnam and few other places such as Chilka and Pulicat lakes.

ENDEMISM

The most difficult but important task is to attempt in knowing the endemic species among the six hundred and odd species of marine algae enumerated from the Indian coasts. There are various causes for the existing confusion as far as taxonomy and endemicity are concerned. Descriptions of Indian marine algae are scattered through a range of publications which are not readily available. There are few detailed studies despite several publications in Algal taxonomy and the general distribution of algae in India has not been studied thoroughly. Some work has been done by foreign phycologists each of whom was in the country for a few months only. Some of the species recorded earlier are now not recognised as specially distinct, some of the species names used earlier are considered to be synonyms, while the names of some of the genera have been changed recently. Moreover, the references to scientific literature are not restricted to original literature but also include general publications.

As regards the world distribution of Indian marine algae, several species are found recorded in the algal flora of Sri Lanka, Mauritius and Japan. However, in the present endeavour an attempt has been made to list out atleast some of the Indian species which are not recorded elsewhere especially from Sri Lanka, Mauritius, Danish, West Indies, Japan, Mediterranian sea, Atlantic ocean and Red Sea, the marine algal flora of which is thought to be well studied relatively. Also given are some of the species described from the Indian coast earlier whose present status might have altered or being studied thoroughly to remove many nomenclatural tangles. It is felt worth mentioning here that late Prof. Papenfuss remarked that probably about half the identifications of Indian marine algae were incorrect. Although one would hesitate to believe such a sweeping condemnation of previous work, one can not escape the feeling that many algae have been identified more from superficial similarities to published species than by a systematic study. The ideal thing would have been to compare with type specimens of the suspected taxa. As mentioned above and owing to the predicament as regards incomplete nature of the knowledge at our disposal, any attempt on the endemicity of Indian marine algae would be futile. Neverthless, we need to have a preliminary data towards this goal which can be improved upon and pooled at later stages. On the basis of the information provided in the Table III, the percentage of endemic species is well below 10% which may still go down further after detailed studies are undertaken. As the aquatic species are unique on account of their characteristic forms and adaptations to aquatic environment and due to the absence of factors like isolation and barriers, endemicity is less pronounced.

Table III
Species of Marine Algae endemic to Indian coasts

CHLOROPHYCEAE

Ulvales

Enteromorpha clathrata
E. complanata
E. flexuosa
E. gujaratensis
E. linza
E. plumosa
E. polyclados
Ulva beytensis
U. covelongensis
U. lobata

Cladophorales

Chaetomorpha darwinii
C. intestinalis
C. linoides
C. littorea
C. torta

C. torulosa
Cladophora clavuligera
Codium dwarakense
C. crispata
C. crystallina
C. expansa
C. fritschii
C. indica
C. patentiraema
C. saracenica
C. traquebarensis
C. utriculosa
Rhizoclonium hookeri
R. kerneri
R. kochianum
Spongomorpha indica
Willeela ordinata

Chaetophorales
Phaeophila dendroides

Siphonales
Halicystis boergesenii
Bryopsis corymbosa
B. tenuissima
Caulerpa fastigiata
C. veravalensis
Trichosolen pambanensis
Acetabularia crenulata var. *monodisca*
C. iyengarii

PHAEOPHYCEAE

Fucales
Sargassum binderi
S. vulgare

RHODOPHYCEAE

Erythropeltidales
Erythrotrichia carnea

Nemalionales
Acrochaetium canarense
A. dwarakense
A. krusadii
A. iyengarii
Galaxaura plicata

Cryptonemiales
Grateloupia comorinii
Hydrolithon iyengarii
Jania iyengarii

Rhodomeniales
Gastroclonium iyengarii

Ceramiales
Myriogramme bombayensis
M. okhaensis
Caloglossa bombayensis
Acanthophora wightii
Lenormandiopsis parthasarathii
Laurencia pedicularioides
Neurymenia kappannai
N. tuticorinensis
Dasya flagelliformis
D. iyengarii

ECONOMIC IMPORTANCE

Although there are as many as 680 species of marine algae occuring on the Indian coast and are beneficial to us in one way or the other, but only 49 species are presently found to be useful either as directly edible forms or as industrial raw materials. A systematic list of these species following the classification of Fritsch is given in Table IV.

Table IV
Important and common Indian seaweeds of economical importance

CHLOROPHYCEAE

Ulotrichales	**Siphonales**
Ulva fasciata	*Caulerpa racemosa*
U. lactuca	*C. sertularioides*
U. rigida	*C. taxifolia*
U. reticulata	*Codium adharens*
Enteromorpha compressa	*C. decorticum*
	C. tomentosum
Cladophorales	
Chaetomorpha antennina	

PHAEOPHYCEAE

Dictytales	**Fucales**
Dictyota dichotoma	*Cystoseira trinodis*
Padina commersoni	*Hormophysa triquetra*
P. gymnospora	*Sargassum johnstonii*
P. tetrastromatica	*S. myriocystum*
	S. swartzii
Punctariales	*S. tenerrimum*
Copomenia sinuosa	*S. wightii*
Hydroclathrus clathatus	*Turbinaria conoides*
Rosenvingea intricata	*T. ornata*
Chnoospora minima	

RHODOPHYCEAE

Bangiales

Porphyra vietnamensis

Gelidiales

Gelidiella acerosa

Cryptonemiales

Halymenia floresia

Grateloupia filicina

G. lithophila

Gigartinales

Gracilaria corticata

G. crassa

G. foliifera

G. edulis

G. verrucosa

Sarconema furcellatum

Hypnea musciformis

Gigartina acicularis

Rhodomenials

Rhodomenia dissecta

Ceramiales

Centroceras clavulatum

Spyridia filamentosa

S. fusiformis

Acanthophora spicifera

Laurencia papillosa

L. obtusa

COMMERCIAL EXPLOITATION OF SEAWEEDS IN INDIA

It is well known that seaweeds are the only source for certain natural products. Most important of all the products obtained from the seaweeds since time immemorial worldwide are various phycocolloids which are used sometimes directly as food. They are harvested by man for centuries particularly in Japan and China, where they form a part of the staple food. The uses of many seaweeds are well known as food, fodder and manure in India too but mostly as a source of agar-agar and sodium alginate. Seaweeds also contain protein, iodine, bromine, vitamins and substances of stimulatory and antibiotic nature. Many phytochemicals are extensively used in various industries such as of food, confectionary, textile, pharmaceutical, dairy and paper mostly as gelling, stabilising and thickening agents. Apart from these biochemicals, other products such as mannitol, laminarin and fucoidin are also obtained from marine algae. Now, attempts are being made for screening pharmaceutically active compounds from seaweeds in many countries. However, various products obtained from Indian seaweeds and their uses are dealt with here:

Agar-agar: A colloidal carbohydrate obtained from red algae like *Gelidium, Gelidiella* and *Gracilaria* and has a great commercial value because of its utilisation in ice-creams, jams, jelly, marmalade, lime jelly and tomato sauce. It is also reported to be a laxative besides its use in microbial culture in the laboratories. It goes in the manufacture of paints, photographic film coatings and pharmaceuticals.

Agaroids: The gel-like extracts produced from certain types of red seaweeds. Carrageenan obtained from *Chondrus, Gigartina* and *Eucheuma* come under this catogary. Some species belonging to *Hypnea, Laurencia* and *Acanthophora* growing along the Indian coast yield gel-like extracts.

Algin: It is the main polysaccharide occuring in the cell walls of brown algae. Species of *Sargassum, Turbinaria, Dictyota, Padina, Cystoseira, Hormophysa* are some of the brown algae occuring in Indian waters which yield algin. It is extensively used in the preparation of pharmaceuticals, food and rubber products, textile products, adhesives, paper products, food packages, butter cartons, leather finishers, auto- polishes, wax emulsions and various other products.

Algal proteins: Some green and red sea weeds such as *Ulva fasciata, U. rigida* and *Porphyra* sp. contain very rich protein some with iodine containing amino acids. These seaweeds are known to contain more protein than other food materials such as cereals, eggs and fish. Dry powders extracted from these seaweeds can be added to various foods deficient in protein or taken along with other food stuffs in small quantities.

Seaweed as food: Fresh and dried processed seaweeds are utilised for human consumption. Many seaweeds such as species of *Caulerpa, Codium, Sargassum, Porphyra, Gracilaria, Laurencia* and *Acanthophora* are used as food in Japan, Indonesia, China, Philippines and other countries of Indo-Pacific regions. They are eaten as salad, curry, soup or vegetables. There are infact large industries in Japan using edible seaweeds like *Porphyra.* Some of the edible seaweeds occuring in different localities on the Indian coast are the species of *Ulva, Enteromorpha, Turbinaria,* *Chnoospora, Halymenia, Gracilaria,* and *Porphyra.* The seaweed *Gracilaria* is being used since decades for making gruel in the coastal areas of Tamilnadu.

Seaweed meal: Seaweeds are cheap source of minerals and trace elements. They are suggested to be given as supplements to the daily rations of the cattle, poultry and other farm animals. Seaweed meal can be obtained by grinding cleaned and washed seaweeds such as *Ulva, Enteromorpha, Dictyota, Padina, Sargassum, Gracilaria* etc.

Seaweed manure: Use of seaweeds as manure is a common practice in coastal areas throughout the world. Extracts of many seaweeds are known to promote germination in ground nuts, maize etc. Large quantities of seaweeds including seagrasses can be used as manure in all parts of the country in coastal areas either directly or in the form of compost.

Seaweeds as source of energy: Utilising *Sargassum* as raw material in the digesters and about six micro-organisms from marine environments for digestion, it is said that fuel gas for domestic use can be produced.

Medicinal uses of seaweeds: They are considered to be of medicinal value in the Orient as early as 3000 B.C. The Chinese and Japanese used several seaweeds in the treatment of goitre and other glandular diseases. The British used *Porphyra* to prevent scurvy during long voyages.. Various red algae were also employed as vermifuges in ancient times. The stipes of *Laminaria* have been used to treat various stomach and intestinal disorders. A number of species of marine algae have been found to have anticoagulant and antibiotic properties. However, there are very few studies made on the medicinal uses of seaweeds occuring on the Indian coasts. The antibacterial and antifungal activity of the extracts of several seaweeds is investigated by Rao and Shelat at CSMCRT followed by various workers. Though the importance of different seaweed extracts in pharmacology is known, the development and production of antimicrobial, antifungal and antiviral substances is still in an initial stage of research and development.

CONSERVATION STATUS

The marine algal resources on the Indian coasts are not unlimited. Although we have long coastline, only at certain regions the substratum is suitable for immense growth of seaweeds. Besides, there are various factors determining the diversity and luxuriance of growth other than the human factor. The most disturbing and devastating factors of recent origin are pollution of coastal waters and indiscriminate exploitation of algal resources for sea weed based industries. Moreover, various projects initiated by some national laboratories under CSIR and ICAR have other priorities for seaweed utilisation than to conserve the biodiversity. In view of lack of serious efforts by governmental agencies and the seaweed industry for seaweed conservation, many of the natural habitats known for their algal diversity are denuded although it is not triggering any extinction of known species. This implies that we must set priorities for different localities in terms of the significance for conservation of algae and focus our efforts accordingly.

As known, the microscopic and unicellular algae inhabiting the aquatic environment are less influenced than the benthic algae in a rocky coast where the nature of substratum, wave action and clearness of sea water play important role. Many of the seaweeds are susceptable to turbidity and pollution of sea water, and only a few forms can sustain such environment but attain their luxuriance both in growth and number where sea water is very clear with good penetraction of sun light to greater depths. Besides, seasons also have a marked effect on the growth of several species flourishing on the upper limits of the littoral belt. The large scale commercial exploitation of coral rocks from the sea beds is yet another factor of high magnitude causing concern since such activities deprive the algae of their natural habitats and substratum. Not only the decreasing number of species but also the irreversible diminishing of the size of a species population is a matter of concern especially in case of endemic species. If such tendency is not halted, chances of the species getting eliminated and eventually becoming extinct are imminent. During the months of March-May, many of the macroscopic forms at the upper limits of littoral belt are exposed to dry spell and become scarce.

The conservation of marine algae is as important as that of the land plants for nature conservation. There is no national policy as of now to conserve our marine algal wealth except some measures taken in the form of coastal zone regulation. This is inadequate and not directly related to any programmes on conservation of seaweed resources. As the esturies and salt marshes, mangrove forests, and seagrass/seaweed beds near cities and towns are severely degraded not only in India but world wide, marine conservation has become an issue of global concern. Several distinctive aspects of sea complicate the task of conservation and most important of them is that marine ecosystems are at the receiving end of drainage from the land. To ensure rich biodiversity in marine ecosystems all the categories of marine species including the marine algae are to be taken care of. Integrated resource management in the coastal zone, though the key to conservation and sustainable use, is hardly being applied anywhere. Probably, one of the steps for conservation of marine algal resources for sustainable use would be by community marine resource management programme called the "Marine Conservation and Development Programme." (MCDP) as conceived and initiated in 1984 in the Philippines which will certainly stop over-harvesting and promote regeneration. Introduction of selected exotic seaweed species in Indian waters for augmenting phycocolloid production should also be considered so as to ease the mounting pressure on existing seaweed resources. This has to be resorted to with care and caution in order to avoid likely impact on ecology of the marine ecosystem. For using seaweed resource on sustainable basis, the economically important species need to be cultivated by employing improved maricultural techniques which will ensure uninterrupted supply to the industry. However, emphasis has to be given on all the marine algal species for conserving the species diversity in Indian waters.

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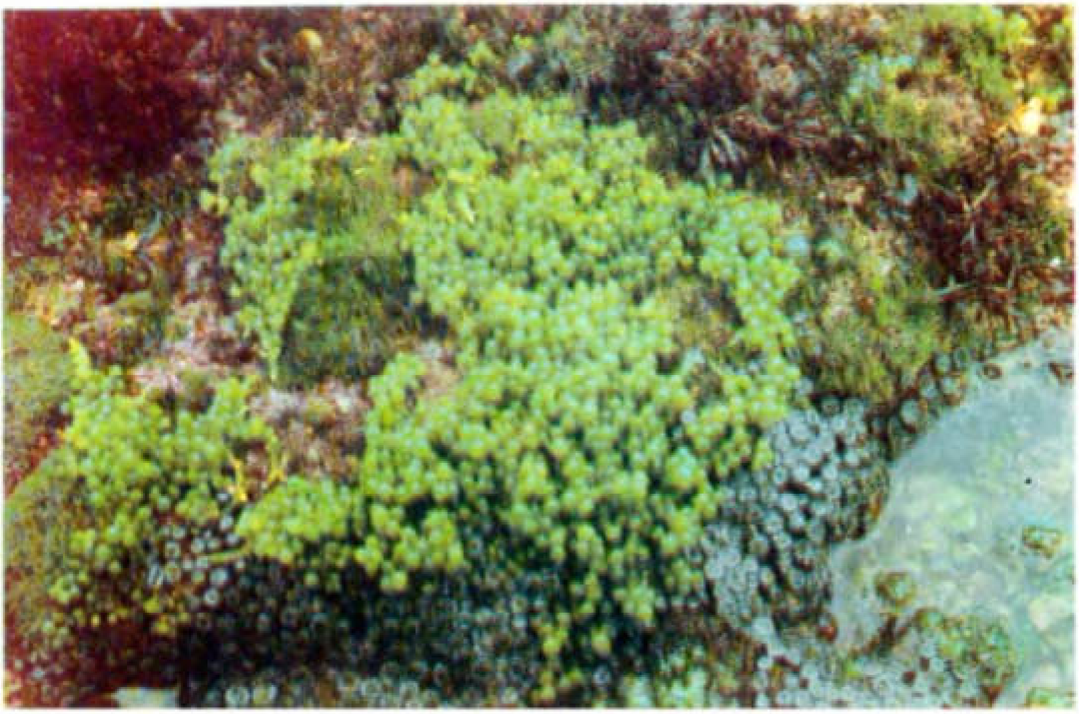
Exposed inter tidal belt with luxuriant growth of brown and green seaweeds

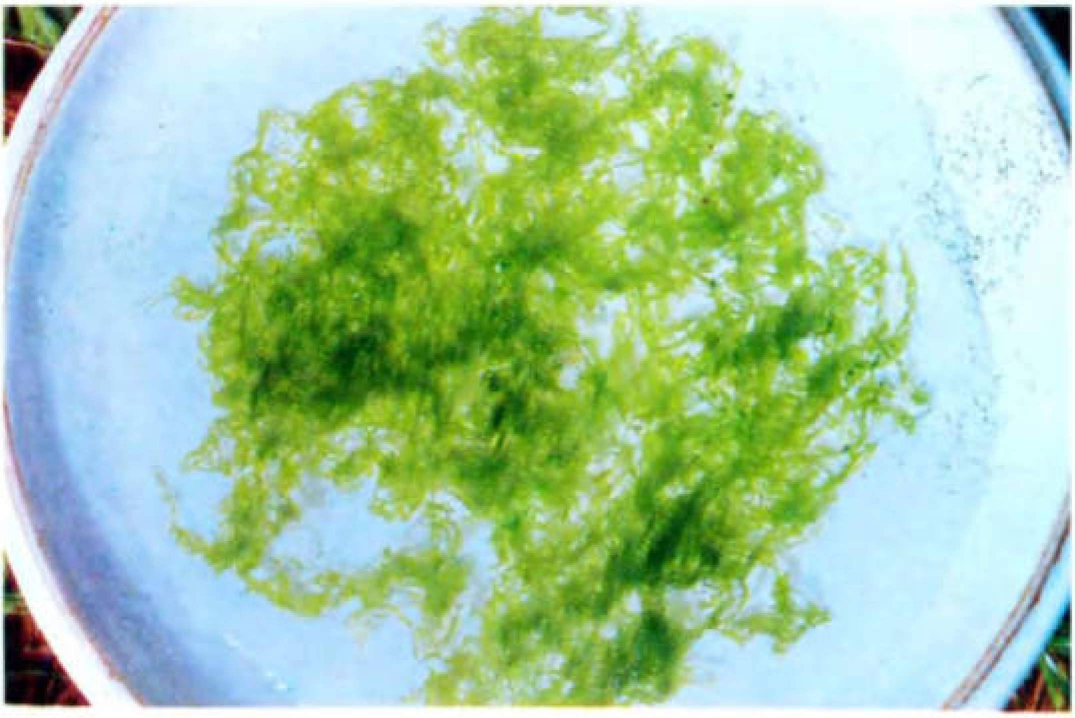
Coralline rocks colonised by *Ulva lactuca* populations with *Sargassum* beds in the background

Boergesenia forbessi

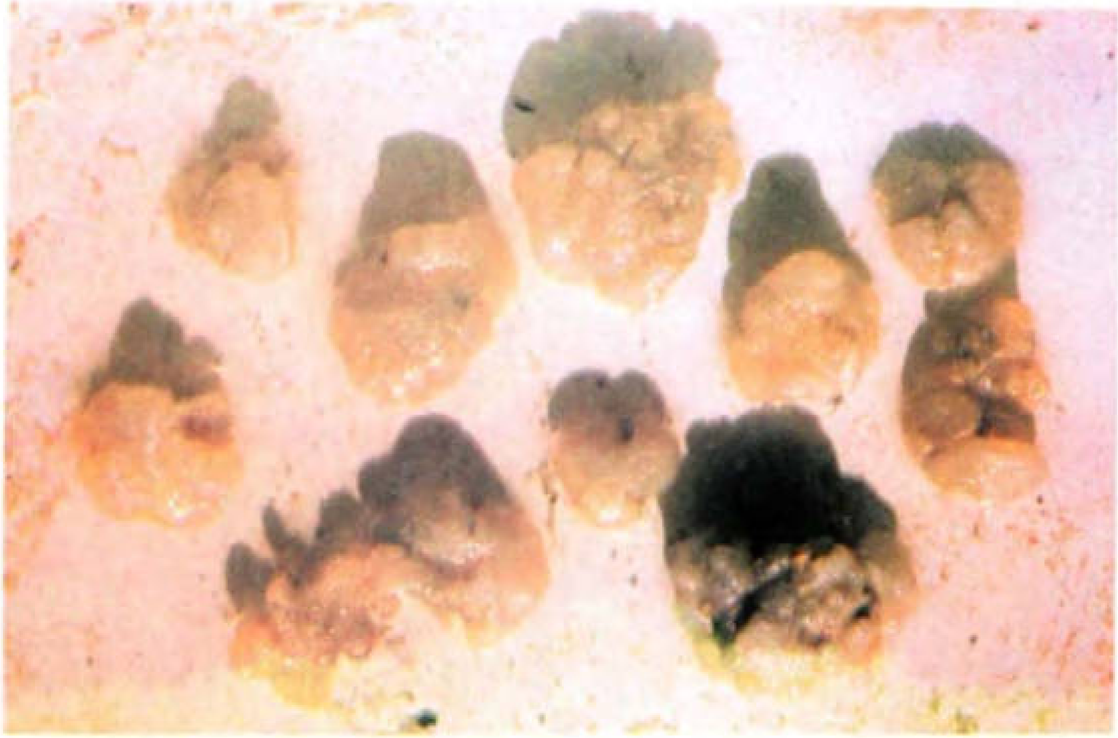
Acetabularia crenulata var. *monodisca*



Caulerpa racemosa



Ulva reticulata



Dictyosphaeria cavernosa

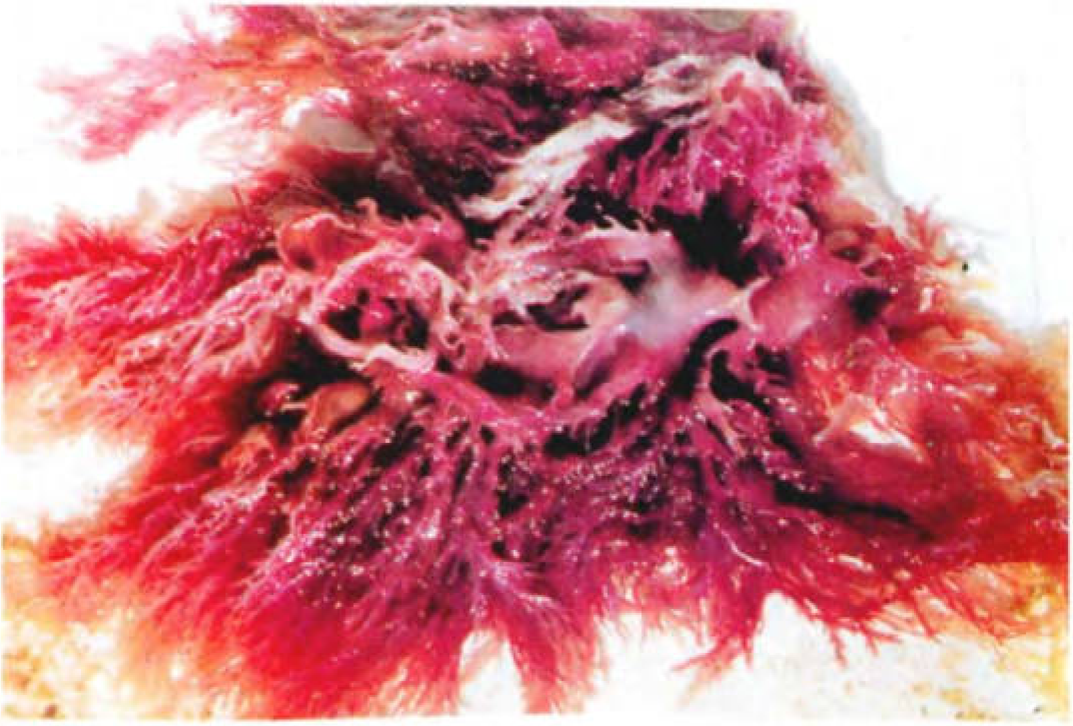
Avrainvillea erecta

Caulerpa sp.

Caulerpa serrulata

Exposed *Sargassum* (brown seaweed) 'beds' along the Andaman coast

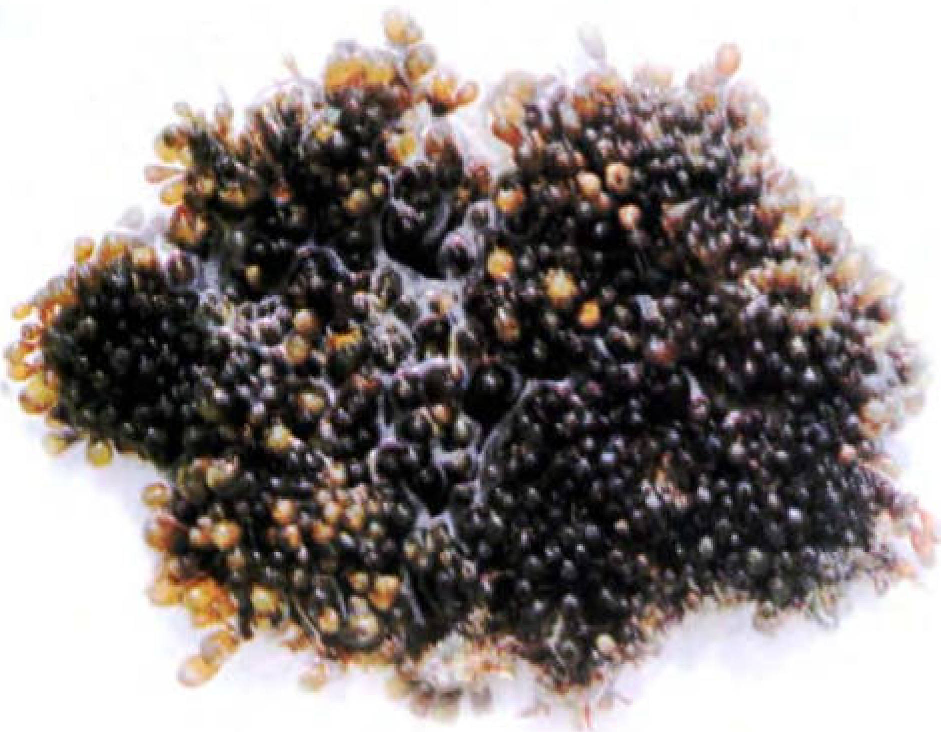
Gracilaria corticata



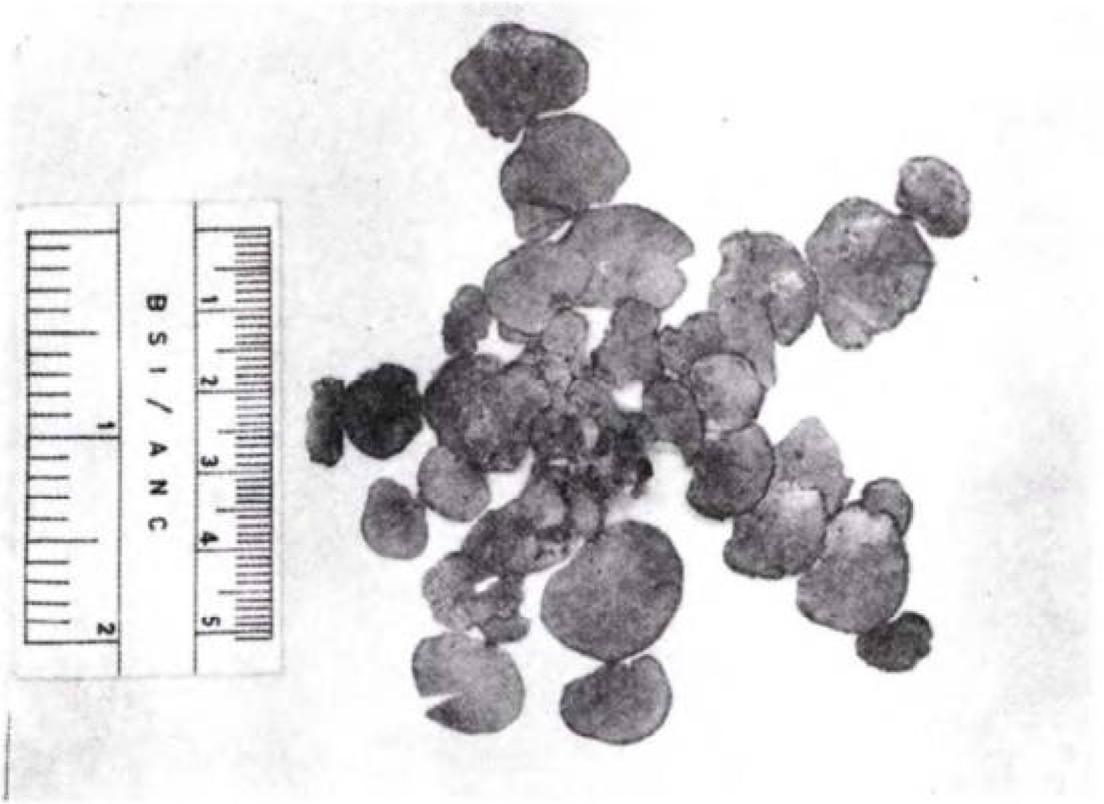
Halymenia venusta

Amphirova anceps

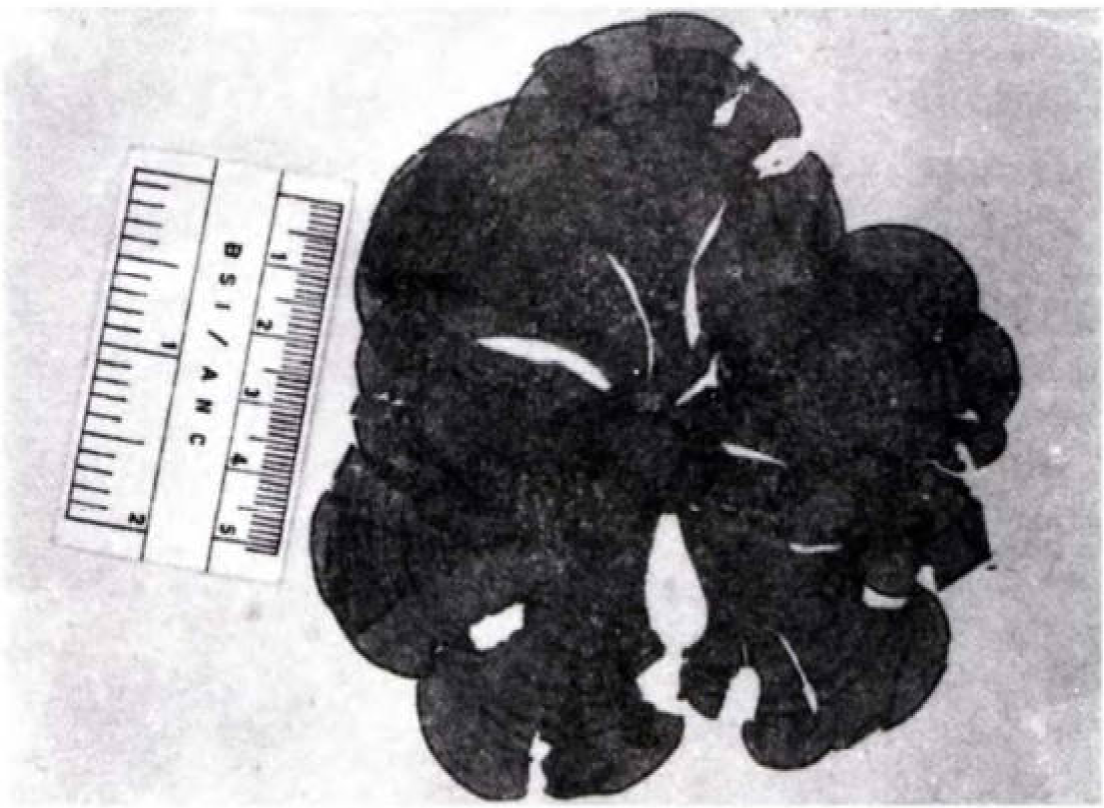
Cheilosporum spectabile



Botryocladia skottsbergii



Halimeda tuna



Padina pavonia

FUNGI

J.R. Sharma

Fungi include the majority of non-flowering plants and constitute a group of heterotrophic organisms subsisting as parasites or as saprophytes on other organisms or their residues. They span the world and are as numerous and varied as flowering plants. Fungi range from microscopic organisms to huge solid bodies; from life savers like pencillin to killers such as ergot; from rusts and mildews which damage growing crops to yeasts which have been used since time immemorial in the preparation of food and drink. Fungi of all kinds are of vital importance to nature's house keeping as they break down and recycle all the organic debris of the world which would otherwise long since have smothered and buried all the plants and animals that produced it.

DIVERSITY

The fungi in India, number more than 2300 genera and approximately 14,500 species (Bilgrammi *et al.* 1991 and other relevant literature) as compared to over 6,000 genera and *ca* 70,000 species so far described (Groombridge 1992) and over 1.5 million species estimated to occur (Hawksworth 1991) throughout the world. Out of the total number known from India, *ca.* 3,500 species are endemic.

Deuteromycotina (Fungi Imperfecti) together with Ascomycotina and Basidiomycotina account for more than 88% of the Indian mycoflora. Deuteromycotina, alone represents *ca* 40% followed by Ascomycotina (*ca* 25%) and Basidiomycotina (*ca* 23%). It is interesting to note that out of *ca.* 2300 genera of Indian fungi, *ca.* 1050 (46%) have only one species, while *ca* 1100 (48%) genera have two to ten species as presented below.

Genera with		1	species	1050
Genera with	2	10	species	1100
Genera with	11	20	species	73
Genera with	21	50	species	44
Genera with	51	100	species	20
Genera with	10	1200	species	9
Genera with	201	500	species	2
Genera with	more than	500	species	1

Some dominant genera representing major groups of Indian Mycoflora are given in Table-I

Table I
Dominant genera in different groups of Indian fungi

Name of group	Some dominant genera with Approx. no. of species in India.
1. Myxomycetes (True slime molds)	*Physarum* (65), *Didymium* (32), *Diderma* (30), *Arcyria* (19)
2. Chyt. Hypochyt.& Oomycetes (Fungi with motile cells)	*Synchytrium* (80), *Physoderma* (50), *Peronospora* (50), *Phytophthora*(28), *Pythium* (40), *Albugo* (18)
3. Zygomycetes (Bread molds)	*Mucor* (56), *Rhizopus* (19), *Mortierella* (15), *Syncephalis* (15), *Conidiobolus* (18)
4. Ascomycetes (Sac fungi)	*Meliola* (130), *Phyllachora* (116), *Chaetomium*(97), *Xylaria*(86), *Hypoxylon* (67), *Leptosphaeria* (54), *Asterina*(51)
5. Ustilaginales (Smuts)	*Ustilago* (80), *Sphacelotheca* (60), *Sorosporium*(43), *Tilletia* (33)
6. Uredinales (Rusts)	*Puccinia*(328),*Aecidium*(100), *Uromyces*(98), *Uredo*(70)
7. Agaricales (Mushrooms)	*Marasmius* (50), *Russula* (40), *Lactarius* (30), *Coprinus* (25), *Collybia* (25), *Boletus*(20)
8. Aphyllophorales (Woodrotting Fungi)	*Phellinus*(54), *Tomentella* (25), *Trametes*(17), *Inonotus*(18)
9. Gasteromycetes (Stomach fungi)	*Lycoperdon*(29), *Scleroderma* (18), *Calvatia*(12).
10. Fungi Imperfecti	*Cercospora* (707),*Phyllosticta* (280), *Aspergillus* (140), *Phoma* (125), *Alternaria* (100)

Based on the present status of information, a summary of the richness and diversified Indian mycoflora under major groups (Ainsworth 1961), is presented below.

MYXOMYCOTA

These organisms are called slime molds and lack a definite cell wall. The cellular slime molds (Acrasiales) are the uninucleate, naked, haploid, amoeba-like organisms feeding on bacteria. *Dictyostelium* (*ca* 8 species) is the only genus inhabiting soils of tropical regions in India.

The true slime molds (Myxomycetes) are fungus like organisms which in the growth phase are characterised by a multinucleate, motile mass of protoplasm - the plasmodium and in the reproductive phase generally by a spore case (except *Caratiomyxa*) having a membrane-like wall. Most genera and great number of species are cosmopolitan living in more or less wet places, generally on old plant material undergoing decomposition. Most of the 45 or so genera and about 350 species (30 endemic) of slime molds known from India (*ca* 70 genera and 650 species in the world) have distribution from tropical to temperate regions. The commonly encountered genera are : *Ceratiomyxa* (*ca* 2), *Licea* (*ca* 14), *Lycogala* (*ca* 5), *Cribraria* (*ca* 17), *Echinostelium* (*ca* 4), *Arcyria* (*ca* 19), *Hemitrichia* (*ca* 6), *Trichia* (*ca* 11), *Physarum* (*ca* 65), *Diderma* (*ca* 30), *Didymium* (*ca* 32), *Comatricha* (*ca* 12), *Lamproderma* (*ca* 10), *Stemonitis* (*ca* 17), *Stemonitopsis* (*ca* 6), *Perichaena* (*ca* 6), *Badhamia* (*ca* 8) and *Craterium* (*ca* 7). *Physarum cinereum,* one of the common myxomycetes forms bluish colonies serveral feet in diameter on city lawns. In recent years, these organisms have also been used as ideal tools for experimental studies on the mitotic cycle, morphogenesis, the chemical changes that govern reproduction and the structure and physiology of protoplasm.

The endoparasitic slime molds, are parasitic on algae, fungi and vascular plants, causing abnormal enlargement of the host cells. They have not more than 5 genera and *ca* 15 species in India (*ca* 10 genera, 25 species in the world). Some common species occurring in India are : *Spongospora subterranea* (powdery scab of potato), *Plasmodiophora brassicae* (club root of cabbage and cauliflower), *Sorosphaera veronicae* (galls on green leaves) and *Sorodiscus cookeri* and *S. radicicolus* (both on fungi)

EUMYCOTA

A. Mastigomycotina

This group of fungi produces motile cells (zoospores or planogametes) with one or two flagella.

The motile cells of Chytridiomycetes (*ca* 45 genera, 300 species, 80 endemic to India as compared to world's about 90 genera and 650 species) have a posterior whiplash flagellum and are found in aquatic habitats or rarely inhabit the soil. Most of the species of *Chytridium (ca* 5), *Olpidium* (*ca* 9), *Olpidiopsis (ca* 12) and *Rhizophydium (ca* 7) are parastic. *Rhizophlyctis* species usually parasitize snake skins. *Rhizophydium collapsum* and *R. keratinophilum* are parasitic on human hair in tropical climates. *Olpidium uredinis* grows on the uredospores of rusts.

The species of the two large genera i.e. *Synchytruim (ca* 80) and *Physoderma (ca* 45) inhabit soil and parasitize the vascular plants. *Synchytrium endobioticum* (warts on potato) and *Physoderma zeamaydis* (brown spot of corn) are very destructive parasites. Some other common species of *Synchytrium* occurring in India are *S. macroporum, S. lagenariae* and *S. rhytzii.*

Blastocladia (ca 5) species grow on submerged plant materials. Species of *Nowakowskiella (ca* 5) are aquatic saprobes on decaying plant material. *Allomyces (ca* 8) - a genus first discovered in India and *Blastocladiella (ca* 3) are used for studies on morphogenesis. *Physoderma anneilamae, P. indica, P. sparrowii; Synchytrium ajrekarii, S. astyasiae, S. lecanthi* and *S. phaseoli* are some endemic species of Chytridiomycetes occurring in India.

The Hypochytridiomycetes, whose motile cells are anteriorly flagellate have not more than 2 genera and 10 species in India. *Rhizidiomyces* species *(ca* 5) inhabit soil.

The biflagellate (anterior and posterior) motile cells are produced in Oomycetes, represented by about 40 genera and over 400 species (60 endemic) as compared to world's about 180 genera and *ca* 1200 species. A large number of species belonging to the genera *Lagenidium* (*ca* 4), *Olpidiomyces* (*ca* 12), *Petersenia* (*ca* 4), *Saprolegnia* (*ca* 12) and

Dictyuchus (*ca* 7) grow in aquatic or semiaquatic habitats mostly parasitizing algae.*Saprolegnia parasitica, S. diclina, S. ferax; Achlya diffusa, A orion, A. flagellata, A. prolifera* and *Aphanomyces leavis* are common in pond water and parasitize fish and fish eggs.

Among the other most destructive plant parasites are those causing such serious diseases as damping off of seedlings, white rusts and downy mildews. The causal genera are : *Pythium* (*ca* 40), *Phytophthora* (*ca* 28), *Albugo* (*ca* 18), *Peronospora* (*ca* 50), *Sclerospora* (*ca* 13), *Plasmopara* (*ca* 10), *Pseudoperonospora* (*ca* 4) and *Bremia* (*ca* 2).

Pythium debaryanum and *P. aphanidermatum,* each causes damping off of seedlings of more than 150 host plants (mostly agricultural crops). *Phytophthora infestans* causes the late blight of potato wherever the Potato is grown in India. *P. arecae* (Areca), *P. colocasiae* (Colocasia) and *P. palmivora* (Palms) are also very common and destructive. *Peronospora aestivalis, P. brassicae, P. meliloti, P. parasitica, P. viciae; Plasmopara viticola; Sclerospora graminicola* and *S. sorghi* are well known causal agents of downy mildews on many vascular plants. *Albugo candida* on crucifers and *A.ipomoeae-panduratae* on leaves and flowers of *Ipomoea* are also serious parasites.

Genera like *Hamidia, Sclerophthora* are endemic to India. Some common species endemic to India are : *Achlya aquatica; Aphanomyces brassicae, A. pisci; Hamidia indica; Phytophthora parasitica, P. rubra. P. himalayensis; Sclerophthora macrospora; Pythium graminicolum, P. butleri* and *Dictyuchus lucknowensis.*

B. Zygomycotina

This group includes those fungi which produce a sexual resting spore called zygospore after the gametangial copulation. The mucorales are the largest of these fungi having more than 45 genera and over 300 species (40 endemic) in India as compared to world's *ca* 70 genera and *ca* 700 species. The great majority of them are saprobes on dung, decaying plant or animal matter. Some dominant genera are : *Mucor (ca* 56), *Rhizopus (ca* 19), *Blakeslea (ca* 4), *Cunninghamella (ca* 10),*Choanephora (ca* 8), *Pilobolus (ca* 11), *Syncephalis (ca* 15), *Mortierella (ca* 15), *Zygorhinchus (ca* 3), *Absidia (ca* 2), *Chaetocladium* (*ca* 3), *Circinella* (*ca* 7) and *Sclerocystis* (*ca* 4).

Rhizopus stolonifer, R. nigricans, R. oryzae and R. *arrhizus* cause serious diseases of fruits in transit and storage. *Choanephora cucurbitarum* and *C. infundibulifera* attack flowers and fruits. *Absidia corymbifera* and several species of *Mucor* and *Rhizopus* attack the human nervous system with fatal consequences. *Pilobolus* species prefer dung. *Absidia spinosa, A. corymbefera; Cunninghamella echinulata* and *C. verticillata* are quite common tropical species. Two genera i.e. *Saksenaea* and *Thermomucor* are endemic to India. Some endemic Indian species are: *Absidia clavata, A. ornata, A. ustrina; Blakeslea tondonii, B. monosperma; Utharomyces indicus; Chaetocladium hesseltini; Circinella indica;Helicostylum cordense; Piptocephalis indica, P. debaryana; Syncephalis indica, S. trispora* and *S. vivipara.*

The entomophthorales have *ca* 12 genera and more than 60 species (12 endemic) as compared to world's 30 genera and *ca* 100 species. They are chiefly parasitic on insects, though a few are parasitic on the lower forms of plants and some are saprobic on animal matter such as excreta of frogs and lizards. The familiar genera are *Basidiobolus* (*ca* 3), *Entomophthora* (*ca* 9), *Conidiobolus* (*ca* 18), *Cystopage* (*ca* 5), *Cochlonema* (1) and *Blastocystis* (1). *Basidiobolus haplosporus, B. heterosporus; Entomophthora muscae, E. lecanii, E. aphidis* and *E. brahminae* are some familiar parasites on insects in India. *Stylopage harda, S. grandis* and *S. leiohypha* inhabit soil and kill nematodes. Some endemic species are : *Basidiobolus heterosporus*; *Conidiobolus bangalorensis, C. cronatus, C. couchii, C. lobatus* and *C. nodosus.*

C. Ascomycotina

These fungi produce ascospores in sac-like structures called asci. They are represented in India by *ca* 680 genera and approx. 3,500 species (900 endemic) as compared to world's *ca* 2,700 genera and more than 22,000 species, commonly growing from tropical to temperate zones and less frequently extending up to subalpine zones.

Hemiascomycetes are very primitive, degenerated forms of ascomycetes. They lack mycelium and ascocarps and are well represented by over 15 genera and *ca* 65 species. This group includes yeasts and yeast-like organisms (Endomycetales) and those which cause leaf curl diseases (Taphrinales) on various plant hosts.

The yeasts are predominantly unicellular and are distributed over the surface of the earth especially in substrata having sugars e.g. flowers nectar and surface of fruits. Represented by not more than 10 genera and 25 species (10 endemic), the dominant genera are *Saccharomyces* (*ca* 7), *Debaryomyces* (*ca* 4), *Protomyces* (*ca* 3) and *Protomycopsis* (*ca* 5). *Saccharomyces cerevisiae*- the yeast of commerce is used for baking and brewing. *Nematospora coryli* is parasitic on cotton balls. *Protomycopsis smithiae, P. phaseoli* and *P. patelii* are common in sea water. *Protomyces macrosporus* lives parasitically in green parts of Ammiaceae and Asteraceae. *Protomyces najadis* is ednemic to India.

Taphrinales are responsible for malformations of the tissues, and produce such disease symptoms as leaf curl, puckering, pockets and witches broom. *Taphrina* with about 7 species is the sole representative of this group. *Taphrina deformans* (Peach leaf curl), *T. pruni* (plum pockets) and *T. laurincia)* (fronds of ferns) are some species found frequently in India.

Plectomycetes have more than 60 genera and about 350 species (60 endemic), usually forming well developed cleistothecia with definite walls. Most of the species are saprobes but some are parasitic on plants, animals and human beings. The conidial stages of many of these fungi are of very common occurrence and are familiar to everyone under the name of black molds, green molds and blue molds, chief among them are the species of *Eurotium* (*ca* 4), *Emericella* (*ca* 6), *Kernia* (*ca* 5),*Talaromyces*(*ca* 5), *Carpenteles* (*ca* 2) and *Arachniotus* (*ca* 8). *Thielavia* (*ca* 20) is also a dominant genus with most of its species found in soil. *T. terricola* is frequently found in the soils of central India.

Many parasitic forms produce enormous number of conidia on the surface of the host plant causing serious plant diseases called powdery mildews. Some important causal genera are: *Erysiphe* (*ca* 30), *Uncinula* (*ca* 17), *Phyllactinia* (*ca* 18), *Pseudoarachnoides* (*ca* 10) and *Sphaerotheca* (*ca* 13). The omnipresent *Erysiphe polygoni, Phyllactinia corylea, Sphaerotheca fuliginea* have each been reported on more than 50 hosts. Similarly, *Uncinula necator* (grapes), *Podosphaera leucotricha* (apple), *Erysiphe cichoracearum* (cucurbits and related sp.), *Sphaerotheca pannosa* (roses) and *Leveillula taurica* (on a variaty of hosts) are some other very common Indian species of erysiphales causing destructive powdery mildews.

Genera like *Astomella, Hemicarpenteles, Keratinophyton, Petalosporus, Royella, Salmanomyces, Sclerocleista, Syncleistostroma* and *Warcupiella* are endemic to India. Some of the endemic species are: *Arachniotus indicus, Astomella neolitseae, Microsphaera blumeri, M. prasadii* and *Petalosporus nodulosus.*

Pyrenomycetes are also a large and widely distributed group of *ca* 255 genera and more than 1350 species (250 endemic) in India. They include fungi with dark or carboneous to bright coloured globose or pear shaped, ostiolate, perithecia in which unitunicate asci, typically mingled with paraphyses or pseudoparaphyses form the basal tuft. The perithecia are either loose or rest on top or sunken within the stroma.

Chaetomium (*ca* 97) with long hairs on the perithecia includes saprophytic species. *C. bostrychodes, C. globosum* and *C. indicum* are common on rhizosphere of flowering plants. *Neurospora* (Drosophylla of fungal world) has *N. crassa* as a frequently met species on rotting fruits and bakeries. *Podospora absimilis* grows on animal dung. *Sordaria* species (*ca* 13) are found in the soil/rhizosphere. Most of the 13 species of *Cochleobolus* grow on green leaves.

Species of *Phyllachora* (*ca* 116), *Physalospora* (*ca* 24) *Asteridiella* (*ca* 11) and *Meliola* (*ca* 130) are found growing on green leaves of flowering plants forming their perithecia within the leaf tissues. *Phyllachora graminis* parasitic on grasses is a very common species in tropical to subtropical climates.

Diatrype, having more than 25 species, is a stromatic pyrenomycete and all its species grow on dead bark and wood. *D. mangiferae, D. chlorosarca, D. cryptostegiae* and *D. disciformis* are common on dead woods in plains. *Diatrypella (ca* 18) species like *D. citricola* and *D. quercina* also grow on wood. Some other important stromatic-saprophytic genera are : *Xylaria* (*ca* 86), *Daldinia* (*ca* 8), *Eutypa* (*ca* 10), *Eutypella* (*ca* 12) and *Nummularia* (*ca* 2). *Xylaria nigripes. X. polymorpha*; *Daldinia concentricha* and *Nummularia cinnabarina* are commonly met in tropical regions on rotting wood, while *X. tabacina* is most frequent in temperate forests on bark of Oaks.

Hypoxylon (*ca* 67), *Pringsheimia* (*ca* 12) and *Valsaria* (*ca* 8) species grow mostly on bark and wood as parasites. Serious among the parasitic ones are *Hypoxylon asarcodes (Camellia* canker) and *H. deustum* (charcoal stump rot of forest trees). *H. rubiginosum*, and *H. vogesiacum* are commonly met on bark/wood of hardwoods. Most of the 18 species of *Hypocrea* grow as saprophytes on dead wood/bark.

Diaporthe (*ca* 12), *Balansia* (*ca* 6), *Endothea* (*ca* 2), *Glomerella* (*ca* 9) and *Gnomonia* (*ca* 4) are other important parasitic genera having asci with short evanescent stalks. *Gnomonia leptostyla* (anthracnose of walnut and related hosts), *Endothea parasitica* (Blight of chestnut and related hosts in Kumaon), *Glomerella cingulata* (bitter rot of apple and anthracnose of large number of hosts), *Diaporthe viticola* (Vitis) and *D. taxicola* (*Taxus wallichiana*) are also among serious parasites. *Rosellinia* with more than 20 species in India is parasitic on flowering plants. *R. necatrix* (roots of grape vine) and *R. bunodes* (trunks of many trees) are widely spread species. *Gibberella zeae* causses corn red ear rot and *G. fujikuroi* is the cause of very serious rice disease. *Balansia andropogoins*, *B. oryzae* and *B. sclerotica* are parasites on inflorescences of grasses.

Nectria species (*ca* 40) are parasites on many tree species. *N. cinnabarina* attacks trunks, branches and twigs of *Populus*, *Prunus*, *Pyrus*, *Thea* and related hosts destroying the sapwood and causing bark to die (die back disease). *N. gallingena* grows on *Malus*. *Claviceps purpurea* (source of ergot) is a serious parasite on Rye and other grasses.

Cordyceps (*ca* 4) *Naucoria* (*ca* 10) and *Nectria diploa* are parasites on scale insects, spiders and fruiting bodies of other fungi. *Hypomyces chrysospermus* and *H. floccosus* grow as parasites on *Boletus* and *Lactarius*, *Hypocrella olivacea* and *H. oxystoma* parasitize insects in south India.

Genera like *Achaetomium*, *Tilakomyces*, *Bitrimonospora* and *Tripterosporella* are endemic to India. Following are some of the endemic pyrenomycetes: *Amphisphaeria annonae*, *A. glycosmidis*, *A. lantana*; *Anthostomella spirilla*, *A. jasmini*, *A. agaves*; *Calospora jatropa*, *C. tectonae*, *C. gardeniae*; *Claviceps sorghi*; *Cochleobolus palmivora*, *C. bicolor*, *C. tritici*; *Diaporthe acaciae*; *Didymella mulleri*; *Eutypa combratae*, *E. sivanesii*, *E. tilakii*; *Hypocrea buteae*, *H. munkii*, *H. rhizophilus*; *Meliola glycosmidis*, *M. caryotae*, *M. parviflorae*, *M. zizyphi*; *Physalospora pterolobii*, *P. jasmini*, *P. cordiae*; *Asteridiella meliosmae*; *Phyllachora vahlii*, *P. upali*, *P. scolopiae*, *P. pygei*; *Pringsheimia ailanthi*, *P. acaciae*, *P. crotalariae*; *Valsaria salvadorina*, *V. mundkuriana* and *Tilakomyces indica*.

Discomycetes are also a large and very interesting group of more than 160 genera and about 650 species (140 endemic) in India. They include Cup-fungi, Earth-tongues, Morels and Truffles having cup or disc shaped ascocarps produced above or rarely undergrond (Tuberales) bearing two types of asci i.e. inoperculate (Ostropales, Helotiales) and operculate (Pezizales). Of little importance are the ostropales represented by genera like *Ostropa* (1) *Stictis* (*ca* 6) *Robergea* (*ca* 2) and *Naemacyclus* (*ca* 4). *Ostropa indica; Stictis bengalensis, S. indicae, S. kamatii; Robergea indica, R. marthwadensis; Naemacyclus arxii, N. mulleri* and *N. korfii* are endemic to India.

Helotiales are the larger of the inoperculate Discomycetes and include mostly the saprobes but a few are among the worst fungus enemies on plants. Among the commonly occurring genra are : *Sclerotinia* (*ca* 10), *Rhytisma* (*ca* 12), *Hypoderma* (*ca* 5), *Hypodermella* (*ca* 2), *Lophodermium* (*ca* 14), *Helotium* (*ca* 28), *Hymenoscyphus* (*ca* 30), *Julella* (*ca* 6), *Lachnella* (*ca* 4), *Lachhellula* (*ca* 3), *Lachnum* (*ca* 4), *Lambertella* (*ca* 22), *Lanzia* (*ca* 14),*Lecanidion* (*ca* 4), *Microglossum* (*ca* 4), *Geoglossum* (*ca* 20), *Octospora* (*ca* 8), *Orbilia* (*ca* 7), *Patellaria* (*ca* 9), *Poculum* (*ca* 6), *Pseudopeziza* (*ca* 8), *Trichoglossum* (*ca* 7), *Triblidaria* (*ca* 7), *Leotia* (*ca* 3), *Spathularia* (*ca* 2), *Dasyscypha* (*ca* 5) and *Dasyscyphus* (*ca* 29).

Among the well known parasitic Helotiales are : *Sclerotinia sclerotiarum* (lattuce drop and diseases of other vegetable crops), *Diplocarpon rosae* (black spot of roses), *Rhytisma acerinum* (Tar spot of maples), *R. lagerstroemia* (leaves of *Lagerstroemia), Hypoderma desmazieri, Hypodermella occidentale, Lophodermium indianum, L. pinastri* and *L. orientale* (Needle cast of conifers in Himalayas). *Pseudopeziza medicaginis* is common on leaves of *Medicago.*

Among the saprophytic genera, species of *Helotium* are a common sight on dead plant material. *Geoglossum* (black to brown club to tongue shaped ascocarps) and *Spathularia* (Spoon shaped ascocarps) species are also quite common in the temperate forests. *Leotia* with gelatinous and capitate ascocarps and *Cudonia lutea* with capitate, leathery ascocarps are the other noticeable members of the Indian Halotiales confined mostly to temerate himalayan forests. Genera like *Maasoglossum* and *Thindiomyces* are endemic to India. Indian Helotiales show about 50 per cent endemism. Out of about 170 species known, *ca* 81 in 16 genera are endemic to India. The Himalayas are the main centre of diversity for this group.

Some endemic species of Helotiales are : *Maasoglossum verrucosporum; Lachnum brevispora, L. thindii; Lambertella indica, L. brevispora, L. aurantiaca; Thindiomyces epiphyllum; Poculum cupuloidea; Lanzia quercifolia, L. viburni; Hymenoscyphus cedricola, H. deodarum. H. mussooriensis, H. himalayensis, H. filicinus; Cordierites indicus; Pseudopeziza indica* and *P. rubiae.*

Pezizales are the largest group in Discomycetes. Among the most commonly met genera are : *Scutellinia* (*ca* 15), *Aleuria* (*ca* 9) *Geopyxis* (*ca* 5), *Lamprospora* (*ca* 13), *Humaria* (*ca* 20), *Peziza (ca* 25), *Ascophanus* (*ca* 3), *Nanoscypha* (*ca* 6), *Otidea* (*ca* 8), *Saccobolus* (*ca* 4), *Trichophaea* (*ca* 7), *Ascobolus* (*ca* 14), *Wynnea* (*ca* 4), *Morchella* (*ca* 10), *Helvella* (*ca* 12), *Verpa* and *Gyromitra.*

Among the most common species which one can learn and find among woods throughout the season is *Seutellinia scutellata* - whose blood red apothecia grow on rotten wood or bark among mosses. *Cookenia colensoi* and *Philipsia gigantea* with red or yellow apothecia adorn tropical forests throughout the country. *Sarcoscypha coccinea* - the scarlet cup fungus is one of the earliest and most beautiful species in temperate zones. *Wynnea americans* and *W. gigantea* can grow up to 15 cm high and are known only from a few localities in temperate zones. Species of *Lamprospora* and *Humaria* grow mostly on soil. *Peziza vesiculosa*, *P. echinospora* and *P. postulata* are cosmopolitan. *Arthracobia humillina* and *Pyronema omphalodes* are found on burnt substrata. Some species belonging to *Ascobolus* and *Saccobolus* are coprophilous and grow almost exclusively on dung. *Ascobolus magnificus* (cow dung), *A. glaber* (rabbit dung) and *Saccobolus kerverni* (horse and cow dung) are common.

The members of Helvellaceae have large apothecia and include Morels and Saddle fungi. The true morels (edible) belong to genus *Morchella. M. conica, M. esculenta, M. vulgaris,* and *M. deliciosa* are very delicious and common in the temperate himalayan coniferous forests. *Verpa bohemica* is called the Bell morel. *Gyromitra esculenta* a rare fungus closely resembles a brown brain perched on a white stalk, grows profusely in pine forests on sandy soils and is poisonous. *Helvella* species known as Saddle fungi or false morels adorn the temperate himalayan forests with their variously coloured saddle-like ascocarps. *H. crispa* is a cosmopolitan species.

About three genera i.e. *Backusia, Korfiella* and *Thindia* are endemic to India. Some endemic species of Pezizales are : *Aleuria dalhausiensis, A. taxicola, A. rubra; Ascobolus indicus; Ascophanus striatus; Backusia terricola; Copratus saranpurensis; Geopyrix grandis; Humaria cacaina, H. indica, H. mussooriensis, H. subreticulata; Tricharia bisetosa; Nanoscypha denisonii; Trichophaea narkandensis, T. tumidosa; Iodophanus kimbroughii; Korfiella karnika; Lamprospora chopriana* and *L. varanasiensis*.

Truffles (Tuberales) are the hypogean Discomycetes native to France and Italy and are detected by trained dogs and pigs. They belong to genera like *Tuber, Elaphomyces* and *Terfizia. Tuber indicum, Elaphomyes fici* and *E. darjeelingensis* are endemic to India.

Laboulbeniomycetes are minute, almost microscopic, specialized parasites on insects found especially in the warmer regions of the country. They are represented by *ca* 5 genera and *ca* 20 species (1 endemic). The plant body consists of a receptacle and its appendages. *Laboulbenia* is the well known genus with about 15 species occurring in India. Some well known and frequently met species are: *Laboulbenia craspidophori, L. fissa; Rickia coleopterophagi; Sphaleromyces indicus; Enarthromyces indicus* and *Ceratiomyces selinae*.

Loculoascomycetes refer to the stromatic locules in which these fungi produce their bitunicate asci. The group has a representation of about 1000 species (300 endemic) spread over 185 genera. The important genera are : *Elsinoe* (*ca* 20), *Myriangium* (*ca* 10), *Mycosphaerella* (*ca* 62), *Guignardia* (*ca* 16), *Capnodium* (*ca* 20), *Pleospora* (*ca* 4), *Venturia* (*ca* 3), *Parodiella* (*ca* 8), *Didymosphaeria* (*ca* 28), *Leptosphaeria* (*ca* 54), *Cochliobolus* (*ca* 12), *Ophiobolus* (*ca* 15), *Cucurbitaria* (*ca* 4), *Microthyrium* (*ca* 8), *Hysterium* (*ca* 9), *Massarina* (*ca* 20), *Lophodermium* (*ca* 14), *Leptosphaerulina* (*ca* 10), *Botryosphaeria* (*ca* 23), *Otthea* (*ca* 9), *Preussia* (*ca* 8), *Asterina* (*ca* 51), *Bagnisiella* (*ca* 11), *Asterinella* (*ca* 4), *Chaetothyrium* (*ca* 9), *Lambosina* (*ca* 2), *Leptodothiorella* (*ca* 5), *Hysterographium* (*ca* 4) and *Dothidea* (*ca* 3).

Among the common and very destructive parasites are: *Elsinoe faweetti* (Citrus scab), *E. ampelina* (grape anthracnose); *Venturia inaequalis* (apple scab); *Mycosphaerella fragariae* (Strawberry leaf spot), *M. musicola* (Sigatoka of Bananas), *M. tassiana* (leaves of many plants); *Guignardia bidwellii* (grapes); *Pleospora allii* (blight of onion), *P.*

infectoria and *P. herbarum* (leaf blights of many plants); *Ophiobolus gramminis* and *O. oryzinus* (leaf sheaths of Poaceae); *Parodiella perisporioides* (Legumes) and *Stigmatea piperis* (Piper betle). Other species like *Leptosphaeria typharum, L. sacchari, L. eustoma; Leptosphaerulina australis, L. trifolii; Parodiella perisporioides; Cochliobolus lunatus, C. nodulosus*, etc. also frequently parasitize leaves of many flowering plants in the warmer regions.

The species of *Capnodium* (sooty molds) are abundant in the tropical to subtropical climates growing on leaf surfaces and associated with the insects secretions. *C. anonae* (Ficus), *C. citri* (Citrus) and *C. brasiliensis* (Coffee) are the common ones.

Mycosphaerella tassiana is a common species in the arctic and alpine zones. Species of *Myriangium* are mostly parasitic on scale insects. *M. duriaei* is the commonest. *Cucurbitaria indica* and species of *Massarina, Bagnisiella* and *Herpotrichia* prefer dead woods while species of *Asterina, Asterinella, Ceuthospora, Lambosina, Leptodothiorella* grow as leaf parasites. Genera like *Annajenkinsia, Lambosina Bitancourtia Cerodothis, Chadefaudiomyces* and *Thaxteriellopsis* are endemic to India. Some endemic species of Loculoascomycetes are : *Aphanostigme scutiae, A. glycosmidis; Asterina drimycarpi, A. natsiata, A. mitteriana, A. woodfordiae, A. jambolanae; Bagnisiella celastrina, B. colebrookiae, B. vitatis; Botryosphaeria kumaoensis, B. arxii, B. indica; Capnodium indicum, C. kamatii, C. jasminae; Ceuthospora litchii, C. phacidioides; Didymosphaeria acaciae, D. cajani, D. duranti, D. munkiana, D. sadasivanii; Haplovalsaria anonae, H. delphini; Hysterium indicum, H. tamarindi, H. lantanae; Leptodothiorella creberrima, L. ficicola; Leptosphaeria abuensis, L. aquatica, L. bambusae; Massarina capparicola, M. graminicola, M. jasminicola; Microdothella caesalpiniae; Otthea indica, O. tamarindi, O. zizyphi; Parodiella crotalariae* and *Thaxteriellopsis lignicola.*

D. Basidiomycotina

This group includes fungi that produce their basidiospores on basidia. They have a world wide distribution of more than 1,050 genera and *ca* 16,500 species. In India, these fungi are known by *ca* 520 genera and *ca* 3400 species (500 endemic) distributed from tropical to alpine zones.

Exobasidiales are the primitive of the basidiomycetes and are known only by *ca* 4 genera and *ca* 30 species (4 endemic) in India. The genus *Ceratiosorus* is endemic to India. Other genera are *Exobasidium* (*ca* 13) and *Muribasidiospora* (4). Endemic exobasidiales are : *Ceratiosorus bambacis; Exobasidium nilagiricum; Muribasidiospora indica* and *M. celtidis*.

The smuts constitute an order of fungi called Ustilaginales forming black dusty spore masses which resemble soots or smuts. They are normally parasitic. The group is represented by over 30 genera and *ca* 350 species (180 endemic) in India. The more prevalent genera are: *Ustilago* (*ca* 80), *Sphacelotheca* (*ca* 60), *Sorosporium* (*ca* 43) *Urocystis* (*ca* 10), *Entyloma* (*ca* 22), *Cintractia* (*ca* 17), *Tilletia* (*ca* 33), *Melanotaenium* (*ca* 11), *Doassansia* (*ca* 5), *Graphiola* (*ca* 3), *Neovossia* (*ca* 6), *Pericladium* (*ca* 3) and *Tolyposporium* (*ca* 9).

The universally distributed *Ustilago maydis* (corn smut), *U. tritici* (wheat smut), *U. avenae* (oat smut), *U. nuda* (barley smut), *U. striiformis* (smut of grasses); *Tilletia caries* and *T. foetida* (bunt of wheat) and *Urocystis cepulae* (onion smut) are some of the very destructive smuts in India. Species of *Cintractia, Sorosporium, Tilletia, Tolyposporium, Sphacelotheca sorghi* are injurious and harmful to inflorescences and ovaries of a number of flowering plants. Some endemic genera are: *Zundelula, Narsimhania, Mundkurella, Franzpetrakia* and *Jamesdicksonia*.

Following are some of the important endemic species of smuts occurring in India: *Doassansia hemigraphiae, D. hygrophilae; Narsimhania alismatis; Entyloma globigenum, E. scripicola, E. thirumalacharii; Georgefischeria narasimhanii, G. rivea; Melanotaenium apludae, M. sporoboli; Mundkurella heptaleuri; Neovossia sumatii, N. punensis; Pericladium tiliacearum; Sorosporium assamicum, S. buttatum; Sphacelotheca sahayi, S. mysoriensis, S. mutila, S. stewardii; Ustilago eleusinis, U. pimpriana; Zundelula fimbristylidis* and *Z. thirumalacharii*.

Rusts are well known by their harmful effects and enormous damage to cereal crops, conifers and ornamentals. They have about 82 genera and *ca* 950 species (320 endemic) occurring in India as strict parasites of ferns, conifers and flowering plants. Not only the rusts are obligate parasites but in many cases they are highly specialized into biological races which are confined to certain species of a host genus or even to special agricultural varieties of a host species. Among the common genera are *Uromyces* (*ca* 98), *Puccinia* (*ca* 328), *Ravenelia* (*ca* 47), *Uredo* (*ca* 70), *Phakopsora* (*ca* 24), *Aecidium* (*ca* 100), *Phragmidium* (*ca* 18), *Hemileia* (*ca* 12), *Gymnosporangium* (*ca* 4), *Coleosporium* (*ca* 17), *Cronartium* (*ca* 5), *Melampsora* (*ca* 21), *Phakospora* (*ca* 27), *Endophyllum* (*ca* 8) and *Peridermium*(*ca* 8). *Caeoma, Cerotelium, Chaconia, Hamaspora, Kuehneola, Maravalia, Melampsoridium, Monosporidium, Scopella, Tranzchelia, Peridermium* and *Physopella* are some other smaller but interesting genera causing rusts in India.

The most destructive of the Indian rusts are caused by *Uromyces appendiculata* (Bean rust), *U. pisi* (Pea rust), *U. commelinae, U. fabae* (Broad been rust); *Puccinia graminis* (Cereal rust), *P. malvacearum* (Malvaceae rust), *Ravenelia* sp. (rust of forest trees), *Aecidium barleriae, A. cuspidatum, A. memecyli* and *A. poonensis* (rusts of cereals and many angiospermic hosts); *Phragmidium* sp. (rust of roses and rasberries); *Hemileia vastatrix* (Coffee rust); *Gymnosporangium* sp. (rust of conifers and apples); *Coleosporium* (rust of angiosperms and rarely conifers); *Cronartium himalayensis* (Pine blister rust) and *Melampsora lini* (linseed rust).

Genera like *Cerospora, Didymosporella, Kernella, Dasturella, Mehtamyces, Santpauella, Acervulopsora, Gymnopuccinia, Scopellopsis, Catenulopsora, Hapalophragmiopsis, Hapalophragmium, Jacksoniella, Kamatomyces, Kulkarniella, Peridispora, Stakmania* and *Tunicospora* are endemic to India. Some endemic species of rusts are: *Caeoma indicum, C. euphorbiae-geniculatiae; Catenulopsora grewiae, C. zizyphi, C. flacourtiae; Ceropsora piceae; Cerotelium kirganeliae, C. wagateae; Chaconia tectonae; Coleosporium barclayense; Corbulopsora cumminsii; Endophyllum cassiae, E. maheshwari, E. heliotropii; Kernella lauricola, Hapalophragmium mysorensie, H. tondonii; Hemileia thomsii, H. jasmini; Kuehneola flacourtiae; Mehtamyces stereospermi; Monosporidium pavettae; Peridermium piceae, P. himalayensis; Ravenelia acaciae-arabicae, R.spicigera, R. sumatii, R. taslimii; Trochodium ajerkarii; Uromyces pavgei, U. acori* and *Tunicospora bagchii.*

Jelly fungi are a group of *ca* 25 genera and 60 species (5 endemic) growing on woods and conspicuously gelatinous having variable shapes and colour. When dry often very inconspicuous and horny or forming varnish like patch but swelling to previous gelatinous state when moistened. Some common genera are: *Calocera* (*ca* 6), *Tremella* (*ca* 3), *Exidia* (*ca*

3), *Septobasidium* (*ca* 6), *Auricularia* (*ca* 9), *Dacryomitra* (1), *Dacryopinax* (1) *Guepinia* (*ca* 3), *Hirneola* (*ca* 6) and *Heterochaete* (*ca* 2).

Auricularia auricula (Jew's ear fungus), *A. mesentrica. A. polytricha; Calocera cornea* (orange yellow clubs), *C. viscosa* (bright yellow branched clubs); *Tremella mesentricha* (yellow pendant brain like mass) and *T. fuciformis* (cinnamon or reddish brown foliose masses) are commonly found species on dead woods. Species of *Exidia* are common on tree trunks of deciduous trees covered with mosses, while *Septobasidium* and *Uredinella* species are parasitic on scale insects rendering them sterile. *Calocera indica, Heterochaete mussooriensis* and *Sirobasidium indicum* are some tremellaceous fungi endemic to India.

The large order Agaricales includes those Basidiomycetes whose fruiting-bodies are fleshy and commonly called mushrooms or toadstoos. Ordinarily, the edible species are called mushrooms and the poisonous ones the toadstools. The spores are born on the surface of gills or inside the pores (Boletes), generally on the underside of umbrella like sporophores. They have more than 850 species (40 endemic) spread over *ca* 125 genera in India.

Cantharellaceae- a small family of two (*Cantharellus* and *Craterellus)* dominant genera, mostly terrestrial or humicolous, with tubular or infundibuliform, membranous, toughish basidiocarps and smooth to wrinkled or strongly folded hymenophore. Instead of normal, bladelike gills, the under surface of the pileus bears folds or wrinkles with blunt rounded edges or a network of thick obtuse veins. *Cantharellus cibarius*- the fleshy, egg yellow, funnel shaped flaring fruitbody with irregularly branched shallow fold-like gills and smell of apricots, is an important species in the Pine forests. It is also a much sought after and collected for sale in markets and can be easily dried for use in cooking. *C. congregatus, C. infundibuliformis* and *C. minor* are other frequently growing species. *Craterellus* has tubular or infundibuliform, membranous, tough, centrally stalked basidiocarps with a smooth to rugose hymenophore. *C. cornucopioides* with horn shaped, sooty brown to blackish basidiocarps is edible and is the most common species amongst fallen leaves in deciduous woodlands. *C. cymatodermoides* and *C. musooriensis* are endemic to Western Himalaya. *C. odoratus* and *C. sinuosus* are other species commonly found in temperate Himalayan forests.

Pleurotus and *Lentinus* are also large genera having a good representation in the Indian mycoflora. Their position is controversial between Aphyllophorales and Agaricales, although some people still prefer them to be kept in agaricales stressing the lamellate nature of their hymenophore. *Pleurotus* has more than 20 lignicolous species forming solitary or clustered, tough, fleshy, shell-shaped, bracket-like fruitbodies with eccentric or lateral stems and are distributed from tropical to timberline zones. *P. anserianus*, *P. flabellatus*, *P. cretaceus* and *P. membranaceus* are common on dead wood in the tropical areas. *P. placentodes* is a beautiful white species, growing on living *Betula* stems in Sikkim Himalaya. *P. ostreatus* has a wider range of distribution varying from subtropical to *Betula* forests in the Himalaya. It prefers both living and fallen tree trunks especially Beach and Betula. Other common species of temperate zone on dead woods are : *P. salignus*, *P. eryngii* and *P.dryinus*. Almost all Indian species of *Pleurotus* are edible. Species like *P. flaballatus* and *P. sojarcaju* have been put under cultivation.

Lentinus with more than 20 species is also a well represented genus having tough, persistent and firm textured basidiocarps growing abundantly on dead woods particularly in tropics. *L. velutinus*, *L. strigosus*, *L. squarrosulus* and *L. connatus* are amongst the most common species and have wide distribution on dead rotting tree trunks, fencing logs and electricity poles in clusters.*L. connatus* forms large imbricate masses of very thin, flexible pilei with greyish brown marks and short and distinct stipes with thin, narrow crowded lamellae. It is nearly always found on fallen decaying wood on forest floors. *L. lepidus* grows in clusters on coniferous stumps. *L. cinitus* is a very rare and small species. *L. decaisneanus* and *L. blepharodes* grow on stumps of palms. *L. fasciatus*, *L. hookerianus* and *L. melanophyllus* are common on stumps of *Shorea* and *Mangifera*. *L. cladopus*, *L. polychrous*, *L. tuberregium* and *L. edodes* (Shiitake mushroom) are commonly edible species.

The family Schizophyllaceae is essentially a family of Aphyllophorales producing cyphelloid basidiocarps. The only genus *Schizophllum* of this family has a lamellate hymenophore and is traditionally referred to Agaricales, although the lamellae are not homologous with those of Agaricales. *S. commune*, having world wide distribution is the only species occurring in India. It grows parasitically or saprophytically on many deciduous trees but rarely on conifers. The caespitose basidiocarps are easily recognised by the leathery, flabelliform pilei which are deeply cleft, the greyish white upper surface and the longitudinally divided lamellae becoming revolute in dry weather. Its ability to withstand the xerophytic conditions allows the species to persist throughout the dry season and it is undoubtedly one of the commonest fungus in tropical parts of India.

Tricholomataceac also forms a dominant element of Indian Agarics in both tropical and temperate floras. Species of genera like *Collybia, Tricholoma, Mycena* and especially *Marasmius* show a considerable range of variation and speciation. Included here are the Agarics which are mostly lignicolous to terrestrial or rarely parasitic on other macrofungi. The basidiocarps are minute, delicate and putrescent to large and fleshy and are mostly with a central stem.

Armillaria with more than 9 species occurs on both living and dead hosts. Among the parasitic mushrooms, *A. mellea* is the most common and damaging, growing in tufts with a well developed annular ring at the bases of a variety of trees from tropical to temperate zones. *A. fuscipes* is parasitic on *Acacia decurrens*, while *A. horrens* is common on the bark of many living trees in temperate areas. Among the other species growing on dead wood are : *A. adelpha A. multicolor, A. duplicata* and *A. vara.*

Lactocollybia angiospermarum is a cream coloured lignicolous, tropical species producing abundant latex. The genus *Lepista* includes about 2 (tropical to rarely extending up to coniferous habitats) species of fairly robust, fleshy and mostly bright lilac fruitbodies which are edible. *L. kamatii* is terrestrial and endemic to India. *L. sordida* grows on elephant dung while *L. glabella* prefers compost heaps. *Calocybe indica* is endemic and is edible in the North-east India.

Nyctalis is a small but very interesting genus with its two species, growing parasitically on other mushrooms in the tropics only. *N. parasitica* (pick-a-back-fungus) having a bell shaped, lilac grey, basidiocarps with adnate, distant and distorted gills becoming brown due to the production of chlamydospores and *N. asterophora* (very rare, with powdery brown surface without gills) grow clustered on *Russula nigricans* and *R. annulata* respectively.

Laccaria (ca 3) prefers ground litter in tropical to temperate zones.*L. laccata* having bell shaped, stipitate, reddish brown basidiocarps with striate margins and waxy gills is very common throughout the deciduous forests. *Clitocybe* has funnel shaped basidiocarps and decurrent gills and prefers leaf litter. *C. flaccida, C. eccentrica. C. brummalis* and *C. nebularis* are some commonly met species in tropical forests. *Tricholoma* has about 8 species in India. *T. giganteum* is whitish and common in pastures and road sides in plains, while *T. cremoriceps* is common on tree trunks in temperate forests. *T. calligatum*. *T. georgii* and *T. sulphureum* are excellent edible species in the tropical regions of India.

Collybia is represented by more than 25 species of humicolous or lignicolous fungi growing mostly in temperate to rarely tropical areas. *C. dryophyla* is a widespread species, very common on soil and among mosses in temperate areas of Himalaya. *C. maculata* is another beautiful species with reddish brown cap and a long and striate stem in the coniferous woodlands. It sometimes also forms fairy rings. *C. albuminosa* is characteristic as it grows from termite nests. Three species of *Trogia* i.e. *T. belengerii*, *T. koenigii* and *T. montagnei* have all been reported to occur in South India only.

The genus *Marasmiellus* having mostly marasmioid basidiocarps with a well developed central stem has about 5 species occurring in tropics on both living and dead woods. *M. ramealis* grows in abundance in tropical forests.

Marasmius is a very complex and varying genus of lignicolous, folicolous and humicolous species having worldwide distribution (*ca* 50 species in India) and growing abundantly in tropics. *M. oreades*, *M. goosensiae*, *M. rhizophilus*, *M. caperatus*, *M. graminum* and *M. rotula* are some of the common species. *M. nilgiriensis* and *M. hookeri* are endemic to India. *M. echinosphaerus* is common on the stems of many living trees. The well known *M. oreades* (edible) has the habit of growing in circles forming fairy rings in tropical grasslands and gardens.

Another large genus of Indian Agarics is *Mycena* (*ca* 20) having small, delicate, conical and bell shaped caps borne on a fragile elongated stem, clustered on stumps, burried or rotting wood. Among the common and wide spread species are : *M. arata*, *M. galericulata* (edible), *M. flavo-miniata*, *M. inclinata* and *M. epipterygia*. Most of the species have been reported from Sikkim Himalaya only. *Hemimycena indica* is endemic to India. *Mycenella bryophila*- a rare species of Tricholomataceae is reported from Nilgiris only. *Oudemansiella canarii* is a charactaristic species having white, convex, translucent striate caps covered with white squamules growing on both dead and mostly living trees (particularly *Mangifera)*. It is a common species throughout the tropical regions and is also edible.

O. radicata is edible in Eastern Himalaya. *Hohenbuehelia mixotricha* and *H. petaloides* having reniform to spathulate basidiocarps with a small lateral stipe can be frequently seen on dead wood throughout the tropical regions.

Amanitaceae is also a large family, well represented in tropical areas and particularly characterized by the specialized genera like *Amanita* and *Termitomyces*. Considerable value is attached to many species as these being either highly regarded as edible mushrooms or producing hallucinogenic and toxic effects. Some other representative genera are *Volvariella* and *Pluteus*.

Volvariella has about 12 species growing in tropical parts of India and ranging in size from small to robust. They have a fleshy cap which is dry and silky fibrillose to smooth and a stem without an annulus but with a well formed volva. These species are humicolous, lignicolous, coprophilous or mycophilous. *V. volvacea* is the paddy straw mushroom, widely cultivated commercially in tropical parts of India. Some other common species are : *V. bombycina, V. esculenta, V. thwaitesii* and *V. terastria.*

Termitomyces is a very interesting genus because all its eight or so species grow on termite mounds in the tropical climates. *T. microcarpus*- a small white edible fungus frequently occurs in swarms over large areas where termites have been active. *T. albuminosus, T. eurhizus* and *T. striatus* are among common edible species of mushrooms. *T. robustus* grows on red laterite soil above termite mounds in South India. *T. heimii* and *T. radicatus* are endemic to South India and Jammu & Kashmir respectively.

Amanita is one of the most important Agarics having fleshy, small to large basidiocarps, with well developed universal veil leaving a free volva or friable remains at the stipe base and on the pileus. Although, only 10 species have been reported but there are not less than 30 species occurring in tropical to temperate forests of India. The paucity of the species reported so far must surely be due to limited collecting in different areas. Amanitas are among the most poisonous species known (about 1%). Deaths caused by fungus eating are in the great majority of cases due to four closely related species, all members of the genus *Amanita.* i.e. *A. muscaria* (fly agaric), *A. verosa* (destroying angel) *A. verna* (fool's mushroom) *A. phalloides* (death cap), all common in deciduous and coniferous woodlands in temperate forests. Some other common species are : *A. regalis, A. vaginata* and *A. caesarea* occurring in temperate areas. The genus *Pluteus* includes about 8 species of terrestrial and lignicolous agarics occurring from tropical to temperate zones in India. *P. cervinus, P. gemmellarii* and *P. subcervinus* are common in plains while *P. chrysoprasius* and *P. cuspidatus* are more frequently found in temperate Himalayan forests. *P. plumbinus* is a parasite on living tree trunks. *P. cervinus* is edible.

Members of Hygrophoraceae are conspicuous from tropical to more commonly in temperate zones. *Hygrocybe*, the most common and prominent member of the family, is known for its vivid coloured basidiocarps, which have convex to conical caps with widely spaced gills growing mostly on ground in grasslands to very rarely on dead wood. *Hygrocybe miniata, H. conica* and *H. fulvus* with red to yellow basidiocarps are common on grass in temperate pine forests of Himalayas. *H. farnicata, H. hobsoni* and *H. pomova* have a preference to grassy grounds in tropical areas. *H. miniata, H. pratensis* and species of *Hygrophorus* (*ca* 12) with most vivid and attracting colours, adorn the temperate grasslands during rainy season. *Hygrophorus chrysodon, H. pustulatus* are common in cold climates. *H. goetzii* is one of the snowbank mushrooms (fungi which fruit in or along the edges of melting snow banks as they recede in springs) in India.

Agaricus and *Lepiota* are the important genera of Agaricaceae, more frequent in the tropics, both in number and in terms of species. They are small and delicate to very large and robust and vary from terricolous, humicolous to sometimes lignicolous.

Agaricus has more than 15 terrestrial species without a volva but with a membranous ring on the stem. Most of its species occurring in India are edible. Common species found in the tropical regions are :*A. placomyces, A. micromegatha, A. arvensis, A. campestris* and *A. elevensis*.Most commonly eaten and relished species among the tribals are *A. campestris* (Field mushroom) and *A. arvensis* (Horse mushroom). The latter is also known to grow in circles forming fairy rings.*A. bisporus* and *A. bitorgius* are widely and commercially cultivated species in India.

Lepiota with about 30 species, mostly having scales on the pilear surface and base of the stem without any volva, are particularly frequent in tropics on living plants or their debris. *L. cristata, L. leprica, L. mimica, L. mamosa* and *L. punica* are commonly met species in the lowland forests. *Macrolepiota mastoidea* is one of the largest mushrooms growing on ground in the lowland rainy areas. *M. procera* is also common and edible in tropics. *M. rachodes* is a temperate species. The rare *Cystoderma amianthinum* is found among mosses and grass in the Oak forests. The genus *Chlorolepiota* with its one species i.e. *C. mahabaleshwarensis* is rare and endemic to tropical rain forests of India. *Leucocoprinus caespaestipus* is frequently found on living tree trunks of many trees in the plains of India.

The family Coprinaceae is also well represented in Indian Mycoflora and includes such large genera as *Coprinus, Psathyrella* and *Panaeolus* of tropical, terrestrial, coprophilous to humicolous or rarely lignicolous fungi. The spore prints vary from black to dark purple.

Coprinus- a large genus of more than 25 species in India is common on dung or richly manured ground or tufted at the bases of rotting stumps. Gills are black, usually liquefying after a few hours giving ink like fluid. *C. atramentarius* grows on the compost of edible mushroom. *C. gibbsii, C. hendersonii* and *C. stellatus* grow on the dung of Zebra while *C. cinereus* and *C. filiformis* are common on the dung of Nilghai. *C. niveus* prefers heaps of rotting straw, while *C. disseminatus* grows in clusters around the rotting wooden stumps. *C. comatus* grows on a variety of hosts ranging from dung to refuse or ashes or even on garden soils. *C. micaceus* grows typically in dense clusters from buried roots and is also one of the common species of *Coprinus* in the plains. *C. micaceus, C. comatus* (Shagy ink cap; Lawyerwig) and *C. atramentarius* (Anatabase ink cap) are edible (the last one causing sickness if eaten with alcohol due to the drug Antabuse in it).

Panaeolus (ca 7) is another common genus whose species have corn like caps with a tall delicate and narrow stems, mostly growing on dung. *P. indica* is endemic to India and grows on dung and manured soil. *P. semiovatus* is common on compost of edible mushrooms. *P. campanulatus* on grassy ground and *P. cyanescens* on dung heaps are other tropical species occurring in India. *Psathyrella* includes about 8 centrally stipitate and short lived species, widely distributed in tropical and subtropical areas on soil or wood. *P. gracilis* with dark gills edged with pink, is the most common species growing in tufts among the grasses or leaves in deciduous forests or hedge bottoms. *P. hypsipoda* grows on the bark of living trees. *P. prona* and *P. hydrophora* grow in tufts on dead woods. *P. terrestris* is endemic to India.

Bolbitiaceae is a small family, with majority of its species being humicolous, lignicolous or coprophilous occurring in tropical to temperate zones. *Bolbitius* species (*ca* 5) with thin pubescent and viscid pilei are usually associated with dung and probably have a world wide distribution. *B. flavellus* grows on decaying dung of donkey and *B. grandiusculus* on ground. *Agrocybe* is known by four species. *A. manihotis* and *A. preceox* grow on soil among mosses in South India. *Conocybe siennosphylla, C. tenera* and *C. zeylanica* having large basidiocarps and subbulbous base are also common in tropical areas.

Family Strophariaceae is also well represented in the Indian Mycoflora and includes genera like *Stropharia, Hypholoma, Psilocybe, Pholiota,* etc. *Stropharia* has about 10 species with strongly glutinous caps, black spore print and a prominent ring or a ring zone on the stipe. *S. semiglobata, S. aurivella, S. psathyroidea* and *S. merdaria* are among the commonly seen species on grassy grounds in the tropical areas. *Hypholoma* is another prominent genus of this family with about 10 terrestrial or lignicolous species growing mostly in tufts.*H. sublateritium* and *H.fasciculare* are quite frequent on dead wood in subtropical to temperate forests. *H. velutinum* and *H. hemisodes* are common near earth banks.

Psilocybe species (*ca* 5) grow on dead twigs and sawdust humicolous soils in the tropical areas. *P. alborunnea* and *P. caespiticia* are common species in India. *Pholiota* is represented by about 10, mostly lignicolous species having smooth or scaly, bright-yellow caps. *P. aurivella* and *P. examinans* are fairly common on dead rotting tree trunks. *P. squarrosa* and *P.gollani* are parasitic on many species of deciduous trees in the temperate forests. *P. mahabaleshwarensis* is know from India only.

Cortinariaceae includes terrestrial or lignicolous often mycorrhizal mushrooms, which are largely found in the temperate areas and are far less common in the tropics. This is at least partly due to the ectotrophic relationship known to exist with certain forest trees, which are not present in the tropics. The genus *Cortinarius* though known only by *ca* 10 species, has many more other species with a cobwebby cortina (ring zone) and produces the rusty brown spore prints. They are usually common in the pine forests. Commonly found species growing mycorrhizically with higher plants in the temperate forests are:*C. flameus, C. saniosus, C. vinosulus* and *C. violaceus.*

Galerina mutabilis grows in tufts at the bases of stumps of deciduous trees. *G. truncata* on soil and *G. tropicus* on the tree trunks of *Peltophorum* sp. are endemic to India. *G. sapineus* is found on wood from tropical to temperate areas. *Naucoria* (*ca* 10) species grow among mosses or grasses. *N. khasiensis* and *N. micromegala* are endemic to temperate forests of Eastern Himalaya.*Galera zeylanica* and *G. lateritia* are commonly found in grassy grounds in tropics while *G. vinolenta* and *G. tenera* grow among the mosses on living or dead trees in Himalayas. *Hebeloma,* a small genus having two species i.e. *H. catervarium* and *H. thomasianum,* is mostly confined to teopical zones. *Inocybe echinata* and *I. holophlebia* grow on grassy grounds.

The two small genera i.e. *Crepidotus* (*ca* 2) and *Tubaria* (*ca* 3) are the important representatives of the family Crepidotaceae. *Crepidotus alveolus* and *C. applanatus* (both pure white with lateral stipes) are the common sights on the bark of rotting stumps in India. *Tubaria furfuracea* is a very common species on dead twigs in tropics. *T. saharanpurensis* is endemic to India.

Entoloma(*ca* 5) is the only comparatively better known genus of the family Entolomataceae and includes rather robust, fleshy, terrestrial fungi with sinuate gills and pink spore print. *E. ochrospora* is endemic to India. *E. cystopodum* and *E. euthelum* are common among the mosses in temperate forests. Other known species like *Eccilia blanfordii* and *E. griseo-rubella* prefer grass in garden soil. *Nolanea* is an interesting genus having mammillate or papillate pilei and angular subglobose spores. *N. nana* and *N. mammifera* are confined to litter or dead wood in tropical forests. *Clitocybe*- a small genus is usually associated with compost of cultivated mushrooms.

Paxillus (Paxillaceae) has all its 5 species distributed from temperate to alpine forests in India. *P. chrysites, P. sulphureus, P. pinguis* and *P. panuoides* are common on dead wood. *P. involutus* (Roll Rim) is easily recognised by its association with *Betula* at higher altitudes.

Family Russulaceae includes two genera i.e. *Russula* and *Lactarius* the most beautiful and coloured agarics distributed both in grasslands and forested areas. The context is heteromerous with sphaerocysts and the spores are ornamented. *Russula* is one of the largest of agaric genera with over 40 terrestrial and mycorrhizic species distributed mostly in temperate zones. The basidiocarps are often brilliantly coloured in shades of pink, red, orange, yellow, etc. with hot and mild taste and brittle gills. The spore print is pure white to ochre. *R. nigricans* and *R. lepida* are common in the grassy ground of tropics. *R. emetica, R. sardonia, R. caerulea, R. sanguinea, R. cyanoxantha* and *R. delica* are common temperate species growing up to subalpine zones. *R. subalpina* is a common snowbank mushroom. *R. himalayana* and *R. scheafferina* are confined to Western Himalaya. *R. emetica, R. atropurpurea* and *R. fragilis* are the common poisonous species. *R. emetica* is prominent among the mycorhizae forming Agarics.

The genus *Lactarius* (*ca* 30) is also a large genus with small to robust, mostly funnel shaped, milky caps. The milky juice is mild to hot and Peppery in taste. *L. vellereus* (distant gills) and *L. piperatus* (crowded gills) have white, robust, funnel shaped basidiocarps and are most common in the deciduous forests. *L. turpis*, the ugly looking *Lactarius* is common in grass lands and on *Betula. L. rupus* and *L. stramineus* with sticky caps are frequent under the litter in Pine forests. *L. deliciosus*, producing a carrot like milk from all its parts, staining green on exposure, is also quite common in pine forests. *L. crysorrheus* is associated with oak roots and its milk turns yellow on exposure. *L. himalayana* is endemic to North-western Himalaya.*L. piperatus* is among the most poisonous Agarics. *Lactarius subresinus* prefers snowbanks. *L. piperatus* is mycorrhizic with Poplars, Oaks and Birches.

Boletes comprising two families-Boletaceae and Strobilomycetaceae are also interesting members of the fleshy fungi with a cap and central stalk. The underside of the cap is sponge-like with many tiny pores. They form ectotrophic mycorrhizae with conifers and other deciduous trees in the temperate to subalpine zones. *Boletus* has more than 20 species of terrestrial, mostly mycorrhizic to rarely lignicolous fungi in India. *B. areolatus, B. delphinus, B. pusillus, B. scrobiculatus, B. flavipes* and *B. edulis* are very common species. *B. gigas* is common in *Betula* forests. *B. erythropus* and the rare *B. satanas* (blood red pore surface) and *B. chrysenteron* (dull yellow pore surface) turn their flesh and pore surface to blue or greenish on exposure/bruising. A very rare *B. parasitica* is a parasite on *Scleroderma citrinum. B. edulis* (Penny Bun Bolete) which is very common in oak forests is edible. *Suillus* is another characteristic genus of Indian Boletes with a viscid to glutinous pileus and glandular stipe with or without a ring, growing very frequently in pine forests probably micorrhizically. *S. luteus, S. grevillei, S. granulatus* and *S. furfuraceus* are important subtropical to temperate species.

Leccinum scabrum, L. versipellis and *L. ustale* (stem covered over major part with small to large black scales) form ectomycorrhizae, with Poplars. Oaks and Birches in temperate zones. *Gyroporus* with pure white hymenophore, chestnut brown caps and bright yellow spores has only *G. castaneus* as a common species in the oak forests.

Phaeogyroporus fragicolor grows on *Protelus* sp. in Khasi hills. *Xerocomus* (*ca* 10) has very wide range of distribution from temperate to subalpine zones. *X. bakshii* and *X. indicus* are endemic to India.

Strobilomyces (*ca* 6) and *Boletellus* are two characteristic genera of the Strobilomycetaceae. *Strobilomyces* includes mostly terrestrial to rarely lignicolous species having blackish grey caps covered with thick scales. *S. floccopus* has a wide range of distribution from tropical to temperate and even up to subalpine zones. *S. montosus, S. nigricans* and *S. polypyramis* are other common temperate species. *Boletellus* with yellowish to reddish hymenophore often bluing on bruising has only one temperate species i.e. *B. emodens* growing on soil or on dead wood.

The order Aphyllophorales includes those fungi whose basidiocarps are not soft and putrescent and has more than 200 genera and *ca* 980 species (50 endemic to India). Thelephores, probably are the most primitive forms of aphyllophorales. The fruiting bodies in many cases are so thin as to resemble a coating of grey or pink paint on a fallen twig (*Tomentella*, etc.). The more advanced members (*Stereum*, etc.), however, have definite recognisable basidiocarps of papery, leathery or woody consistency having smooth, roughened or wrinkled hymenium borne unilaterally. Known by more than 2,000 species from all over the world, have *ca* 100 genera and more than 250 species in India (spread over families like Corticiaceae, Stereaceae, Lachnocladiaceae, Echinodontiaceae, Thelephoraceae, Hymenochaetaceae, etc.). Most of the species are lignicolous in the tropical to temperate zones. Majority of the thelephoroid fungi have been reported from Himalaya. Out of the 250 or so species reported from India, 75% are resupinate, while the remaining are stereoid.

Tomentella of resupinate, arachnoid to floccose basidiocarps and echinulate to warted spores, (more than 125 species in the world) is probably the largest genus of Thelophores having not less than 25 species in India. Some commonly met species are : *T. rubiginosa, T. pilosa, T. epiphylla T. chlorina, T. fimbriata* and *T. microspora. Phanerochaete* has about 8 resupinate species in India. *P. filamentosa* with yellow to orange fructifications and rhizomorphs is widely distributed. *P. gigantea* is associated with white rot of conifers. *Metulodontia queletii* with odontoid hymenial sufrace is common on dead hardwoods. The yellow atheloid fructifications of *Amphenema byssoides* are usually quite common on the slash under conifers.

Phlebia is also an important genus of about 10 resupinate, membranous to ceraceous fructifications becoming rigid and horny on drying. *P. albida* is fairly common and is marked by the reticulately folded hymenial surface. *Phlebiopsis gigantea* and *P. ravenelii* commonly inhabit the logs and stumps of conifers. *Aleurodiscus taxicola* is quite rare and confined to Western Himalaya. *Cereceomyces fibuligera* and *C. reidii* are endemic to India. *Gloeocystidiellum* with resupinate, smooth to odontoid fructifications has about 5 species in tropical and temperate zones. *G. sulcatum* and *G. lactescens* are very common temperate species.*G. luteocystidium* with its deep orange coloured fructifications is widely distributed in India.

Scytinostroma (*ca* 6) is another characteristic genus without dichohyphidia but with skeletal hyphae present abundantly in the context and hymenium. *S. duriusculum* and *S. portentosum* are common on dead angiospermic twigs while *S. odoratum* is among the rare species. Fructifications of *Peniophora* are resupinate, adnate (Less than 200 um in thickness) and coloured in shades of red, blue to brown or grey. *P. cinerea* and *P. quercina* are commonly seen on the bark of hardwood trees in the temperate zones while *P. incarnata* is quite a rare species, *Chaetoderma luna* attacks the freshly cut stumps of conifers causing brown rots.

Hyphodontia species (*ca* 12) have resupinate, floccose to membranous fructifications with smooth tuberculate or distinctly toothed hymenial surface. *H. arguta* is one of the commonest species occurring mostly on conifers and marked by distinctly hydnoid fructifications. *Hyphoderma* (*ca* 10) is another important genus of resupinate, smooth to tuberculate fructifications. *H. pubera, H. setigerum* and *H. praetermissum* are common species on dead coniferous woods in the temperate to subalpine zones.

Trechispora (*ca* 6) is a variable genus of resupinate to pileate fructifications with hymenial surface varying from smooth, tuberculate to poroid. *T. mollusca* and *T. vaga* are some common Indian temperate species. *Coniophora* (*ca* 8) and *Serpula* (*ca* 5) have double walled basidiospores with outer walls more strongly cynophilous. *C. puteana* is associated with dry rot of Gymnospermous woods. *C. betulae* and *C. arida* are high altitude species growing on *Abies, Betula* or *Rhododendron.* In *Serpula,* the hymenophore is reticulately folded. *S. lacrymans* and *S. himantoides* are common temperate species on the gymnospermous woods. *S. mollusca* is quite rare. *Amylostereum chailletii* has thick, effuso-reflexed to pileate fructifications and is widely distributed in the coniferous forests of Himalayas and causes white rot. *Stereum* (*ca* 5) includes species with effuso-reflexed to pileate basidiocarps. *S. hirsutum* with hirsute and radially sulcate pileus, *S. sanguinolentum* (on conifers) and *S. gausapatum* (on oaks) with bleeding hymenium are the widely distributed species and serious parasites infecting heartwood of many living trees in Himalayas. *Xylobolus subpileatus* and *X. frustulatus* are very common species causing white pocket rots to hardand coniferous wood respectively. *Chondrostereum purpureum* is known to cause silver leaf disease of many Rosaceous plants. Several species of *Pellicularia (=Koleroga)* are serious pathogens of economic plants. *P.salmonicolor* causes pink diseases of tea, rubber, coffee and mango, while *P. koleroga* causes rot diseases (kalrog) of coffee in South India. *Sparassis crispa,* is called the "goat of the woods" or the "bath sponge fungus", because of its appearance from a distance usually nestling at the base of pine or *Abies* trees in the temperate forests of Himalayas. The creamy flesh, divided into countless flattened lobes is very brittle in a full grown species.

Hymenochaete (*ca* 12), *Vararia* (*ca* 5) and *Asterostroma* (*ca* 2) are the nonporoid genera of the family Hymenochaetaceae widely distributed from tropical to temperate zones mostly on dead rotting woods. *Hymenochaete* has resupinate to pileate fruitbodies while they are only resupinate in the remaining two.*Hymenochaete aspera, H. carteri, H. depellans* and *H. damaecornis* are common tropical while *H. tabacina, H. rubiginosa, H. mougeotii, H. leonina* and *H. fusco-badia* are common temperate species. *Vararia* is characteristic in having dichotomously to irregularly branched dichohyphidia. *V. rhodospora* is the commonest resupinate fungus in the coniferous forests of North-western Himalaya. *V. pallescens* and *V. effuscata* on dead woods are quite rare. *Asterostroma* is a small genus characterized by the presence of brown Asterosetae in the context. *A. cervicolor* (more common) and *A. musicolum* are well represented in the temperate and subalpine zones.

Some other rare and smaller genera having representation in the Indian Mycoflora are : *Basidioradulum, Radulomyces, Radulodon, Irpiciporus, Pulcherricium, Dacrybolus, Confertobasidium, Galzinia, Epithele, Xenasma, Subulicystidium, Cristinia, Tubulicrinis,* etc.

The Hydnaceous or the Hedgehog fungi produce their basidia on spines or tooth-like projections which point downwards. They may appear crust like or like mushrooms or coral fungi. They are represented by *ca* 18 genera and *ca* 100 species in India. Some important representative genera are : *Hydnum* (*ca* 20), *Hericium* (*ca* 3),*Sarcodon* (*ca* 7), *Auriscalpium* (1) and *Steccherinum* (*ca* 5). Among the widely spread and frequently occurring species are *Auriscalpium vulgare* (with a slender, erect stalk and kidney shaped cap) growing on burried cones and *Hydnum repandum* (fleshy stipitate, pale orange to flesh coloured fruitbodies) on ground in temperate forests. *Echinodontium japonicum* produces hard, woody perennial fruitbodies and is fairly common on bark of oaks in Himalayas. *Kavinia alboviridae* (resupinate, toothed basidiocarps); *Resinicium bicolor* (resupinate, ceraceous, crustlike on drying); *Steccherinum fimbrianum,* S. *ochraceum and S. laetecolor* (effused to pileate basidiocarps,distinctly toothed in pink to brown shades) are among the other common Himalayan species. *Hericium erinaceum* and *H. coralloides* are edible and are among the most beautiful of hydnums with massive pure white and intricately branched fruitbodies having spines up to 6 cm long and growing parasitically on beach and other deciduous trees. *Sarcodon scabrosus* is another large stipitate pale yellow to brick red hydnum found on soils of temperate forests.

The Clavarias are commonly called the coral fungi because the erect intricately branched basidiocarps of some species resemble coral growth. The basidiocarps may be simple and more or less club shaped (*Typhula*) or may be branched (*Clavulina*) sometimes intricately so (*Ramaria*). The hymenium covers the stem and branches on all sides being absent only in the basal portion of the stem near the level or under the surface of the grounds. These fungi (*ca* 20 genera and 100 species) include important genera like *Clavaria* (*ca* 21), *Clavulina* (*ca* 13), *Clavulinopsis* (*ca* 15), *Ramaria* (*ca* 32), *Typhula* (*ca* 3) and *Mucronella* (*ca* 5). *Typhula ovata* (yellowish clubs); *Ramaria stricta* (pale yellow to orange, densely branched fruiting bodies growing near rotting wooden stumps); *Clavulinopsis corniculata, C. fusiformis, C. helvola, Clavulina cristata* (all with ultimate branches tending to be cristate) and *C. cinerea* (coral like with ultimate branches rather blunt) are some of the commonly met clavarias. Temperate zones in Himalayas are the main deversity cerntres for these fungi.

Polypores constitute one of the most important group of woodrotting fungi represented by more than 100 genera and about 400 species in India. Though species of polypores are distributed over many families like

Corticiaceae, Coniophoraceae, etc. but mostly they are placed under the families like Polyporaceae, Hymenochaetaceae, Ganodermataceae and monotypic families like Fistullinaceae and Bondarzewiaceae.

Hymenochaetaceae forms a well marked family (Xanthochroic series) recognised by darkening in KOH, clampless hyphae causing white rots and with setae present in great majority of species. More than 50% of these fungi are tropical in distribution and include some very serious parasites of trees. About 3% of them grow on soil; 15% are serious parasites and the remaining ones grow as saprophytes on dead wood.

Phellinus is the largest and most diverse of all polypore genera and has more than 160 species all over the world as compared to *ca* 54 in India, distributed form tropical to subalpine forests. The following species are obligate parasites in the plains (tropical zones): *P. adamantinus, P. badius* (especially heartrot of Khair), *P. rimosus, P. fastuosus* (serious heartrot of *Shorea* and *Terminalia*), *P. senex* (most common and a wound parasite especially on trees of Meliaceae), *P. durrissimus* and *P. merrillii.* are commonly seen on the dead/living branches of standing trees. *P. glaucescens, P. cereus* and *P. ferruginosa* are frequently met on dead rotting wooden stumps. *P. pachyphloeus* is the most serious parasite on many trees especially Mango and Fig in the plains and its basidiocarps are the biggest among the polypores (up to 50 cm x 10 cm). *P. lamaensis* and *P. noxius* beside growing on dead hardwoods, are serious parasites on *Tea, Coffee* and Rubber plantations in North east and South India. *P. melanodermus* and *P. portoricensis* are very rare and confined to North-east India on *Shorea, Casuarina* and *Schleichera* only causing white pocket rots.*P. hohnellii* is also very rare confined to the tropical rainy forests of Western Ghats only on *Terminalia.*

In the second group are the species which have a wider range of distribution i.e. from tropical to temperate or even to subalpine zones. *P. conchatus* prefers dead branches of Mango, *Salix* and *Pyrus. P. gilvus* and *P. contiguus* on dead woods and *P. pectinatus* as parasite on many hardwoods are the other common species of this group.

In the third group are the species preferably growing in temperate zone. *P. allardii* and *P. xeranticus* (bright yellow pore surface) on dead/ living oaks are probably among the most common hymenochaetes in temperate forests. *P. pini* causing serious heartrot of living pines, *P. robustus* on living/dead *Abies* or *Picea* and *P. igniarius* on *Viburnum* are the next in the list of frequently met polypores in this zone. Some rarely met species are *P. linteus*, *P. extensus*. *P. sanfordii*, etc.

There are a few species characteristic of *Abies-Betula* zone (Tree line in Himalayas). *P. leavigatus*, *P. nigricans* and *P. lundelli* are more common species of this zone. *P. acontextus* a rare species grows on *Rhododendron lepidotum* in Western Himalaya and Nepal only.

Inonotus is an interesting genus with *ca* 18 species mostly confined to the temperate and subalpine zones on both dead/living hosts (usually Oaks and *Betula*). *I. patouillardii*, *I. subhispidus* and *I. hispidus* are common in temperate zones. *I. dryadeus* (weeping polypore) with its massive basidiocarps is commonly found at the bases of Oak/*Abies* trees. *I. sciurinus* reported from Japan is present abundantly on dead hardwoods in Western Himalaya. *I. diverticuloseta* on oaks is endemic to W. Himalaya. The rare *I. hammusetulus* is known only from Nepal and Sikkim Himalayas. *I. radiatus* and *I. tenuicarnis* have large basidiocarps and are found from subtropical to subalpine zones on Oaks, *Abies* and *Betula*. *I. tomentosus*, and *I. circinatus* are common in pine forests probably growing parasitically on roots.

Among the other poroid genera of hymenochaetaceae are : *Aurificaria* (*ca* 4),*Coltricia* (*ca* 9), *Cyclomyces* (*ca* 4) and *Phylloporia* (2). *Aurificaria indica* and *A. luteoumbrina* are serious parasites on many hardwood trees in the plains. *A. shoreae* an endemic species to India causes about 10% wood loss to sal. *Cyclomyces tabacinus* is very common on dead wood in tropical to temperate zones. *C. turbinatus* is peculiar in having concentric gills. *Coltricia bambusicola*, *C. cinnamomea*, *C. pusilla*, *C. pyrophylla*, *C. vallata* and *C. spathulata* are met in tropical forests. *C. perennis* is of interest being the only polypore demonstrated to be mycorrhizal with flowering plants. *Phylloporia ribis* is a tropical species on many shrubs (especially *Murraya* while the massive reddish brown fruit-bodies of *P. weberiana* are common on dead woods or oaks in the temperate zones.

Polyporaceae has white, cream, red, brown to blackish basidiocarps with generative hyphae mostly clamped to rarely septate without any black reaction with KOH and setae always absent. These fungi are cosmopolitan growing from tropical to timberline zone in Himalayas on both hardwoods (*ca* 46%) and softwoods (*ca* 54%). Only about 16% of them cause brown rots while the rest (*ca* 84%) are responsible for white rot infections. The genera of the group fall widely into following three categories :

(i) The genera generally restricted to the tropical zones with very few exceptions are : *Earliella* (1), *Flavodon* (1), *Grammothele* (7), *Hexagonia* (3), *Megasporoporia* (3), *Amylosporus* (1), *Pachykytospora* (1), *Cystostiptoporus* (1), *Favolus* (2), *Funalia* (1), *Loweporus* (2) and *Tinctoporellus* (1)

(ii) The genera known to occur in all major climatic and forest zones of India are : *Antrodiella* (5), *Daedalea* (5), *Datronia* (1), *Dichomitus* (1), *Fomitopsis* (9), *Incrustoporia* (2), *Gloeophyllum* (6), *Lenzites* (5), *Gloeoporus* (2), *Irpex* (1), *Junghunia* (4), *Laetiporus* (1), *Perenniporia* (8), *Polyporus* (7), *Pycnoporus* (2), *Oxyporus* (7), *Pyrofomes* (1), *Rigidoporus* (5), *Schizopora* (2),*Trichaptum* (3), *Trametes* (17), *Tyromyces* (2) and *Writoporia* (1).

(iii) The genera confined to temperate or boreal zones with a few exceptions are : *Albatrellus* (4), *Antrodia* (10), *Ceriporiopsis* (3), *Cerrena* (2), *Daedaleopsis* (2), *Diplomitoporus* (1), *Fistulina* (1), *Fomes* (1), *Heterobasidion* (2), *Meripilus* (1), *Hapalopilus* (1), *Skeletocutis* (1), *Oligoporus* (6), *Piptoporus* (1), *Piloporia* (1), *Phaeolus* (1) and *Spongipellis* (2).

The following species are common in the tropical zone : *Amylosporus campbelli* on grassy grounds, probably parasitic on grass roots; *Coriolopsis telfarii* (most common), *C. floccosa, C. aspera, C. caperata, C. sanguinaria, C. strumosa; Cystostiptoporus violaceo-cinerascens; Earliella scabrosa* (most common); *Funalia leonina; Grammothele delicatula, G. fuligo; Hexagonia tenuis, H. apiaria; Loweporus tephroporus; Nigrofomes melanoporus; Nigroporus vinosus, N. durus; Pachykytospora papyracea; Pseudofavolus miquelii; Tinctoporellus epimiltinus.*

Following species are cosmopolitan and grow from tropical to subalpine zone : *Antrodiella semisupina, A. minutispora, A. hunua, A. liebmanii, A. straminea; Bjerkendera adusta, B. fumosa; Bondarzewia berkeleyi; Ceriporia viridans, C. mellea, C. purpurea, C. xylostromatoides; Daedalea incana, D. andamani, D. sulcata, D. sprucei; Datronia mollis, Dichmitus leucoplacus; Favolus brasiliensis, F. spathulatus; Fomitopsis dochmius, F. feei, F. palustris, F. rosea, F.*

scutellata; Gloeophyllum abietinum, G. sepiarium, G. subferrugineum, G. trabeum; Gloeoporus dichrous; Incrustoporia carneola; Irpex lacteus; Junghunia nitida, J. collabens; Laetiporus sulphureus (Bright yellow, edible); *Lenzites acuta, L. betulina, L. elegans, L. vespacea; Lignosus sacer; Microporus affinis, M. xanthopus; Oxyporus spiculifer, O. ravida, O. populinus, O. latimarginata; Perenniporia fulviseda, P. medulla-panis, P. ochroleuca, P. tenuis; Polyporus varius, P. tricholoma, P. squamosus, P. grammocephalus, P. arcularis, P. brumalis; Pycnoporus cinnabarinus, P. sanguineus; Pyrofomes albomarginatus* (Shorea only); *Rigidoporus lineatus, R. microporus, R. ulmarius, R. vincta; Schizopora paradoxa, S. flavipora; Trametes cingulata, T. cotonea, T. gibbosa, T. hirsuta, T. lactenea, T. tephroleuca, T. varians; Trichaptum byssogenus, T. biformis, T. abietinum; Tyromyces chioneus* and *Writoporia lenta.*

Following species occur frequently in the temperate and boreal zone: *Albatrellus dispansus, A. confluens A. ovinus; Antrodia albida, A. carbonica, A. gossypina, A. lenis, A. serialis, A. oleracea, A. albobrunnea; Boletopsis subsquamosa; Ceriporiopsis rivulosa, C. gilvescens, C. mucida; Cerrena unicolor, C. meyenii; Daedaleopsis confragosa, D. purpurea; Diplomitoporus rimosus; Fistulina hepatica* (Beefsteak fungus, edible); *Fomes fomentarius* (very common), *Hapalopilus nidulans; Heterobasidion insulare* and *H. annosum; Oligoporus fragilis, O. leucospongia, O. tephroleucus; Phaeolus schwenitzii, Piloporia indica* (endemic); *Piptoporus betulinus* (*Betula* only); *Skeletocutis amorpha; Spongipellis delectans* and *S. unicolor.*

Among the very rare and interesting species present in the Indian mycoflora are : *Daedaleopsis purpurea, Fistulina hepatica, Piptoporus betulinus, Bondarzewia berkeleyi* and *Piloporia indica.*

In Ganodermataceae, the round to truncate spores are double walled with inner wall having elongated ridges or a coarse reticulated pattern and the outer thin and hyaline, enveloping the inner wall. *Ganoderma* (*ca.* 6) and *Amauroderma* (1) are only two Indian genera of this family. *G. lucidum* is a serious root parasite causing white pocket rot on many broad leaved species and enter into the host plants through wounds, all over the plains and up to temperate regions. Similarly *G. applanatum* is a wound parasite on a variety of host plants, from tropical to temperate zones. *Amauroderma rugosum* grows on ground in tropical zone.

Genera like *Amylosporomyces, Lutypa* and *Cystostiptoporus* are endemic to India. Some endemic species of Aphyllophorales are : *Tomentella subcorticoides, T. himalayana, T. indica; Coniophora dimitiella, C. cordensis; Dentipellis subseparans; Gloeocystidiellum donkii; Scytinostroma rhizomorpharum; Vararia brevispora; Stereum acanthophysatum; Ceratobasidium subtratum; Botryobasidium subbotryosum; Sistotrema lacrymispora; Xenasma subclematidis; Aleurodiscus taxicola; Amylocorticium indicum; Amylosporomyces echinosporium; Ceraceomyces fibuligera; Leptosporomyces globosum; Chondrostereum himalaicum; Metulodontia indica; Hyphodontia longicystidiosa, H. subdetritica; Ramaria brevispora, R. camelicolor, R. clarobrunnea, R. flaviceps, R. flavovirides, R. laevispora, R. pura, R. petersoni, R. rubro-gelatinosa; Typhula longispora; Mucronella subalpina; Clavulinopsis aurantio-brunnea, C. subtilis; Clavulina mussoriensis, C. limosa, C. hispidulosa; Hymenochaete fuscobadia; Cystostiptoporus violaceo-cinerascens; Cyclomyces turbinatus; Coltricia bambusicola* and *C. pusilla.*

Gasteromycetes or the stomach fungi have basidiocarps where the hymenium remains closed atleast until the spores are released from the basidia and include Puffballs, Earth stars, Stinkhorns and Bird's nest fungi having *ca* 45 genera and over 150 species (17 endemic) in India.

The earthstars belong to genera like *Geastrum* and *Myriostoma* and have *ca* 22 terrestrial species mostly confined to temperate zones. *Geastrum rufescens* and *G. triplex* are the common earthstar fungi. The *Geastrum fornicatum* and *Myriostoma coliformis* where the inner peridium bulges out and rests on outer peridium on several short stalks are among the interesting and noteworthy earthstars occurring in temperate forests.

The puffballs are represented by genera like *Calvatia* (*ca* 12), *Lycoperdon* (*ca* 29) and *Bovista* (*ca* 2). *Lycoperdon pyriforme, L. perlatum* and *L. xanthospermum* are usually common on soils, grasslands, rotting wood or even living tree trunks. *Calvatia caelata* - the giant puffball can grow up to 30 cm in diam. and is commonly encountered on grassy grounds in tropical zones. *Scleroderma* (*ca* 18) has hard ball like basidiocarps. *Scleroderma verrucosum* and *Tulostoma ammicola* are common terrestrial species. *Calostoma junghunii* grows on leaves and dead stems in Sikkim Himalaya. *Scleroderma citrinum* is parasitized by another fungus (*Boletus parasiticus*). The very rare puffballs belonging to genera *Batterea* and

Tulostoma with their tall, tapering stalks, covered in rough brown fibres looking like miniature pine tree with a small head, have also been reported from India.

The bird's nest fungi are so called because of their hollow mature plant body containing a number of small hard lentil shaped structures, arranged like eggs, thus looking like the bird's nest. *Cyathus* (*ca* 10) and monotypic *Crucibulum* are the common genera of these fungi. *Cyathus stercoreus, C. striatus* with black peridioles are not uncommon in tropical to subtropical zones. Also commonly growing gregariously on plant debris are monotypic genera *Nidula* and *Nidularia* in tropical zones.

Stinkhorns with their foetid odour that accomplishes the exposure of the gleba and the horn like receptacle of most species are quite interesting member of Indian Gasteromycetes. Except the unfortunate smell, the phalloids are among the most beautiful of fungi with their pink to reddish brown colour.*Phallus impudicus* (Stinkhorns), *Mutinus curtisii* (Dog phallus), *Aseroe arachnoides, A. rubra,* and species of *Clathrus* (3) known to spring up year after year in the same place are common under bamboo culms in deciduous woodlands. The rare *Dictyophora indusiata* and *D. merulina* with their beautifully perforated pure white, skirtlike indusia hanging from the base of the receptacle have also been reported to occur in tropical zones. Species of *Lysurus* (*ca* 2), *Simbulum* (*ca.* 2) *Anthurus* (*ca* 2) and *Aseroe* (*ca* 2) are quite rare.

E. **Deuteromycotina**

A great many fungi known by over 900 genera and ca 6000 species (1850 endemic) in India as compared to world's more than 2000 genera, and 28,000 species, have septate mycelium and reproduce only by means of conidia (apparantly lacking sexual phase), are grouped under Deuteromycotina. Some of them are parasites causing diseases of plants, animals and human beings.

All the form genera and their species (*caa* 200 genera, 2000 spp., 450 endemic), producing their conidia in globose or flask- shaped pycnidia are placed in Sphaeropsidales. Among the common Indian representative genera are : *Phyllosticta* (*ca* 280), *Phyllostictina* (*ca* 25), *Phoma* (*ca* 125), *Macrophoma* (*ca* 51), *Phomopsis* (*ca* 90), *Sphaeropsis* (*ca* 15), *Coniothyrium* (*ca* 23), *Diplodia* (*ca* 72), *Septoria* (*ca* 140), *Haplosporella* (*ca* 38), *Hendersonia* (*ca* 20), *Botryodiplodia* (*ca* 18), *Camarosporium* (*ca* 12), *Cytospora* (*ca* 22), *Discosia* (*ca* 11) *Dothiorella* (*ca* 21), *Microdiplodia* (*ca* 18), *Ascochyta* (*ca.* 50), *Robillarda* (*ca* 11), *Pleosphaeropsis* (*ca* 11), *Guignardia* (*ca* 18) and *Aschersonia* (*ca* 7).

Phyllosticta solitaria (Apple blotch),*Macrophoma theicola* (Tea canker), *M. musae* (on Musa), *Sphaeropsis malorum* (Black rot of apples), *Diplodia netalensis* (on Citrus and 50 other hosts in tropics) are a few serious parasites. *Phoma herbarum*, *P. exigua*, *P. sorghina* and *P. glomerata* are parasites on leaves and fruits of many economically important plants. Species of the form genus *Septoria* with long, slender, curved and usually septate conidia are widely spread causing destructive leaf spots. Commonly occurring ones are : *S. chrysanthemella* (on Chrysanthemum), *S. apii* (late blight of many plants), *S. lycopersici* (Tomato), *S. rubi* (on Rashpberry) and *S. arcuata*(*Ficus* leaf spot). Species of *Phomopsis*, *Ascochyta* and *Aschersonia* are also parasites on green leaves. *Botryodiplodia theobromae* and *Macrophomina phaseolina*, each occur on more than 150 hosts. *Darluca filum* is parasite on the Uredospores of many rusts while, *Aschersonia papillata* and *A. placenta* are parasites on insects.

Following genera are endemic to India : *Ajrekarella*, *Amphitiarospora*, *Vollutellopspora*, *Anthasthoopa*, *Asteromella*, *Bartalinia*, *Bartaliniopsis*, *Caudophoma*, *Cyclodomella*, *Didymopsorella*, *Discosiellina*, *Kamatella*, *Leeina*, *Peltostromopsis*, *Petrakiopsis*, *Petrakomyces*, *Plagionema*, *Pycnotera*, *Ramakrisnaella*, *Sadasivanella*, *Sarikeeta*, *Shanoria*, *Subramaniella*, *Vasudavella* and *Veronaeella*.

Melanconiales produce threir conidia in acervuli and are represented by *ca* 60 genera and 600 species (130 endemic) in India. Many parasitic ones cause a group of diseases called anthracnoses. Chief among them are *Gloeosporium* (*ca* 36) and *Colletotrichum* (*ca* 130) with elongated conidia in the acervuli. *Gloeosporium artocarpi* (on Artocarpus), *G. psidi* (on *Psidium*); *Collletotrichum lagenarium* (on Cucurbits), *C. atramentarium* (on Tomato and egg plant) are among the serious parasites. Some species like *C. dematium*, *C. capsici* and *C. gloeosporioides* occur on more than 150 hosts in India. Species of *Cylindrosporium* (*ca.* 13), *Microstroma* (*ca* 7), *Sphaceloma* (*ca* 42) and *Marssonina* (*ca* 6) are serious parasites on green leaves.

The form genus *Pestalotia* and its segregant *Monochaetia* have more than 100 form species, many of which are leaf parasites. *P. versicolor* and *P. palmarum* attank many ornamentals and other plants. *Monochaetia unicornis* is parasitic on conifers in Himalayas. *Pestalotiopsis* species (*ca* 45) are also parasitic on leaves. *P. adusta, P. dissseminata, P. versicolor* and *P. neglecta* occur on many hosts. Genera like *Barnetella, Rostrospora* and *Starkeyomyces* are endemic to India.

Those fungi imperfecti (over 620 genera and 3,200 species) that produce their conidia on hyaline conidiophores or hyphae or in sporodochia are placed in the order Moniliales. The form genera *Penicillium* and *Aspergillus*, each has more than 100 reported species from India. Their several species are often found on exposed food stuffs and cause decay. *Penicillium digitatum* and *P. expansum* are common pathogens on citrus and apple fruits. *P. chrysogenum* and *P. notatum* are the source of now famous antibiotic called Penicillin. *Aspergillus niger* and its related species are widely spread in the soil and are known to cause decay in tropical climate. *A. amstelodami, A. candidus, A. flavus, A. fumigatus, A. luchuensis, A. nidulans, A. oryzae, A. ochraceus, A. sulphureus, A. terreus, A.folitorius, A. sydowi* and *A. variecolor* are commonly met in Indian soils.

Many dermatophytes, causing diseases of skin of man and animals occur in India. *Epidermophyton floccosum* (Athlete's foot), *Trichophyton mentagrophytes* and *T. violaceum* (Athlete's foot and several other skin diseases), *Microsporum audouini* and *M. gypseum* (Tinea capillis in children); *Pityrosporum ovale* (dandruff), *Trichosporon cutaneum* (foot skin), *Sporotrichum beurmanni* (human skin), *Hormodendrum compactum* (warty tissues over legs, arms and hands) are some common dermatophytes occurring in tropical zones of India.

Some species cause more serious and chronic deep mycosis. Such species are : *Histoplasma capsulatum* (Histoplasmosis - a serious and fatal disease of man) *Blastomyces dermatitidis* (Blastomycosis skin and pulmonary disease). *Candida albicans* and *C. viswanathii* (Candidiosis serious human disease in many forms) and *Aspergillus fumigatus, A. flavus, A. niger* (Aspergillosis-lungs of man, birds and animals).

The form genus *Cercospora* (*ca* 4000 species all over the world) has more than 700 described form species in India and out of them about

500 are parasites on green tissues causing leaf-spots. Among most common are *Cercospora citrullina, C. canescens, C. dolichii, C. jasminicola, C. oryzae* and *C. zizyphi*. Some other form-genera growing on living or dead leaves and branches are : *Stigmina* (*ca* 25), *Cercosporella* (*ca* 12), *Pseudocercospora* (*ca* 40), *Ramularia* (*ca* 25), *Stemphyliomma* (*ca* 16), *Exosporium* (*ca* 23), *Harposporium* (*ca* 9), *Helicomyces* (*ca* 9), *Helicosporium* (*ca* 17), *Myrothecium* (*ca* 18), *Phaeoisariopsis* (*ca* 10), *Curvularia* (*ca* 43), *Periconia* (*ca* 49), *Torula* (*ca* 13), *Cladosporium* (*ca* 40) and *Oidium* (*ca* 35). *Myrothecium roridum; Curvularia verruculosa, C. lunata; Periconia byssoides, P.cookei; Torula herbarum* - each grows on more than 100 living/dead hosts. *Cladosporium oxysporum* and *C. herbarum* are also common leaf parasites.

The universally occurring form-genus *Alternaria* has *ca* 100 species in India and several of them are saprobes on dead plant material or in soil and in laboratory cultures. *A. alternata* causes leaf spots of more than 200 hosts of flowering plants. *A. brassicae* and *A. brassicicola* (leaves of Crucifers), *A. citri* (Rutaceae); *A. tenuissima* (ornamentals) and *A. zinniae* (Asteraceae) are other commonly met species.

Heterosporium (*ca.* 20) and *Helminthosporium* (*ca.* 90) are other larger genera causing damage to economic plants. *Heterosporium colocasiae* parasitizes *Colocasia* while *Helminthosporium hawaiiense, H. rostratum, H. oryzae, H. sativum* and *H. turcicum* cause destructive diseases of cereal crops. Form genera *Cylindrosporium* (*ca.* 10) is responsible for leaf spots and leaf fall of many plants. Most of the 40 species of *Cephalosporium* are soil-borne.

Form-genus *Verticillium* (*ca* 19) with small hyaline conidia borne on whorled branches is the cause of wilt diseases in many vascular plants. *V. alboatrum* causes "Hadromycosis" leading to death of many woody and herbaceous plants. *Trichothecium roseum* causes pink rot of apple. *Stachybotrys* (*ca* 19) and *Sporidesmium* (*ca* 37) species are common on dead wood and litter, while *Geotrichum candidum* is destructive to many ripe fruits. *Piricularia* has about 18 species in India. *P. oryzae* and *P. grisea* cause serious damage to rice and other grasses throuthout India. *Mycogone perniciosa* is a dangerous pest in the commercial culture of mushrooms in India.

Form-genera *Tubercularia* (*ca* 4) and *Fusarium* (*ca* 95) produce their conidia in sporodochia. In *T. vulgaris* (on juglans), the sporodochium is shaped like a mushroom. *Fusarium* with long, lunate, septate conidia borne singly or in sporodochia have most of its species growing as saprophytes. The parasitic fusaria cause wilts of vascular plants by plugging the conducting tissues and by secretion of toxins. Among the most destructive form species in India are : *F. moniliformae* and *F. equiseti* (each on more than 100 hosts). *F. oxysporum* (Panama disease of Banana); *F. solani* (Potatoes) and *F. semitectum* (on many hosts).

The friendly fungi which capture and kill nematodes are found in genera like *Arthrobotrys* (*ca* 12), *Dactylella* (*ca* 7) and *Harposporium* (*ca* 8) and are commonly found in the soil in plains. In *Arthrobotrys conoides* and *A. oligospora*, the sticky mycelium forms loops, while in *Dactyllela asthenophaga* and *D. bembicodes*, the mycelium forms constricting rings which swell up when a worm passes through. *Harposporium anguillulae, H. bysmatosporium, and H. lilliputanum* produce sticky conidia which adhere to an eelworm, then germinate, invade and digest the worms.

Some endemic genera of Moniliales are : *Abgliophragma, Adhogamina, Agarwalia, Amerobotryum, Angulimaya Annellophorella, Annellophragmia, Gangliostilbe, Gliocladiopsis, Asperisporium, Bahugada, Bahaukalasa, Bahupaathra, Bahusakala, Bahusandhika, Bahusganda, Basifimbria, Beltraniella, Bhargavella, Biharia, Bilgramia, Camposporium, Carmichaelia, Chlamydorubra, Colemaniella, Delortia, Corynesporella, Dendrographiella, Drumopama, Duosporium, Dwayabeeja, Endosporostilbe, Gliophragma, Hyalostachybotrys, Iyengarina, Kamatia, Kameshwaromyces, Koorchalomella, Kramasamuha, Kumanasamuha, Kutilakesa, Kutilakesopsis, Lecythispora, Mahabalella, Malustela, Monacrosporiella, Moorella, Multicladium, Mystrosporiella, Paathramaya, Panchanania, Parasympodiella, Phaeodactylium, Phaeotrichoconis, Phialographium, Phialomyces, Phialotubus, Phragmospathula, Pirozinskia, Polyschema, Prathigada, Prathoda, Pseudotorula, Putagravium, Raizadenia, Sadasivania, Satwalekera, Searchomyces, Subramania, Subramaniomyces. Syamithabeeja, Sympodina, Sarbhoyomyces, Tandonella, Tawdiella, Tharoopama, Tretophragmia, Vakrabeeia, Vanbeverwijkia,* and *Vinculum.*

Mycelia sterilia is a heterogenous group of about 7 genera and *ca* 20 species (4 endemic) of nonsporiferous mycelial structures. *Rhizoctonia bataticola* and *R. solani* (imperfect stage of *Pellicularia vaga* are commonly found in the soil and cause root rots and damping off of many cultivated plants. *Sclerotium rolfsii* is an omnipresent (on more than 200 hosts) and is a destructive parasite of many plants in plains of India. *S. oryzae* grows on lower leaf sheaths and within the stem cavity of paddy plants throughout India. *Ozonium taxanum* destroys the roots of potato and many other cultivated plants in the temperate zones. The genus *Sclerotiella* is endemic to India.

CONSERVATION STATUS

The fungi form one of the largest kingdom of organisms. It is necessary therefore, to ensure their full representation internationally under the umbrella organisation of IUCN-SSC.

Under the criteria for including plants in Appendix-I (species included in the Appendix-I become protected by the signatory countries under the Articles of the Conservation) criterion 7 mentions for selection of the threatened lower plants. Lower plants the particularly Fungi have been badly neglected by conservationists, probably due to limited knowledge about their conservation status. Documentation is necessary both about their wild populations and their conservation requirements before the fungal flora can be subdivided into rare versus the endangered species.

There are problems which on the whole are not experienced within many large groups of organisms. For example, Fungi may occur at certain times of the year (August-September) and there may be gaps when fruiting does not occur. One is left guessing -are they quiscent, or more correctly non-fruiting or are they extinct ? One either has to be at the right place at the right time or the potential rarity must be recognised by those unfamiliar with it and have it identified by an expert before decomposition takes place.

This all has however, not deterred some European countries and they have just realized the need for preventing extinction of species of fungi. The recently formed "European Council for Conservation of Fungi" consists of official representation of all the European countries. Some of the countries which have published Red Data Lists on fungi are : Federal German Republic (Lettau 1982; Benkert 1982; Winterhoff 1984; Winterhoff & Krieglsteiner 1984; Derbsch & Schmitt 1984, 1987); Austria (Krisai 1986); Poland (Wojewoda & Lawrynowicz (1986); Finland (Rassi & Vaisanen 1987); Norway (Hoiland 1988) and Sweden (Hallingback 1988). Arnolds (1989) has published more recently Red Data List where he considered that 28% of the larger fungi are threatened in Netherlands. Ingelog and Pegler had also proposed a list of about 20 fungi from England but at the Berne Convention Workshop held in Cambridge, U.K. during November 1990, only four species were proposed for Appendix-I namely: *Buglossoporus quiecinus* (Coriolaceae), *Ramariopsis crocea* (Clavariaceae), *Lactarius mairei* (Russulaceae) and *Sarcodon martiflavus* (Thelephoraceae).

Unfortunately, there is no uniformly accepted agreement on how to define threatened, endangered fungi, etc. although Rassi & Vaisanen (1987) have tried to define the catergories in which fungi can be placed meaningfully. Even the term extinct is often inappropriate as some species thought to have been lost from the flora mysteriously reappear e.g. *Porona punctata* (Whalley & Dickson 1986). The picture of rarity is also complicated because it brings together species which are rare because of their distributional patterns (Lange 1974) and those now rare because of man's activities. It appears that the habitat preferences and species distributions are so significantly linked that it would be nice to conserve habitats first compared to the efforts of producing Red Data Lists at this stage. And further, the Red Data Lists proposed for some Eurôpean countries are only for macrofungi while there are no chances of such lists being prepared for microfungi which constitute about 50% of the total micoflora.

FACTORS RESPONSIBLE FOR LOSS OF FUNGAL DIVERSITY AND SOME CONSERVATION MEASURES PROPOSED:

India with such a huge latitudinal range with many contrasting topographies and very many distinct vegetational communities, make it difficult to comprehend a Red Data List which would be meaningful. Perhaps a better approach under the present conditions would be to produce Red Data List for specific areas and thus to identify fungal habitats which are under threat. With limited resources it should be tackled immediately. The habitats good for one group (macrofungi) should also be good for other (microfungi), There are some rather rich habitats for fungi which occur in communities generally accepted as very much less worthy of conservation e.g. grazed grass lands, improved hill or alpine pastures, etc. If these areas disappear what would happen to all the beautiful species of *Hygrocybe* and other snow bank mushrooms. This influence must be incorporated into our thoughts, for the plant communities so created are just as much an integral part of our heritage as the pine or oak forests, etc. There is no reason for these habitats to be rejected.

Harvesting of wild mushrooms for commercial purpose by way of overpicking, habitat disturbance, overturning logs and trampling is also a major reason leading to the reduction in the number of many species. Some attempts should be made to control the harvesting of wild mushrooms especially for commercial purposes. The preparation of a code of conduct for collections with a coloured brochure and issue of licence/brochures for picking up the wild mushrooms will help to some extent. As in Washington State, USA and British Columbia province - Canada, a licence is required for picking up of wild mushrooms.

Of particular concern is raking the leaf-needle away to expose the mycelium and button stages of many wild mushrooms e.g. *Tricholoma* sp., *Boletus edulis, Leccinum,* etc. This practice practically destroys both rootlets and mycelium and endanger the survival of many species at site.

One of the most important factors is extensive deforestation leading to wide scale destruction of many of the natural and seminatural habitats and fungi as much as the indigenous fauna and flora are at risk. This is responsible for the loss of the unique ectomycorrhizal flora associated particularly with Oaks and Pines which are also the hosts of many parasitic fungal species. The largest number of threatened species are agarics (mushrooms and toadstools) as nearly half of them are ectomycorrhizal species. A possible solution is preservation of forests by establishing National Parks and Biosphere reserves in different biologically rich and natural areas of the country. By conserving a mosaic of habitats in healthy states, in-decline and in-formation, we will not only provide environments for a full range of fungi both large and small, but also for the insects and other invertebrates which rely on them.

The paucity of information on Indian mycoflora poses a problem in the design of conservation measures. One of the main problems lies in lack of local expertise and the contacts between the various mycologists. The training of mycologists is a contentious issue, as the few universities giving courses in mycology concentrate only on the economically important species particularly human and plant pathogens. A broad based mycology curriculum in Indian universities, therefore, needs to be developed through conferences, workshops in association with national scientific organisations.

Lack of data on the occurrence with detailed distribution maps, substrates and ecology of the fungi is the main hurdle before any serious consideration of conservation status of any fungal species can be made.

There are no studies in Indian Mycoflora comparable to the exhaustive work of Arnolds (1981, 1982), Hering (1966), Richardon (1970), Wilkins *et al.* (1937), Wilkins & Patrick (1940) and Gilbertson & Ryvarden (1987). Works such as these will allow a rapid assessment of the occurrence and the general distribution of these fungi. After all, fungi cannot be conserved without the knowledge of present distribution and whether a species is rare or not. Our knowledge of a species rarity and therefore, whether it is worthy of protection is based on little more than hunches and personal ideas. What is required is the analysis of all the records.

"Cross off Cards" for larger fungi (Discomycetes, Gasteromycetes, Aphyllophorales, Pyrenomycetes, Agaricales) much the same as those used by Phanerogamic botanists based on the foray records and herbarium materials (Whalley & Watling 1977, 1980) can also be used for preparing maps. Such maps can act as a pilot scheme and stimulate interests among other people also. With these maps, we will atleast be able to make the first attempt to ascertain the rarity of a particular fungus. This information coupled with the extensive data base at National Fungal Herbaria will enable us to develop and modernize our approach to conservation. Soon it will be possible to prepare species lists for various habitats either to indicate their characteristic species or to help in saving sites of particular interests or even to identify new sites which should be considered for conservation.

So far, conservation measures are limited to animals and higher plants with no policies or measures for the lower groups of plants especially for fungi. Fungi, unfortunately, are treated as curiosities by many conservationists, just as their role in nature is frequently given only a lip service by other naturalist disciplines.

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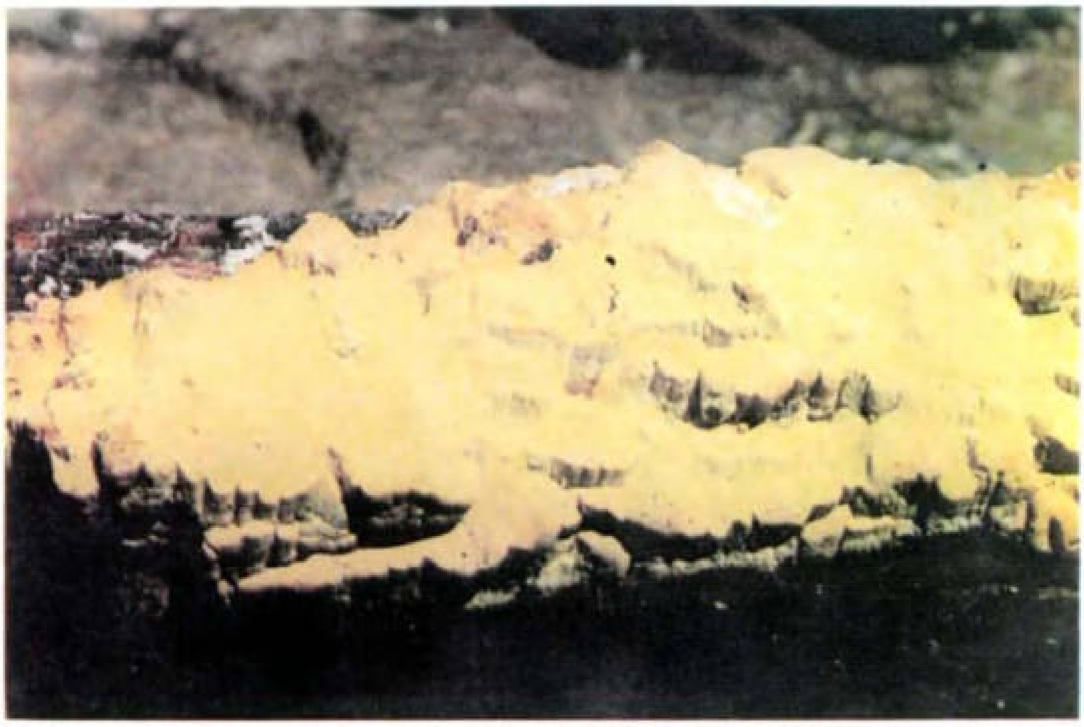
"NATURE ALONE IS ANTIQUE AND THE OLDEST ART IS MUSHROOM"

-Carlyle



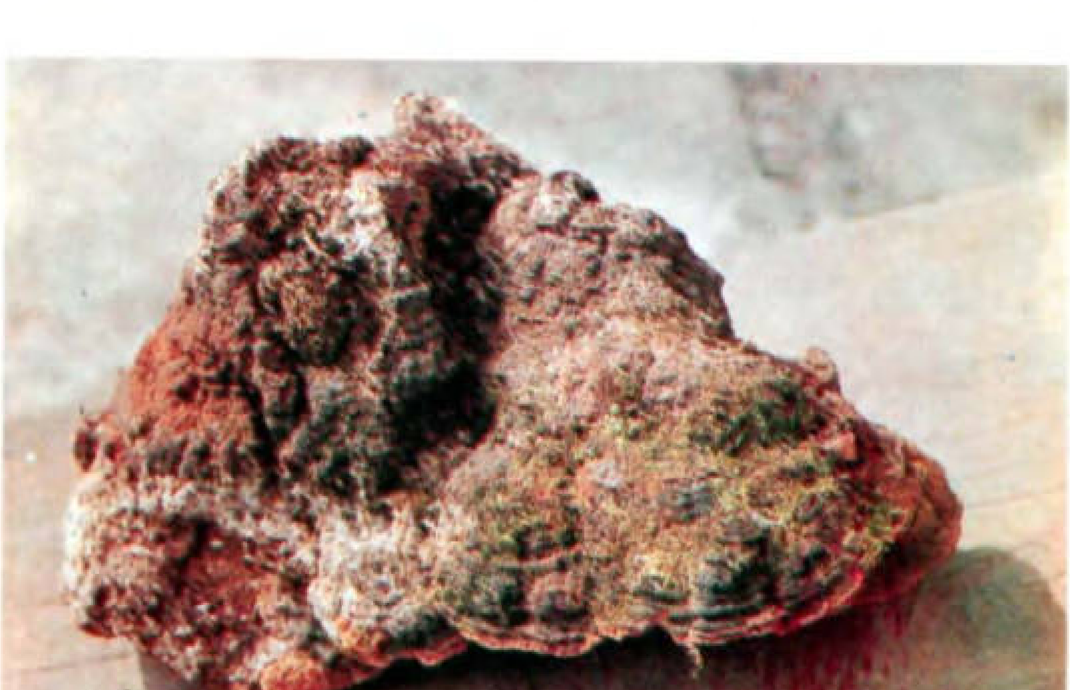
Perenniporia tenuis - Growing on *Cupressus torulosa*, reported recently from India

Bondarzewia berkeleyi - A very rare polypore growing on Oak roots in Western Himalaya

Fomes fomentarius - A most common species in the Temperate Himalayan forests, causing damage to hardwoods, particularly Oaks

Heterobasidion insulare - A very common species causing white rots on coniferous woods

Spongipellis unicolor - A common woodrotting polypore in temperate forests



Phellinus robustus - A serious parasite on temperate coniferous trees

Daedaleopsis purpurea - A very rare Polypore collected recently from Western Himalaya.

Russula nitida - A poisonous and probably a mycorrhizic mushroom found in subalpine forests

Lycoperdon muscorum - A common species growing among mosses on Oak tree trunks in subalpine forests

Stereum hirsutum - A common and widely distributed species on all types of hardwoods

Rigidoporus microporus - A serious heartrot polypore growing usually at the bases of coniferous trees

Trametes versicolor - A widely distributed species mostly on Oak woods in Himalayas.

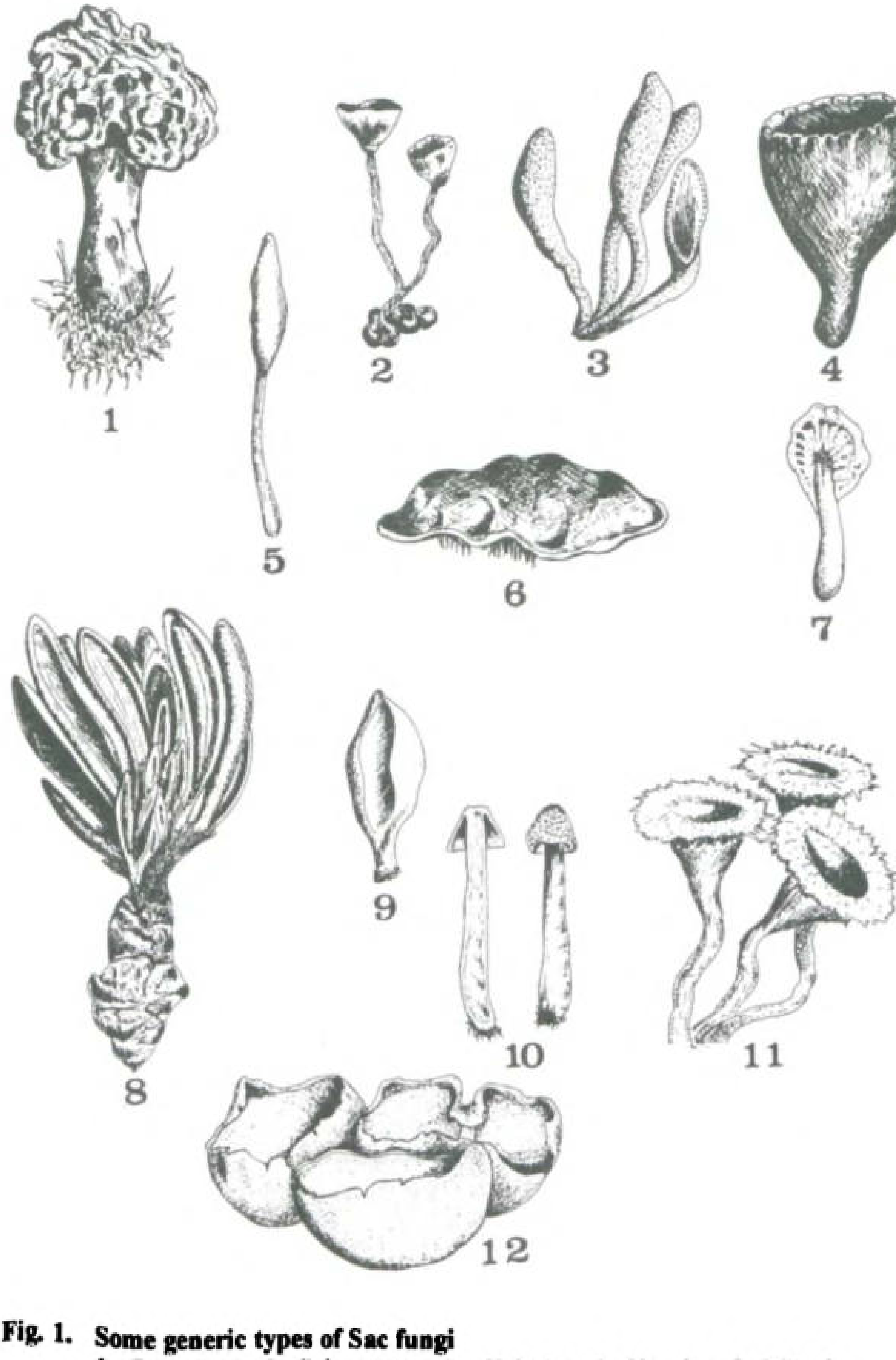


Fig. 1. Some generic types of Sac fungi
1. *Gyromitra*, 2. *Sclerotinia*, 3. *Xylaria*, 4. *Urnula*, 5. *Mitrula*, 6. *Rhizinia*, 7. *Spathularia*, 8. *Wynnea*, 9. *Otidea*, 10. *Verpa*, 11. *Sarcoscypha*, 12. *Peziza*

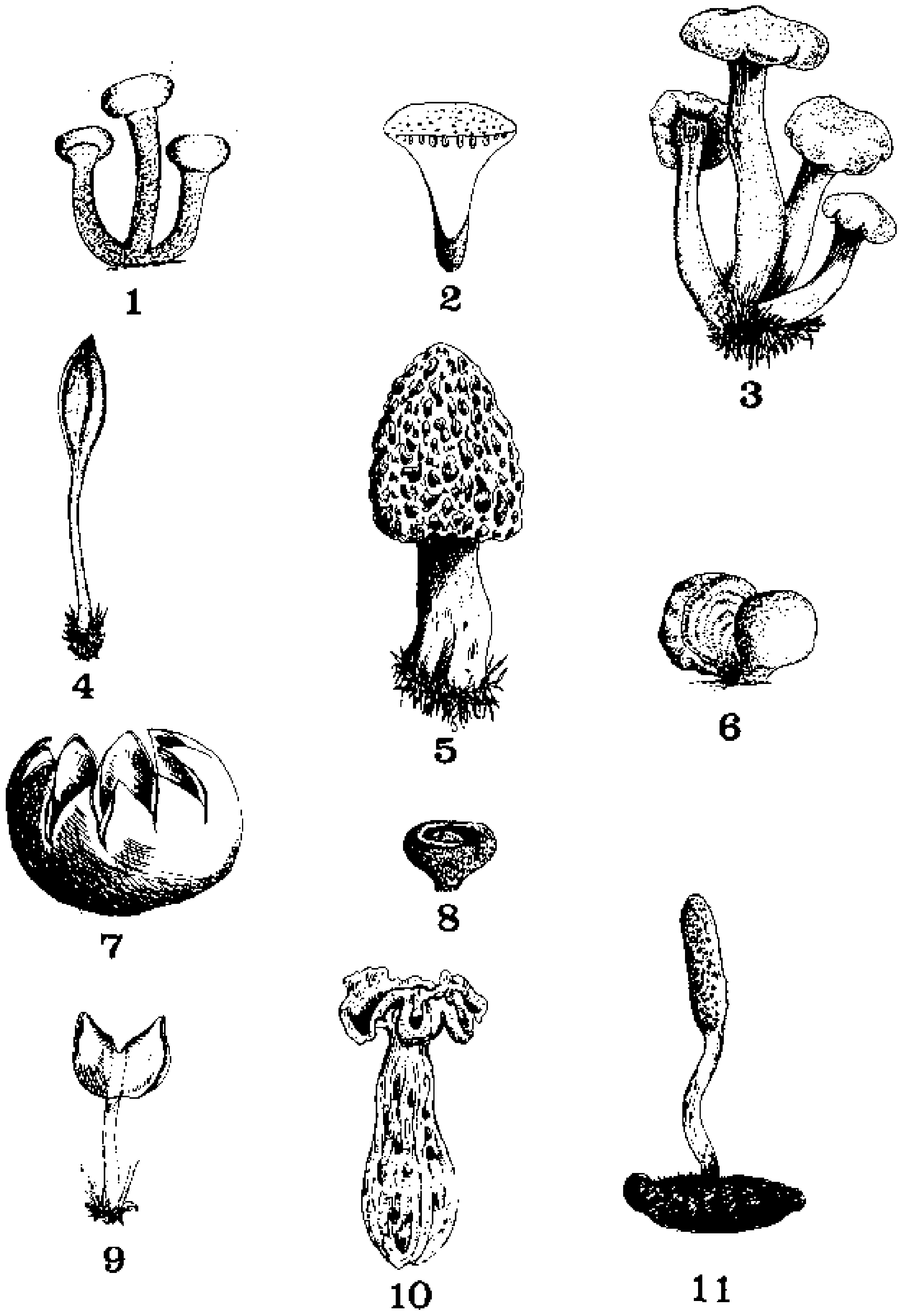


Fig. 2. Some generic types of Sac fungi

1. *Leotia*, 2. *Poronia*, 3. *Vibrissea*, 4. *Geoglossum*, 5. *Morchella*, 6. *Daldinia*, 7. *Sarcosphaera*, 8. *Bulgaria*, 9. *Helvella*, 10. *Helvella*, 11. *Cordyceps*.

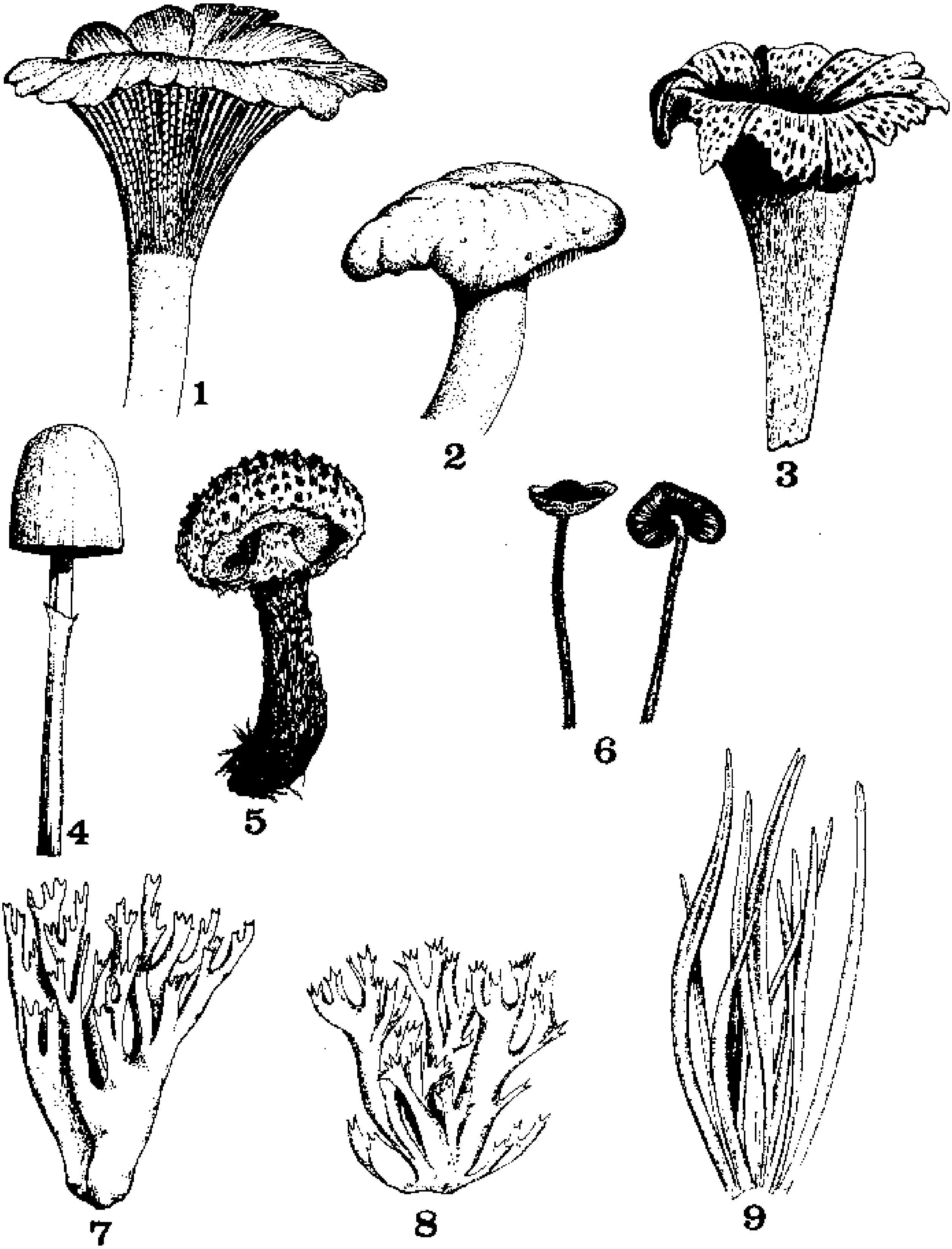


Fig. 3. Some generic types of Mushrooms & woodrotting fungi
1. *Cantharellus*, 2. *Hydnum*, 3. *Craterellus*, 4. *Panaeolus*, 5. *Strobilomyces*, 6. *Auriscalpium*, 7. *Clavulina*, 8. *Clavulina*, 9. *Clavulinopis*.

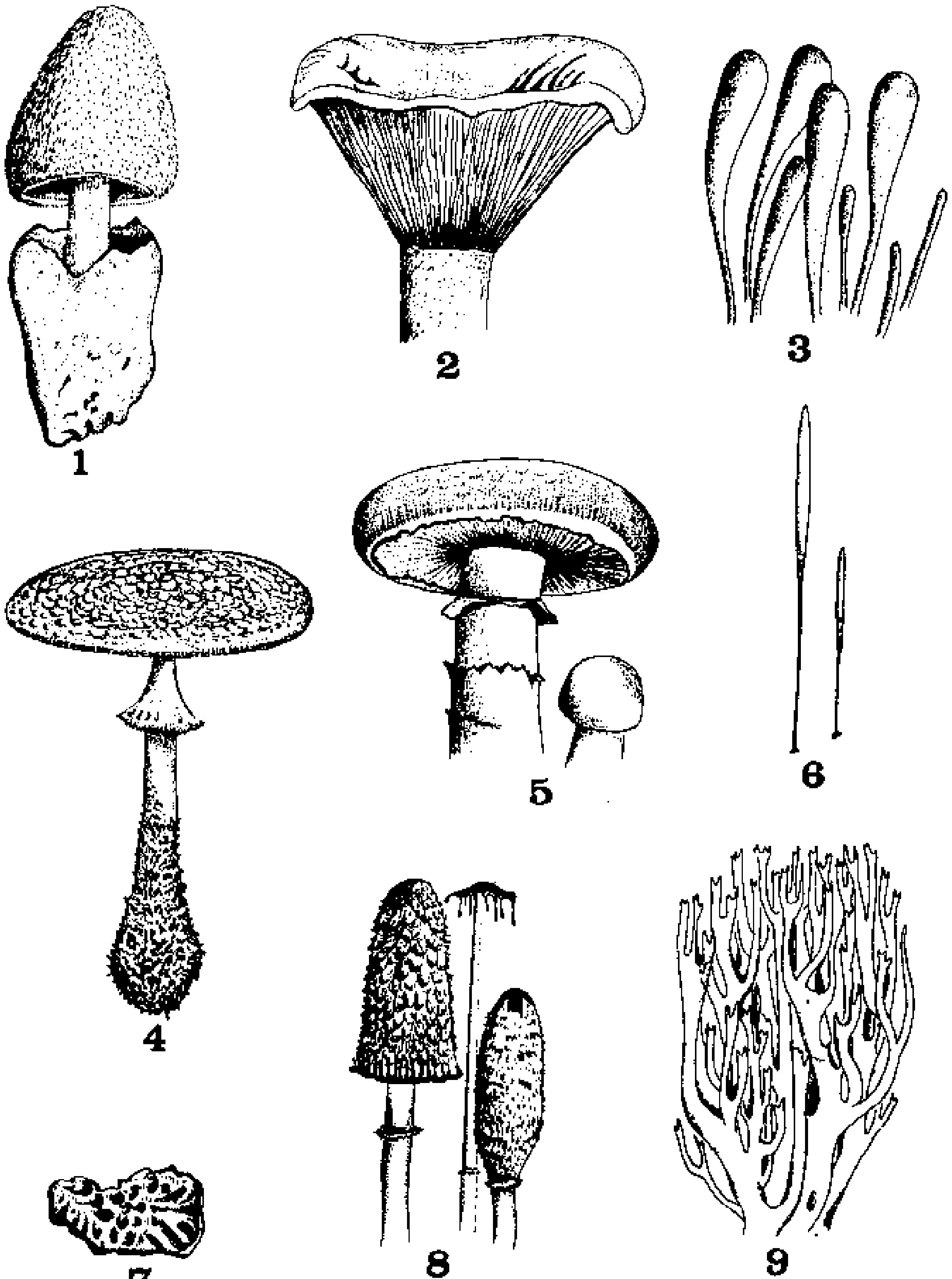


Fig. 4. Some generic types of Mushrooms woodrotting fungi
1. *Volvariella*, 2. *Lactarius*, 3. *Clavaria*, 4. *Amanita*, 5. *Agaricus*, 6. *Typhula*, 7. *Auricularia*, 8. *Coprinus*, 9. *Ramaria*.

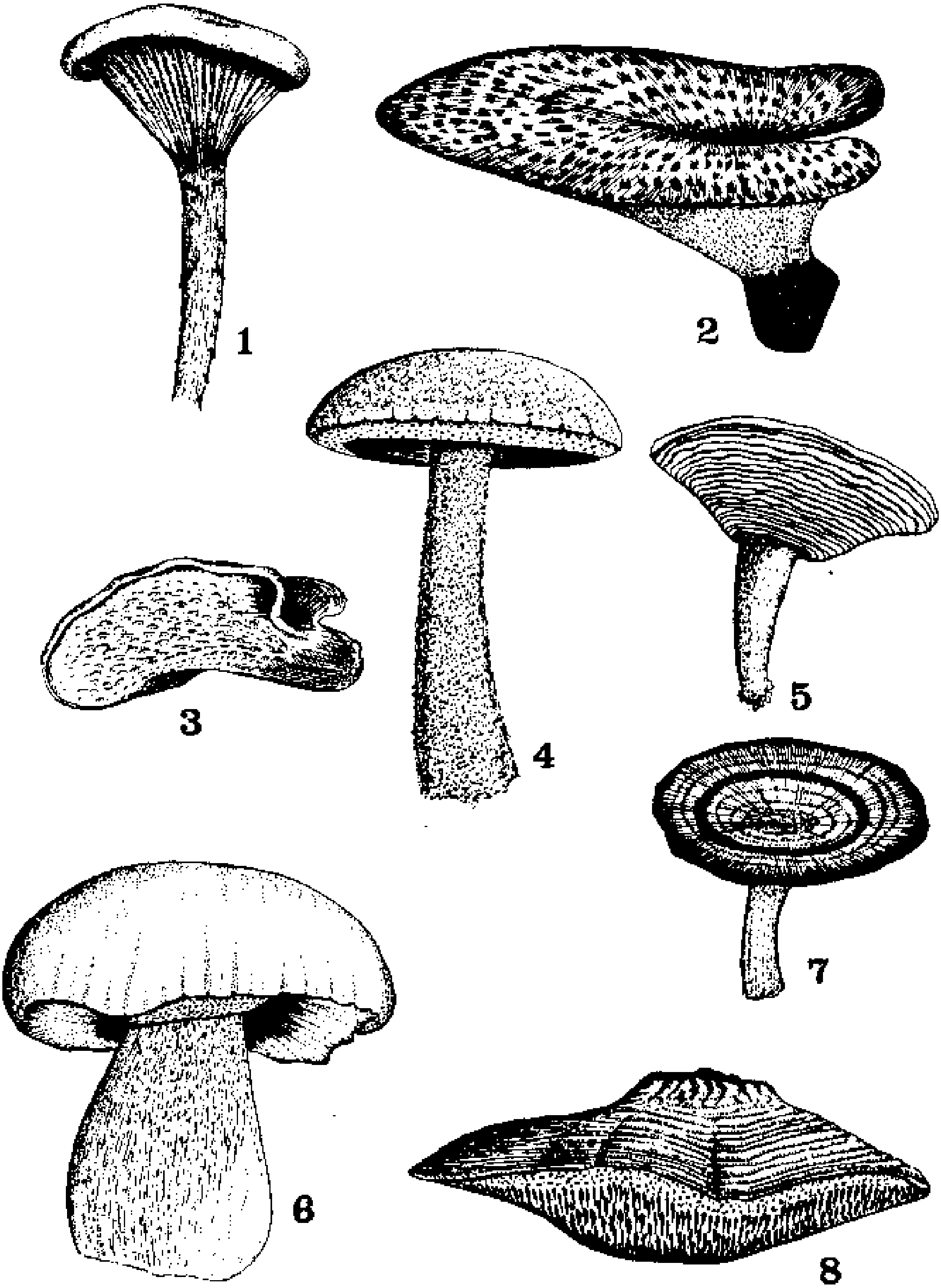


Fig. 5. Some generic types of Mushrooms & woodrotting fungi

1. *Gomphidius*, 2. *Polyporus*, 3. *Boletinus*, 4. *Leccinum*, 5. *Cyclomyces*, 6. *Boletus*, 7. *Coltricia*, 8. *Daedalea*.

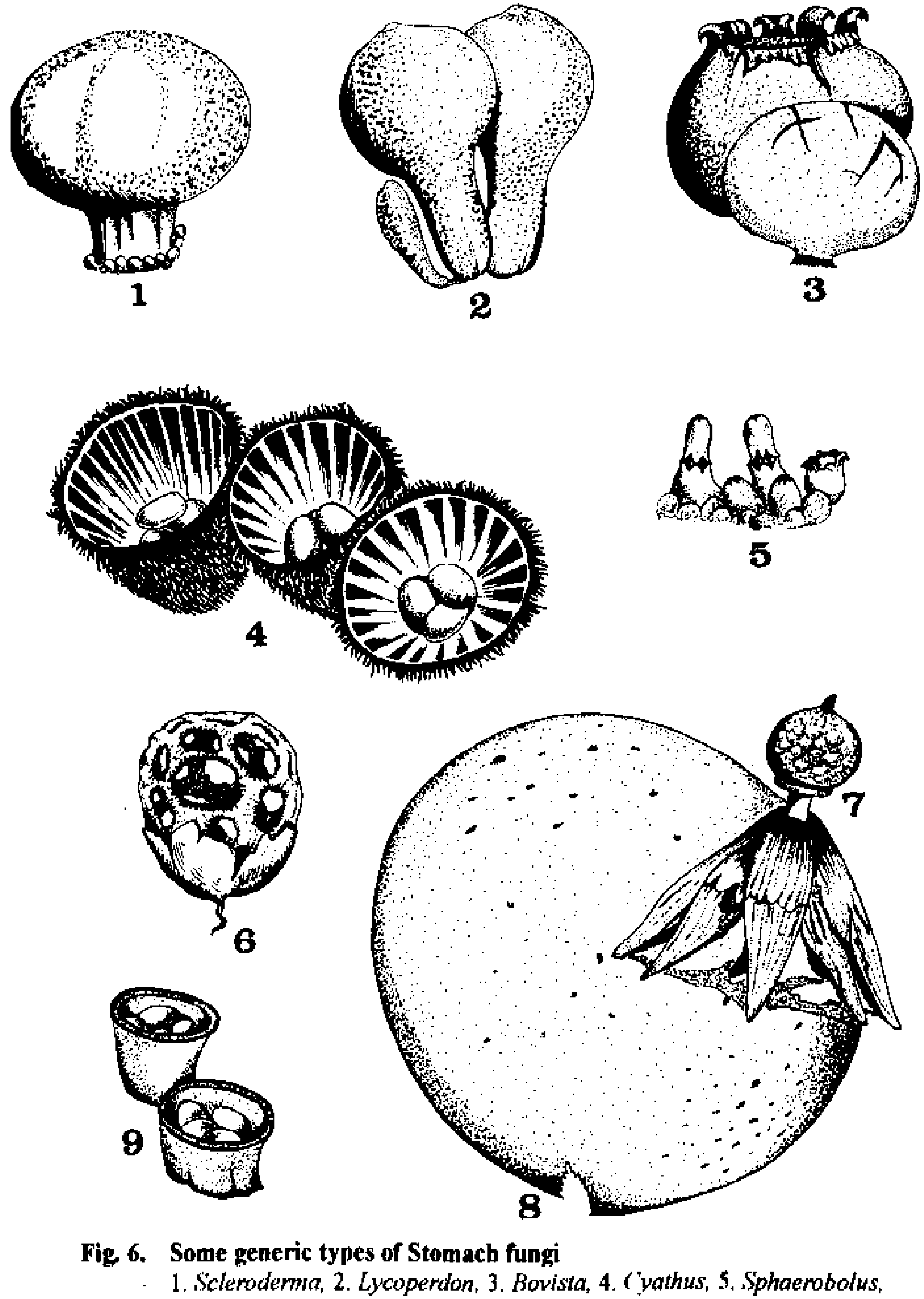


Fig. 6. Some generic types of Stomach fungi
1. *Scleroderma*, 2. *Lycoperdon*, 3. *Bovista*, 4. *Cyathus*, 5. *Sphaerobolus*, 6. *Clathrus*, 7. *Geastrum*, 8. *Calvatia*, 9. *Crucibulum*.

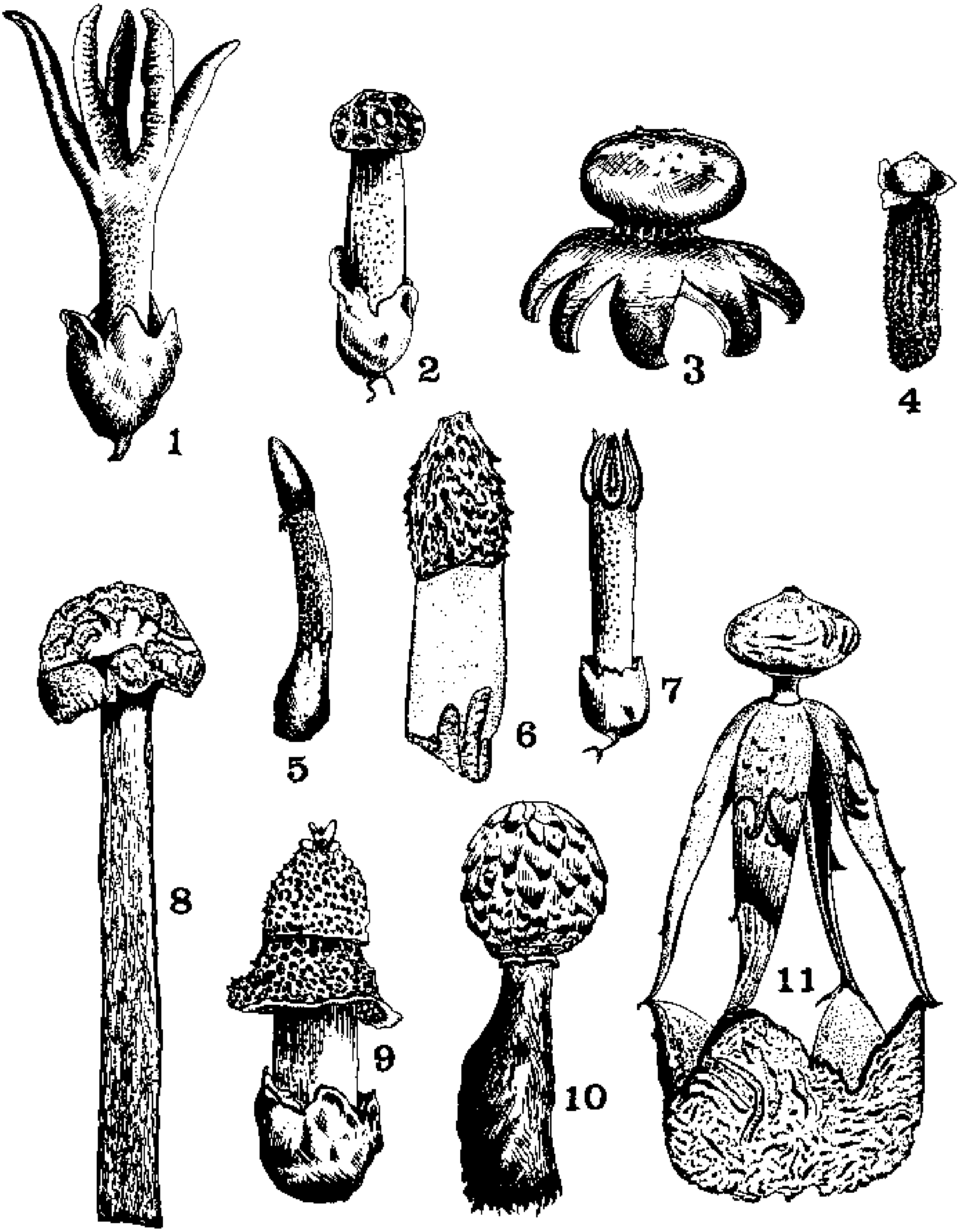


Fig. 7. Some generic types of Stomach fungi

1. *Anthurus*, 2. *Simbulum*, 3. *Myriostoma*, 4. *Calostoma*, 5. *Mutinus*, 6. *Phallus*, 7. *Lysurus*, 8. *Battarea*, 9. *Dictyophora*, 10. *Gyrophragmium*, 11. *Geastrum*.

WOODROTTING FUNGI OF TEMPERATE TIMBERLINE ZONE

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The woodrotting aphyllophorales constitute a cosmopolitan group of fungi fruiting mostly on dead woods or wood products throughout the world under different environmental conditions. The decades of fungi by Berkeley (1850-54) was the first systematic information on survey and study of aphyllophoraceous mycoflora of Himalaya which was enhanced by Thind (1961); Anony. (1969, 1970a, 1970b); Bakshi (1971); Rattan (1977); Rattan and Khurana (1978) and Sharma (1995). The other incidental and scattered reports of these fungi occurring in between temperate and timberline zone are found in Bakshi & Bagchee (1950); Bagchee and Bakshi (1954); Bagchee *et al.* (1954); Thind & Adlakha (1956); Reid *et al.* (1958, 59); Rehill and Bakshi (1965, 66); Imazeki *et al.* (1966); Thind & Khara (1968, 1975); Khara (1977a & b); Thind & Rattan (1968-73); Mass Geasteranus (1971); Rattan (1974) and Sharma (1996). Apart from these reports, no systematic and consolidated account of the rich and diversified aphyllophoraceous woodrotting mycoflora found in between temperate and subalpine forests i.e. from 2200 m to timberline, is available.

The temperate forests in WH (states of Jammu & Kashmir, Himachal Pradesh and Garhwal and Kumaon regions of Uttar Pradesh and EH (states of Sikkim, Arunachal Pradesh and Darjeeling district of West Bengal) extend approximately from 2200 m to 3000 m (-3500 m) and form a major part of the forest vegetation in the Himalayas. The temperate broad leaved forests in the lower parts dominated by species of *Quercus, Platanus, Aesculus, Juglans, Populus, Salix, Alnus, Acer, Pyrus, Lyonia, Viburnum, Elaeocarpus, Lindera, Castanopsis, Ilex* and *Engelhardtia* are followed by rich stands of *Pinus, Cedrus, Abies, Picea, Taxus, Cupressus, Larix* and *Tsuga* at higher altitudes. The subalpine forests are mostly marked by *Quercus-Abies* or *Betula-Abies* or *Rhododendron-Abies-Betula* associations. At places, *Betula utilis* forests form a narrow belt covering an area approx. 100 m near the timberline. Trees do not occur beyond 3600m (-4500 in EH).

The sufficient substratum provided both by angiospermic and coniferous tree species, and coupled with a great diversity in ecological habitats, provide rich environmental conditions for the growth of a much diversified aphyllophoraceous woodrotting mycoflora in the Himalayas from temperate to timberline. Unless otherwise specified, the substratum is dead standing or fallen trees of the species given. The fungi that cause heartrot in living trees and shrubs are identified as such. All the fungi reported in this contribution belong to the order Aphyllophorales. The grouping of families broadly follows the arrangement of Donk (1964). Table-I, based on the vast survey and study of these fungi by the author, both from Eastern Himalaya (EH) and Western Himalaya (WH) during the last 15 years and supplemented by the notes and material in other Indian Herbaria, provides a concise account of habit, distribution, host specificity, frequency of occurrence and if possible, the type of rot.

DIVERSITY

A total of 388 aphyllophoraceous fungi have been recorded from the zone under study, out of which 50 species (*ca* 12%) grow on ground probably forming mycorrhizic associations with forest trees, while the remaining, 337 species (*ca* 88%) are lignicolous and one species grows exclusively on fungi. About 5 species also share ferns as their hosts. Both angiospermic and coniferous woods provide the major hosts for these fungi. Of 337 lignicolous species, 124 (*ca* 37%) grow on angiosperms, 108 (*ca* 32%) on conifers while the remaining (*ca* 31%) prefer both type of woods.

Out of the total 18 families present, six are represented only by one genus; ten by two to eleven genera while two families have more than thirty genera each. In terms of genera, family Corticiaceae (39) is followed by Polyporaceae (34) and Clavariaceae (11) whereas, in terms of species Corticiaceae (95) and Polyporaceae (88) are followed by Hymenochaetaceae (53). Out of the 127 genera of aphyllophorales found in this zone, 58 (46%) have only one species; 49 genera (38%) have two to five species, 15 genera (12%) have six to ten species and only 5 genera (4%) have more than 10 species each.

Phellinus and *Ramaria*, each with *ca* 21 species are the largest and widely distributed genera in this zone, followed by *Tomentella* (20), *Inonotus* (14), *Hyphodontia* (11), *Antrodia* (10), *Hymenochaete* (9), *Polyporus* (8), *Hyphoderma* (8), *Oligoporus* (7), *Stereum* (6), *Trechispora* (6), *Scytinostroma* (6), *Vararia* (6), *Phlebia* (6) and *Coniophora* (6).

Though, the order of frequency of occurrence may slightly vary between Eastern and Western Himalayas, but following are among the most frequently seen species of woodrotting fungi in the temperate-timber line zone of the Himalayas.

Trametes versicolor	*Oligoporus fragilis*
Phellinus xeranticus	*Antrodiella zonata*
Phellinus allardii	*Inonotus flavidus*
Trichaptum abietinum	*Trametes gibbosa*
Xylobolus subpileatus	*Amylostereum chailletii*
Hymenochaete tabacina	*Lenzites butulina*
Stereum hirsutum	*Gloeophyllum subferrugineum*
Daedalea incana	*Phellinus laevigatus*
Fomes fomentarius	*Fomitopsis rosea*

Woodrotting fungi usually occur when the forest site is disturbed to some extent i.e. when the trees are broken or damaged (Eriksson 1958). These fungi colonize various parts of trees as many of them grow on trunks, stumps, butts, logs or fallen twigs but a few like *Amylostereum chailletii, Phaeolus schweinitzii, Botryobasidium subcoronatum, Phellinus igniarius* and *P. laevigatus* uncommonly occur on exposed roots or uprooted bottoms which contact soil surface. Most of these fungi are found on the undersides of fallen trunks where the habitat stays dim and moist for long periods. Broken or cut surfaces of dead trees provide unique habitat for *Gloeophyllum sepiarium, G. subferrugineum, Coniophora arida, Stereum hirsutum, Trichaptum abietinum, Trametes versicolor, Antrodia serialis* and *Gloeocystidiellum citrinum.*

The type of rot could be determined in about 283 species out of which 238 species (82%) caused white rots, while only 45 species (18%) caused brown rots. *Xylobolus frustulatus, X. subpileatus; Inonotus flavidus; Ganoderma applanatum; Trichaptum abietinum; Hymenochaete tabacina, Phellinus pini, P. gilvus, P. ferreus, P. allardii, P. xeranticus; Heterobasidion insulare; Stereum hirsutum; Trametes versicolor; Lenzites betulina* and *Antrodiella zonata* account for more than 80% white rot infections. On the other hand *Laetiporus sulphureus; Oligoporus fragilis; Gloeophyllum subferrugineum; Fomitopsis rosea; Daedalea incana; Coniophora arida, C. betulae; Antrodia serialis, A. albida; Chaetoderma luna; Serpula himantioides, S. lachrimans* and *Dacrybolus karstenii* were responsible for more than 80% of the brown rot infections.

Following species are responsible for significant heartrots and weaken the tree trunks, thus making them subject to windbreaks :

Fomes fomentarius	*Phellinus laevigatus*
Ganoderma applanatum	*Stereum sanguinolentum*
Inonotus dryadeus	*Stereum hirsutum*
Phlebiopsis gigantea	*Stereum gausapatum*
Phlebiopsis ravenelii	*Phaeolus schweinitzii*
Rigidoporus ulmarius	*Trametes gibbosa*
Phellinus igniarius	*Inonotus tenuicarnis*
Phellinus robustus	*Inonotus radiatus*
Amylostereum chailletii	*Gloeocystidiellum sulcatum*

Out of 124 species which grow exclusively on angiosperms, the following species are more prevalent : *Hymenochaete tabacina; Phellinus allardii, P. ferreus, P. igniarius, P. linteus, P. sanfordii, P. xeranticus; Inonotus glomeratus, I. radiatus, I. flavidus, I. tenuicarnis; Bjerkendera adusta; Oxyporus populinus; Polyporus arcularis, P. tricholoma; Rigidoporus ulmarius, R. vinctus; Trametes gibbosa; Xylobolus subpileatus* and *Stereum sanguinolentum.* Of the total 108 lignicolous species which prefer coniferous woods, more frequently found are: *Chaetoderma luna; Dacrybolus karstenii; Hyphodontia alutaria, H. arguta; Resinicium bicolor; Phlebiopsis ravenelii, P. gigantea; Trechispora farinacea; Gloeocystidiellum sulcatum; Phellinus pini; Scytinostroma odoratum; Fomitopsis rosea; Gloeophyllum subferrugineum; Heterobasidion insulare; Oligoporus fragilis; Amylostereum chailletii; Stereum sanguinolentum; Tomentella indica; Scytinostromella heterogena; Amylocorticium indicum* and *Vararia rhodospora.* Similarly, the more prevalent of the species preferring both angiospermic and coniferous woods are : *Ganoderma applanatum; Inonotus dryadeus; Phellinus robustus; Antrodia albida, A. gossypina, A. serialis; Daedalea incana; Dichomitus lenis; Trichaptum abietinum; Steccherinum ochraceum; Stereum hirsutum* and *Xylobolus frustulatus.*

Species of *Quercus* form the most important and major host for these fungi. Both living and dead fallen trees support a rich aphyllophoraceous fungus flora and a rich species diversity up to the extant that about 120 species grow either exclusively on *Quercus* or share it as one of their liked hosts. *Vararia effuscata, Albatrellus dispansus, Antrodiella zonata, Bjerkendera adusta, Daedaleopsis purpurea, Fomes fomentarius, Laetiporus sulphureus, Meripilus percinus, Pilopora indica, Spongipellis unicolor, Tyromyces pelliculosus, Wolfiporia dilatohypha* grow exclusively on *Quercus.* Some other species which also frequently share *Quercus* as one of their hosts are : *Phellinus allardii, P. ferreus, P. xeranticus; Stereum* *gausapatum; Trametes versicolor, T. hirsuta; Xylobolus subpileatus; Inonotus tenuicarnis, I. flavidus; Aleurodiscus oakesii; Phaeolus schweinitzii; Lenzites betulina; Phlebia radiata; Hericium erinaceus* and *Phylloporia weberiana.*

Abies pindrow and *A. spectabilis* are the most liked hosts among the conifers. Species like *Antrodia serialis; Coniophora arida; Hyphoderma setigerum; Fomitopsis pinicola, F. rosea; Inonotus radiatus, Phellinus igniarius, Phlebiopsis ravenalii, P. gigantea, Gloeocystidiellum sulcatum, Trichaptum abietinum* and *Stereum sanguinolentum* grow either exclusively on species of *Abies* or share them as one of the most liked hosts.

Near the timberline *Betula utilis* is also a common host. *Phellinus laevigatus, P. nigricans; Piptoporus betulina, Scytinostroma rhizomorpharum* grow exclusively on *Betula,* while species like *Trametes gibbosa, T. versicolor; Inonotus tenuicarnis, I. flavidus, I. radiatus; Phellinus sanfordii, P. gilvus, P. igniarius; Hyphodontia spathulata; Coniophora betulae; Lenzites betulina; Rigidoporus ulmarius; Spongipellis delactans* and *Polyporus arcularis* are also quite frequently present on *Betula.*

Rhododendron thickets are very poor sites and *Rhododendron* itself is the poorest host for these fungi. However, few species like *Epithele fulva, Hyphodontia crustosa, Xenasma subnitens, Phellinus acontextus* grow only on Rhododendrons. The other species which incidentally grow superficially on dead tissue of standing trunks are : *Botryobasidium subcoronatum, Phanerochaete filamentosa, Phlebia radiata, Phellinus sanfordii, Scytinostroma duriasculum, Hydnum repandum, Antrodia odora* and *A. oleracea.*

Table 1
An account of the woodrotting fungi of the temperate-timberline zone

	Name	Habit	Host	Dist.	Status	Rot
			AURISCALPIACEAE			
1.	*Auriscalpium vulgare*	Pileate, stip.	Cones of Conif.	EH, WH	C	RN
2.	*Scytinostromella heterogena*	Resupinate	*Abies, Cedrus*	EH, WH	C	WR
			BANKERACEAE			
3.	*Phellodon confluens*	Pileate, stip.	CF, MF, gr.	EH, WH	C	RN
4.	*Phellodon indicus*	Pileate, stip.	MF, gr.	WH	C	RN
5.	*Phellodon niger*	Pileate, stip.	CF, gr.	EH, WH	C	RN
			BONDARZEWIACEAE			
6.	*Bondarzewia berkeleyi*	Pileate, stip.	Oak roots	WH	VR	WSR
			CLAVARIACEAE			
7.	*Amylaria himalayensis*	Clavarioid	Oak forests, gr.	EH, WH	R	RN
8.	*Aphelaria pusio*	Clavarioid	Oak forests, gr.	EH, WH	C	RN
9.	*Aphelaria tuberosa*	Clavarioid	Oak forests, gr.	EH	C	RN

	Name	Habit	Host	Dist.	Status	Rot
10.	*Clavaria acuta*	Slender	CF, AF, gr.	WH	R	RN
11.	*Clavaria amoenoides*	Slender, caesp.	Oak forests, gr.	EH, WH	C	RN
12.	*Clavaria fumosa*	Slender, caesp.	Oak forests, gr.	WH	R	RN
13.	*Clavaria indica*	Slender, caesp.	Oak forests, gr.	EH, WH	C	RN
14.	*Clavaria vermicularis*	Clavate, caesp.	Oak forests, gr.	EH, WH	C	RN
15.	*Clavaria zollingeri*	Clavarioid	Oak forests, gr.	EH, WH	R	RN
16.	*Clavaria delphus-junceus*	Clavate-fil.	Oak forests, gr.	EH, WH	R	RN
17.	*Clavaria mirus*	Clavate-fil.	Oak forests, gr.	WH	R	RN
18.	*Clavaria sachalinensis*	Clavate-fil.	*Abies* forests, gr.	EH, WH	R	RN
19.	*Clavaria truncatus*	Clavate-fil.	CF, gr.	EH, WH	R	RN
20.	*Clavulina amethystinoides*	Slender	CF, gr.	EH, WH	C	RN
21.	*Clavaria bessonii*	Slender	Oak forests, gr.	EH, WH	C	RN
22.	*Clavaria cartilaginea*	Clavarioid	*Abies* Needles, gr.	EH, WH	C	RN
23.	*Clavaria castaneopsis*	Clavarioid	MF, gr.	EH, WH	C	RN
24.	*Clavaria cinerea*	Clavarioid	CF, gr.	WH	R	RN

	Name	Habit	Host	Dist.	Status	Rot
25.	*Clavaria cristata*	Clavariod	Oak forests, gr.	EH, WH	C	RN
26.	*Clavaria hispidulosa*	Clavarioid	Oak forests, gr.	EH, WH	C	RN
27.	*Clavaria mussooriensis*	Clavarioid	CF, Oak forests, gr.	EH, WH	C	RN
28.	*Clavulinopsis alcicornis*	Clavarioid	Oak forests, gr.	EH, WH	C	RN
29.	*Clavaria biformis*	Clavarioid	MF, gr.	EH, WH	C	RN
30.	*Clavaria corniculata*	Clavarioid	Oak forests, MF, gr.	EH, WH	VC	RN
31.	*Clavaria dichotoma*	Clavarioid	Oak forests, gr.	EH, WH	R	RN
32.	*Clavaria fusiformis*	Clavarioid	Oak forests, gr.	EH, WH	R	RN
33.	*Clavaria miniata*	Clavarioid	AW, CW	EH, WH	R	WR
34.	*Clavaria subtilis*	Clavarioid	Oak forests, gr.	EH, WH	R	RN
35.	*Deflexula subsimplex*	Clavarioid	*Cryptomeria*, *Tsuga*	EH, WH	R	WR
36.	*Pistillaria fuscipes*	Clavate-fil.	*Trametes versicolor*	WH	R	RN
37.	*Pistillaria granulata*	Clavate	Leaves, angio.	WH	R	RN
38.	*Pterula decumbens*	Clavarioid	CF, MF	EH, WH	VC	RN
39.	*Ramariopsis kunzei*	Clavarioid	Oak forests, gr.	EH, WH	R	RN

	Name	Habit	Host	Dist.	Status	Rot
40.	*Typhula himalayana*	Clavate-fil.	*Aconitum* leaves	EH, WH	R	RN
41.	*Typhula longispora*	Clavate-fil.	Oak, ferns leaves	EH, WH	C	RN
42.	*Typhula ovata*	Clavate-fil.	Oak, conif., fern leaves	EH, WH	VC	RN
			CONIOPHORACEAE			
43.	*Coniophora arida*	Resupinate	*Abies, Cedrus*	EH, WH	VC	BCR
44.	*Coniophora betulae*	Resupinate	*Abies, Betula, Cedrus*	EH, WH	VC	BCR
45.	*Coniophora cordensis*	Resupinate	*Abies*	EH, WH	C	BCR
46.	*Coniophora dimitiella*	Resupinate	*Abies, Cedrus*	WH	C	BCR
47.	*Coniophora puteana*	Resupinate	*Abies*	EH, WH	C	BCR
48.	*Coniophora olivascens*	Resupinate	AW, CW	WH	R	BCR
49.	*Serpula himantioides*	Resupinate	*Abies, Cedrus, Juglans, Aesculus*	EH, WH	VC	BCR
50.	*Serpula lacrimans*	ERf., Pileate	*Abies, Pinus*	EH, WH	C	BCR
51.	*Serpula mollusca*	Resupinate	AW	EH, WH	R	BCR

	Name	Habit	Host	Dist.	Status	Rot
52.	*Serpula similis*	Resupinate, Pileate	Twigs of Bamboos	EH, WH	R	BCR
			CORTICIACEAE			
53.	*Aleurodiscus oakesii*	Resupinate	*Quercus*	EH, WH	C	WR
54.	*Aleurodiscus taxicola*	Resupinate	*Taxus*	WH	R	WR
55.	*Amphinema byssoides*	Resupinate	*Cedrus, Abies, Pinus*	EH, WH	C	WR
56.	*Amylocorticium indicum*	Resupinate	*Abies, Cedrus, Picea*	EH, WH	C	WR
57.	*Amylosporomyces echinosporum*	Resupinate	CW	WH	R	WR
58.	*Botryobasidium candicans*	Resupinate	CW	EH, WH	C	WR
59.	*Botryobasidium subbotryosum*	Resupinate	AW, CW	EH, WH	C	WR
60.	*Botryobasidium subcoronatum*	Resupinate	*Rhododendron, Abies*	WH	R	WR
61.	*Botryohypochnus isabellinus*	Resupinate	*Cedrus, Picea, Abies*	EH, WH	C	WR
62.	*Ceraceomyces fibuligera*	Resupinate	*Cedrus, Picea*	EH, WH	C	WR
63.	*Ceraceomyces reidii*	Resupinate	AW	WH	R	WR
64.	*Ceraceomyces tessulatus*	Resupinate	*Abies*	WH	R	WR

	Name	Habit	Host	Dist.	Status	Rot
65.	*Ceratobasidium subatratum*	Resupinate	*Abies, Pinus, Picea*	WH	R	WR
66.	*Chaetoderma luna*	Resupinate	*Cedrus, Abies*	EH, WH	VC	BCR
67.	*Chondrostereum himalaicum*	Resupinate	Conif. twigs	WH	R	WR
68.	*Chondrostereum purpureum*	Resupinate, ERF.	*Cedrus, Abies*	EH, WH	C	WSR
69.	*Confertobasidium olivaceoalbum*	Resupinate	*Cedrus*	WH	R	WR
70.	*Cristinia helvetica*	Resupinate	*Abies*	WH	C	WR
71.	*Cristinia mucida*	Resupinate	CW	WH	VR	WR
72.	*Cylindrobasidium evolvens*	Resupinate	CW, AW	WH,	VR	BCR
73.	*Dacryobolus costratum*	Resupinate	*Abies, Picea*	WH	VR	BCR
74	*Dacryobolus karstenii*	Resupinate	*Abies, Pinus*	EH, WH	VC	BCR
75	*Dacryobolus sudans*	Resupinate	*Quercus*	WH	R	BCR
76.	*Epithele fulva*	Resupinate	*Rhododendron*	WH	R	WR
77.	*Galzinia ellipsospora*	Resupinate	AW	WH	R	WR
78.	*Hyphoderma argillaceum*	Resupinate	CW	EH, WH	R	WR

	Name	Habit	Host	Dist.	Status	Rot
79.	*Hyphoderma pallidum*	Resupinate	CW	EH, WH	R	WR
80.	*Hyphoderma polonense*	Resupinate	*Abies, Cedrus*	EH, WH	C	WR
81.	*Hyphoderma praetermissum*	Resupinate	*Cedrus, Abies*	EH, WH	C	WR
82.	*Hyphoderma puhera*	Resupinate	*Cedrus, Abies, Quercus*	EH, WH	C	
83.	*Hyphoderma setigerum*	Resupinate	*Cedrus*, AW	WH	R	WR
84.	*Hyphoderma subdefinitum*	Resupinate	*Abies*	EH, WH	R	WR
85.	*Hyphoderma teutoburgense*	Resupinate	*Abies, Picea*	WH	R	WR
86.	*Hyphodontia altaica*	Resupinate	*Abies, Picea*	EH, WH	R	WR
87.	*Hyphodontia alutaria*	Resupinate	*Abies, Tsuga*	EH, WH	VR	WR
88.	*Hyphodontia arguta*	Resupinate	*Pinus, Abies*	EH, WH	VC	WR
89.	*Hyphodontia aspera*	Resupinate	AW	WH	R	WR
90.	*Hyphodontia crustosa*	Resupinate	*Rhododendron*	EH, WH	R	WR
91.	*Hyphodontia epibulata*	Resupinate	*Picea, Abies*	EH, WH	R	WR
92.	*Hyphodontia longicystidiosa*	Resupinate	*Cedrus*	WH	R	WR
93.	*Hyphodontia pallidula*	Resupinate	*Abies, Pinus*	EH, WH	C	WR

	Name	Habit	Host	Dist.	Status	Rot
94.	*Hyphodontia papillosa*	Resupinate	*Cedrus, Abies*	EH, WH	R	WR
95.	*Hyphodontia spathulata*	Resupinate	*Abies, Pinus, Betula, Rhododendron*	WH	VC	WR
96.	*Hyphodontia subdetrica*	Resupinate	CW	EH, WH	R	WR
97.	*Hypochnicium cystidiatum*	Resupinate	AW	WH	R	WR
98.	*Hypochnicium lundellii*	Resupiante	AW	WH	R	WR
99.	*Hypochnicium punctulatum*	Resupinate	*Quercus, Cedrus, Abies*	EH, WH	C	WR
100.	*Hypochnicium sphaerosporum*	Resupinate	*Abies, Pinus*	EH, WH	C	WR
101.	*Irpiciaporus pachydon*	Resupinate	AW	WH	VR	WR
102.	*Leptosporomyces adnatum*	Resupinate	*Taxus, Cedrus, Abies, Quercus*	WH	R	WR
103.	*Leptosporomyces globosum*	Resupinate	Conif. slash	WH	R	WR
104.	*Leptosporomyces ovoideus*	Resupinate	CW, AW	WH	R	WR
105.	*Metulodontia nivea*	Resupinate	*Cedrus, Quercus, Abies*	EH, WH	C	WR
106.	*Metulodontia quelettii*	Resupinate	*Quercus, Viburnum*	EH, WH	C	WR

	Name	Habit	Host	Dist.	Status	Rot
107.	*Mycoacia fuscoatra*	Resupinate	CW	WH	R	WR
108.	*Mycoacia stenodon*	Resupinate	*Berberis* & AW	EH, WH	R	WR
109.	*Mycoacia subochracea*	Resupinate	*Quercus* & AW	WH	R	WR
110.	*Merulius tremellosus*	Resupinate, ERf.	*Quercus* & *Betula*,	EH, WH	C	WPR
111.	*Peniophora cinerea*	Resupinate	*Betula* & AW	EH, WH	C	WR
112.	*Peniophora incarnata*	Resupinate	*Quercus*	EH, WH	VR	WR
113.	*Peniophora quercina*	Resupinate	B, angio., Conif.	WH,	R	WR
114.	*Peniophora violaceolivida*	Resupinate	Conif., twigs	EH, WH	C	WR
115.	*Phanerochaete affinis*	Resupinate	angio., twigs	WH,	R	WR
116.	*Phanerochaete filamentosa*	Resupinate	*Abies, Pinus, Picea, Quercus, Rhododendron*	EH, WH	VC	WR
117.	*Phanerochaete pruni*	Resupinate	angio., twigs	WH	R	WR
118.	*Phanerochaete tuberculata*	Resupinate	AW, CW	EH, WH	C	WR
119.	*Phanerochaete viticola*	Resupinate	AW	EH	C	WR
120.	*Phlebia albida*	Resupinate	*Quercus, Picea, Rhododendron*	EH, WH	C	WR

	Name	Habit	Host	Dist.	Status	Rot
121.	*Phlebia hydnoides*	Resupinate	*Cedrus, Abies*	EH, WH	C	WR
122.	*Phlebia livida*	Resupinate	*Abies, Pinus*	EH, WH	C	WR
123.	*Phlebia radiata*	Resupinate	*Quercus, Rhododendron, Abies*	EH, WH	C	WR
124.	*Phlebia subcretacea*	Resupinate	*Cedrus*	EH, WH	R	WR
125.	*Phlebia subserialis*	Resupinate	*Cedrus, Abies*	WH	R	WR
126.	*Phlebiopsis gigantea*	Resupinate	*Cedrus, Abies, Picea*	EH, WH	C	WR
127.	*Phlebiopsis ravenelii*	Resupinate	*Abies, Picea*	EH, WH	VC	WR
128.	*Pseudomerulius aureus*	Resupinate, ERL	*Abies, Picea, Pinus Cedrus*	EH, WH	C	BCR
129.	*Pulcherricium caeruleum*	Resupinate	*Quercus, Pinus Abies, Taxus*	EH, WH	C	WR
130.	*Radulodon americanus*	Resupinate	CW	EH, WH	R	WR
131.	*Radulodon erikssonii*	Resupinate	AW	WH	R	WR
132.	*Radulomyces molaris*	Resupinate	*Pinus*	WH	R	WR
133.	*Resinicium bicolor*	Resupinate	*Abies, Picea, Cedrus, Tsuga, Pinus*	EH, WH	VC	WR

	Name	Habit	Host	Dist.	Status	Rot
134.	*Sistotrema confluens*	Resupinate, ERf.	*Quercus*	EH, WH	R	WR
135.	*Sistotrema lachrymispora*	Resupinate	CW	WH	R	WR
136.	*Sistotremastrum niveocremeum*	Resupinate	*Cedrus, Abies, Picea*	EH, WH	C	WR
137.	*Subulicystidium longisporum*	Resupinate	*Cedrus*	EH, WH	C	WR
138.	*Trechispora alnicola*	Resupinate	*Abies*	WH	R	WR
139.	*Trechispora confinis*	Resupinate	*Abies*	WH	VR	WR
140.	*Trechispora farinacea*	Resupinate	*Cedrus, Abies, Picea*	EH, WH	VC	WR
141.	*Trechispora mollusca*	Resupinate	AW	EH, WH	R	WR
142.	*Trechispora mutabilis*	Resupinate	AW	WH	R	WR
143.	*Trechispora. vaga*	Resupinate	B, angio.	WH	R	WR
144.	*Tubulicrinis chaetophorus*	Resupinate	*Cedrus, Picea, Abies*	EH, WH	C	WR
145.	*Tubulicrinis subulatus*	Resupinate	All Conif.	EH, WH	C	WR
146.	*Xenasma subclematidis*	Resupinate	*Pinus, Cedrus, Abies*	WH	R	WR
147.	*Xenasma subnitens*	Resupinate	B, *Rhododendron*	WH	R	WR

	Name	Habit	Host	Dist.	Status	Rot
			ECHINODONTIACEAE			
148.	*Echinodontium japonicum*	Resupinate	*Quercus, Cedrus, Abies*	EH, WH	C	WR
			GANODERMATACEAE			
149.	*Ganoderma applanatum*	ERf., Pileate	*Betula, Tsuga, Fagus, Abies, Picea, Aesculus, Quercus*	EH, WH	C	WMR
150.	*Ganoderma lucidum*	Pileate, stip.	*Quercus, Aesculus* AW	EH, WH	C	WR
151.	*Ganoderma resinaceum*	Pileate	*Quercus, Platanus*	WH	R	WMR
			GOMPHACEAE			
152.	*Kavinia alboviride*	Resupinate	CW, AW	EH, WH	C	WR
153.	*Lentaria byssiseda*	Clavarioid	Conif., twigs	WH	R	RN
154.	*Lentaria mucida*	Clavarioid	CW	EH, WH	C	WR
155.	*Ramaria apiculata*	Clavarioid	*Cedrus, Pinus*	EH, WH	C	RN
156.	*Ramaria brevispora*	Clavarioid	Oak forests, gr.	WH	R	RN
157.	*Ramaria camelicolor*	Clavarioid	Oak forests, gr.	WH	R	RN

	Name	Habit	Host	Dist.	Status	Rot
158.	*Ramaria clarobrunnea*	Clavarioid	Oak forests, gr.	WH	R	RN
159.	*Ramaria echino-virens*	Clavarioid	Oak forests, gr.	EH, WH	C	RN
160.	*Ramaria flaccida*	Clavarioid	Oak & CF, gr.	EH, WH	VC	RN
161.	*Ramaria flaviceps*	Clavarioid	Oak forests, gr.	EH, WH	R	RN
162.	*Ramaria flavo-brunnescens*	Clavarioid	Oak forests, gr.	EH, WH	R	RN
163.	*Ramaria flavo-viridis*	Clavarioid	Needles Conif., gr.	EH, WH	R	RN
164.	*Ramaria formosa*	Clavarioid	Oak forests, gr.	EH	R	RN
165.	*Ramaria fumigata*	Clavarioid	Oak forests, gr.	EH, WH	R	RN
166.	*Ramaria fuscobrunnea*	Clavarioid	CF, gr.	EH, WH	R	RN
167.	*Ramaria moelleriana*	Clavarioid	AW	WH	R	RN
168.	*Ramaria obtusissima*	Clavarioid	Oak forests, gr.	EH	C	RN
169.	*Ramaria pusilla*	Clavarioid	Oak forests, gr.	EH, WH	C	RN
170.	*Ramaria sanguinea*	Clavarioid	Oak forests, gr.	EH, WH	C	RN
171.	*Ramaria stricta*	Clavarioid	AW, gr.	EH, WH	C	RN
172.	*Ramaria subaurantiaca*	Clavarioid	Oak forests, gr.	EH, WH	C	RN

	Name	Habit	Host	Dist.	Status	Rot
173.	*Ramaria subbotrytis*	Clavarioid	Oak forests, gr.	EH, WH	C	RN
174.	*Ramaria subgelatinosa*	Clavarioid	Oak forests, gr.	EH, WH	C	RN
175.	*Ramaria zippelii*	Clavarioid	AF, gr.	EH	C	RN
			HERICIACEAE			
176.	*Dentipellis subseparans*	Resupinate	All Conif.	EH, WH	C	WR
177.	*Gloeocystidiellum citrinum*	Resupinate	*Quercus, Abies*	EH, WH	C	WR
178.	*Gloeocystidiellum donkii*	Resupinate	*Quercus, Abies*	WH	R	WR
179.	*Gloeocystidiellum lactescens*	Resupinate	*Quercus, Abies*	WH	R	WR
180.	*Gloeocystidiellum luteocystidium*	Resupinate	AW	EH	R	WR
181.	*Gloeocystidiellum sulcatum*	Resupinate	*Abies, Cedrus*	EH, WH	VC	WR
182.	*Hericium erinaceus*	Ovoid, Pendent	*Quercus*, CW	EH, WH	C	WR
183.	*Hericium clathroides*	Branched, rooting base	*Quercus*	EH, WH	C	WR
184.	*Hericium coralloides*	Branched,	*Quercus*, CW	EH, WH	C	WR
185.	*Laxitextum bicolor*	ERF, Pileate	*Cedrus, Quercus, Rhododendron*	EH, WH	C	WPR

	Name	Habit	Host	Dist.	Status	Rot
			HYDNACEAE			
186.	*Hydnum aitchisonii*	Pileate, stip.	*Quercus*	WH	R	WR
187.	*Hydnum repandum*	Pileate, stip.	*Quercus, Rhododendron, Pinus*	EH, WH	C	WR
188.	*Hydnum rufescens*	Pileate, stip.	CF, MF, gr.	EH, WH	C	RN
			HYMENOCHAETACEAE			
189.	*Asterostroma cervicolor*	Resupinate	*Abies, Quercus*, AW	EH, WH	C	WR
190.	*Asterostroma musicolum*	Resupinate	*Abies, Cedrus*, AW	EH, WH,	A	WR
191.	*Coltricia cinnamomea*	Pileate, stip.	AF, gr.	EH, WH	VC	RN
192.	*Coltricia montagnei*	Pileate, stip.	CF, gr.	EH, WH	VR	RN
193.	*Coltricia perennis*	Pileate, stip.	CF, gr.	EH, WH	VC	RN
194.	*Coltricia pusilla*	Pileate, stip.	CF, gr.	EH	C	RN
195.	*Cyclomyces tabacinus*	Pileate	AW	EH, WH	C	WPR
196.	*Hymenochaete cacao*	Resupinate	AW	WH	R	WR
197.	*Hymenochaete cruenta*	Resupinate	*Quercus, Pyrus, Juglans Rhododendron*	EH, WH	C	WR

	Name	Habit	Host	Dist.	Status	Rot
198.	*Hymenochaete fuscobadia*	Resupinate	AW	WH	R	WR
199.	*Hymenochaete leonina*	Resupinate	AW	WH	R	WR
200.	*Hymenochaete luteobadia*	ERf.	AW	EH, WH	C	WR
201.	*Hymenochaete rubiginosa*	Resupinate, ERf.	HW	EH, WH	C	WR
202.	*Hymenochaete semistupposa*	Resupinate	AW	EH, WH	R	WR
203.	*Hymenochaete tabacina*	Resupinate, ERf., Pileate	AW	EH, WH	VC	WR
204.	*Hymenochaete villosa*	ERf., Pileate	AW	EH	C	WR
205.	*Inonotus brevisporus*	Pileate	*Quercus*	WH,	C	WLR
206.	*Inonotus circinatus*	Pileate, stip.	*Pinus, Cedrus, Larix*	EH, WH	C	WPR
207.	*Inonotus cuticularis*	Pileate	*Quercus*	EH, WH	C	WSR
208.	*Inonotus diverticuloseta*	ERf., Pileate	*Quercus*	WH	R	WR
209.	*Inonotus dryadeus*	Pileate	*Abies, Quercus*	EH, WH	VC	WR
210.	*Inonotus flavidus*	Pileate	*Quercus, Betula*	EH, WH	VC	WPR
211.	*Inonotus glomeratus*	ERf., Pileate	AW	EH, WH	C	WR

	Name	Habit	Host	Dist.	Status	Rot
212.	*Inonotus hamusetulus*	Pileate	*Quercus, Aesculus*	EH, WH	R	WHR
213.	*Inonotus hispidus*	Pileate	*Quercus, Aesculus,*	EH, WH	R	WR
214.	*Inonotus patouillardii*	Pileate	*Quercus*	WH	VR	WR
215.	*Inonotus radiatus*	Pileate	*Betula, Populus, Aesculus, Juglans*	EH, WH	C	WR
216.	*Inonotus rheades*	Pileate	*Populus, Castanea*	EH, WH	R	WR
217.	*Inonotus tenuicarnis*	Pileate	*Quercus, Betula, Castanea*	EH, WH	C	WR
218.	*Inonotus tomentosus*	Pileate, stip.	*Pinus, Cedrus, Abies, Larix*	EH, WH	C	WR
219.	*Phellinus acontextus*	Pileate, Pendant	*Rhododendron*	WH	VR	WPR
220.	*Phellinus allardii*	Pileate	*Quercus*	EH, WH	VC	WPR
221.	*Phellinus conchatus*	ERF, Pileate, Resupinate	*Pyrus, Cotoneaster, Quercus, Betula, Viburnum*	WH	C	WR
222.	*Phellinus contiguus*	Resupinate	AW, CW	EH, WH	C	WR
223.	*Phellinus extensus*	Pileate	*Qurcus, Pinus*	EH	R	WR

Name	Habit	Host	Dist.	Status	Rot
224. *Phellinus ferreus*	Pileate	*Quercus*	EH, WH	VC	WR
225. *Phellinus gilvus*	Pileate	*Quercus, Betula, Populus*	EH, WH	C	WR
226. *Phellinus igniarius*	Pileate	*Viburnum, Salix, Alnus, Quercus, Betula, Populus*	EH, WH	VC	WR
227. *Phellinus inermis*	Resupinate	AW	EH, WH	R	WR
228. *Phellinus johnsonianus*	ERf., Pileate	*Quercus*, AW	WH	R	WLR
229. *Phellinus laevigatus*	Resupinate	*Betula*	EH, WH	VC	WLR
230. *Phellinus linteus*	Pileate	*Quercus, Lonicera, Prunus*	EH, WH	C	WPR
231. *Phellinus melleoporus*	Resupinate	*Quercus, Acer*	WH	R	WSR
232. *Phellinus nigricans*	Resupinate	*Betula utilis*	EH, WH	C	WR
233. *Phellinus pectinatus*	Pilieate	*Pyrus, Prunus, Lyonia, Quercus*	EH, WH	C	WR
234. *Phellinus pini*	Resupinate, ERf., Pileate	*Pinus, Abies, Cedrus, Larix*	EH, WH	VC	WPR
235. *Phellinus robustus*	Pileate	*Abies, Picea, Quercus, Acer, Aesculus*	EH, WH	VC	WR

	Name	Habit	Host	Dist.	Status	Rot
236.	*Phellinus sanfordii*	Pileate	*Quercus, Betula, Rhododendron, Rhus, Viburnum*	EH, WH	VC	WSR
237.	*Phellinus torulosus*	Pileate	*Quercus, Acer, Pyrus*	EH, WH	C	WPR
238.	*Phellinus wahlbergii*	Pileate	AW	EH, WH	R	WPR
239.	*Phellinus xeranticus*	ERf., Pileate	*Quercus*	EH, WH	MC	WPR
240.	*Phylloporia weberiana*	Pileate	*Quercus*, AW	EH, WH	C	WR
241.	*Pyrrhoderma sendaiense*	Pileate, stip.	*Quercus, Acer*	EH	VR	WR
		LACHNOCLADIACEAE				
242.	*Scytinostroma duriusculum*	Resupinate	*Quercus, Berberis, Rhododendron*	EH, WH	C	WR
243.	*Scytinostroma ochroleucum*	Resupinate	CW, AW	WH	R	WR
244.	*Scytinostroma odoratum*	Resupinate	*Picea, Cedrus, Abies*	EH, WH	VC	WR
245.	*Scytinostroma portentosum*	Resupinate	*Berberis*	EH, WH	VC	WR
246.	*Scytinostroma praestans*	Resupinate	*Betula, Abies*	WH	C	WR
247.	*Scytinostroma rhizomorpharum*	Resupinate	*Betula utilis*	WH	R	WR

	Name	Habit	Host	Dist.	Status	Rot
248.	*Vararia brevispora*	Resupinate	AW	EH, WH	VR	WR
249.	*Vararia effuscata*	Resupinate	*Quercus*	EH, WH	VR	WR
250.	*Vararia ochroleuca*	Resupinate	*Cedrus, Abies*	EH, WH	R	WR
251.	*Vararia pallescens*	Resupinate	*Abies, Pinus, Picea*	EH, WH	C	WR
252.	*Vararia rhodospora*	Resupinate	*Cedrus, Rhododendron*	EH, WH	VR	WR
253.	*Vararia vassilievae*	Resupinate	*Abies, Cedrus*	EH, WH	C	WR
			POLYPORACEAE			
254.	*Albatrellus cantharellus*	Pileate, stip.	CF, gr.	EH, WH	C	RN
255.	*Albatrellus confluens*	Pileate, stip.	CF, gr.	EH, WH	C	RN
256.	*Albatrellus dispansus*	Pileate, stip.	*Quercus*	EH, WH	C	BCR
257.	*Antrodia albida*	ERf., Pileate	*Quercus*, CW, AW	EH, WH	VC	BCR
258.	*Antrodia carbonica*	Resupinate	*Tsuga, Abies, Picea*	EH, WH,	R	BCR
259.	*Antrodia crassa*	Resupinate	*Abies, Picea*	EH, WH	C	BCR

	Name	Habit	Host	Dist.	Status	Rot
260.	*Antrodia gossypina*	Resupinate	*Abies, Picea Pinus*, AW	EH, WH	VC	BCR
261.	*Antrodia odora*	Resupinate	*Abies, Quercus, Rhododendron*	EH, WH	C	BCR
262.	*Antrodia oleracea*	Resupinate	*Abies, Quercus, Rhododendron*	EH, WH	C	BCR
263.	*Antrodia serialis*	Resupinate, ERf.	CW, AW	EH, WH	VC	BCR
264.	*Antrodia sitchensis*	Resupinate	CW	EH, WH	C	BCR
265.	*Antrodia sordida*	Resupinate	*Abies, Pinus, Quercus, Salix*, AW	EH, WH	C	BCR
266.	*Antrodia xantha*	Resupinate	*Abies, Cedrus, Pinus, Quercus*, AW	EH, WH	C	BCR
267.	*Antrodiella fissiliformis*	Resupinate	CW, AW	WH	R	WSR
268.	*Antrodiella minutispora*	Pileate	AW	EH, WH	C	WSR
269.	*Antrodiella overholtsii*	Pileate	*Abies, Picea*	WH	R	WSR
270.	*Antrodiella zonata*	ERf., Pileate	*Quercus*	EH, WH	VC	WSR
271.	*Bjerkandera adusta*	ERf., Pileate	*Quercus*, AW	EH, WH	VC	WR

	Name	Habit	Host	Dist.	Status	Rot
272.	*Cerrena unicolor*	Resupinate, ERf.	*Quercus*, AW	EH, WH	C	WR
273.	*Climacocystis borealis*	Pileate	CF	WH	R	WMR
274.	*Daedalea incana*	ERf., Pileate	CW, AW	EH, WH	VC	BHR
275.	*Daedalea quercina*	Pileate	*Quercus, Castanea, Fagus, Juglans, Populus*	EH, WH	R	BCR
276.	*Daedalea sprucei*	Pileate	AW	EH, WH	C	BCR
277.	*Daedaleopsis confragosa*	Pileate	AW	EH, WH	C	WR
278.	*Daedaleopsis purpurea*	Pileate	*Quercus*	EH, WH	VR	WR
279.	*Dichomitus leucoplacus*	Resupinate	AW	EH, WH	C	WPR
280.	*Diplomitoporus lenis*	Resupinate	AW, CW	EH, WH	C	WR
281.	*Diplomitoporus lindbladii*	Resupinate	CW	WH	R	WSR
282.	*Fomes fomentarius*	Pileate	*Quercus*	EH, WH	C	WR
283.	*Fomitopsis pinicola*	ERf., Pileate	*Abies, Pinus, Tsuga, Picea, Cedrus*	EH, WH	VC	BCR
284.	*Fomitopsis rosea*	ERf., Pileate	*Abies, Pinus, Cedrus, Tsuga, Picea*	EH, WH	VC	BCR

	Name	Habit	Host	Dist.	Status	Rot
285.	*Gloeophyllum abietinum*	Pileate	*Picea, Tsuga, Abies, Taxus*	EH, WH	C	BCR
286.	*Gloeophyllum carbonarium*	Resupinate, ERf.	*Abies, Picea, Pinus*	WH	R	BCR
287.	*Gloeophyllum subferrugineum*	ERf., Pileate	CW	EH, WH	VC	BCR
288.	*Heterobasidion annosum*	Resupinate, ERf.	*Cedrus, Pinus, Picea, Quercus*	EH, WH	C	WPR
289.	*Heterobasidion insulare*	ERf., Pileate	*Cedrus, Picea, Abies*	EH, WH	VC	WSR
290.	*Incrustoporia nivea*	Resupinate	*Quercus*, AW	EH, WH	C	WR
291.	*Laetiporus sulphureus*	Pileate, stip	*Quercus*	EH, WH	C	BCR
292.	*Lenzites betulina*	Pileate	*Quercus, Betula, Populus, Acer*, CW	EH	VC	WR
293.	*Meripilus percicinus*	Pileate, stip.	*Quercus*	EH, WH	R	WR
294.	*Oligoporus balsameus*	ERf., Pileate	*Pinus, Abies*	WH	R	BCR
295.	*Oligoporus caesius*	ERf., Pileate	*Toona, Aesculus, Juglans*	WH,	R	BC
296.	*Oligoporus fragilis*	ERf., Pileate	*Abies, Cedrus, Pinus, Picea*	EH, WH	VC	BCR

	Name	Habit	Host	Dist.	Status	Rot
297.	*Oligoporus guttulatus*	Pileate	*Quercus, Abies, Picea*	EH, WH	C	BCR
298.	*Oligoporus leucospongia*	Resupinate, ERf.	*Abies, Pinus, Picea, Cupressus*	EH, WH	C	BCR
299.	*Oligoporus placentus*	Resupinate	*Abies, Cedrus, Pinus*	WH	R	BCR
300.	*Oligoporus sericeomollis*	Resupinate, ERf.	*Abies, Cedrus*	EH, WH	R	BCR
301.	*Oxyporus corticola*	Resupinte	*Quercus, Abies, Picea*	EH, WH	C	WR
302.	*Oxyporus populinus*	Resupinate, ERf., Pileate	*Quercus, Aesculus, Schima, Populus, Betula, Platanus*	EH, WH	C	WR
303.	*Oxyporus ravidus*	Resupinate, ERf.	*Quercus, Picea, Abies*	EH, WH	C	WR
304.	*Oxyporus spiculifer*	Resupinate	*Quercus, Abies, Pinus, Cedrus*	EH, WH	C	WR
305.	*Perenniporia detritus*	Pileate	AW	EH	R	WR
306.	*Perenniporia ellipsospora*	Resupinate	*Quercus, Aesculus Abies, Cedrus*	EH, WH	C	WSR

	Name	Habit	Host	Dist.	Status	Rot
307.	*Perenniporia fulviseda*	Resupinate	*Quercus, Abies, Pinus*	EH, WH	C	WR
308.	*Perenniporia medula-panis*	Resupinate	AW	EH, WH	C	WR
309.	*Perenniporia tenuis*	Resupinate	*Cupressus*	WH	C	WR
310.	*Phaeolus schweinitzii*	Pileate, stip.	*Qeurcus*	EH, WH	C	BCR
311.	*Piloporia indica*	Pileate	*Quercus*	EH	VR	WPR
312.	*Piptoporus betulinus*	Pileate	*Betula*	EH, WH	VC	BCR
313.	*Polyporus arcularis*	Pileate stip.	AW	EH, WH	VC	WR
314.	*Polyporus brumalis*	Pileate, stip	AW	EH, WH	C	WR
315.	*Polyporus grammocephalus*	Pileate, stip.	*Quercus*	EH, WH	C	WR
316.	*Polyporus squamosus*	Pileate, stip.	*Quercus*, AW	EH, WH	C	WR
317.	*Polyporus tricholoma*	Pileate, stip.	AW	EH, WH	VC	WR
318.	*Polyporus udus*	Pileate, stip.	AW	WH	R	WR
319.	*Polyporus umbellatus*	Pileate, stip.	AW	EH, WH	R	WR
320.	*Polyporus virgatus*	Pileate, stip.	AW	EH,	R	WR

	Name	Habit	Host	Dist.	Status	*Rot*
321.	*Pycnoporellus fulgens*	ERf., Pileate	CW	WH	R	BCR
322.	*Rigidoporus microporus*	Pileate	*Aesculus, Quercus*	WH	R	WR
323.	*Rigidoporus ulmarius*	Pileate	*Aesculus, Quercus, Populus, Betula, Juglans*	EH, WH	C	WR
324.	*Rigidoporus vinctus*	Resupinate	AW	EH, WH	VC	WR
325.	*Skeletocutis amorpha*	Resupinate, ERf.	CW, HW	EH, WH	C	WR
326.	*Spongipellis delectans*	ERf., Pileate	*Quercus, Populus, Betula*	WH	C	WMR
327.	*Spongipellis unicolor*	Pileate	*Quercus*	EH	C	WR
328.	*Trametes gibbosa*	Pileate	*Quercus, Aesculus, Betula*	EH, WH	C	WR
329.	*Trametes hirsuta*	ERf., Pileate	AW	EH, WH	C	WR
330.	*Trametes lactinea*	Pileate	AW	EH, WH	R	WR
331.	*Trametes tephroleuca*	ERf., Pileate	AW	EH, WH	C	WR
332.	*Trametes versicolor*	ERf., Pileate	*Quercus, Betula*	EH, WH	VC	WR
333.	*Trichaptum abietinum*	Resupinate, ERf., Pileate	CW, AW	EH, WH	VC	WPR

	Name	Habit	Host	Dist.	Status	Rot
334.	*Tyromyces chioneus*	Pileate	*Quercus, Betula*	EH, WH	C	WR
335.	*Tyromyces pelliculosus*	Pileate	*Quercus*, AW	EH, WH	R	WR
336.	*Wolfiporia dilatohypha*	Resupinate	*Quercus*	EH, WH	C	BCR
		SPARASSIDACEAE				
337.	*Sparassis crispa*	Coralloid	*Abies, Pinus*	WH	C	BCR,
		STECCHERINACEAE				
338	*Steccherinum ciliolatum*	Resupinate	Angio. twigs	EH, WH	C	WR
339.	*Steccherinum fimbriatum*	Resupinate	*Cedrus*, HW	EH, WH	C	WR
340.	*Steccherinum laeticolor*	Resupinate, ERf.	AW	WH	R	WR
341.	*Steccherinum ochraceum*	Resupinate, ERf.	*Quercus, Pyrus, Berberis, Picea*	EH, WH	VC	WR
342.	*Junghunia collabens*	Resupinate	*Abies, Picea*	EH, WH	C	WR
343.	*Junghunia luteoalba*	Resupinate	*Cedrus, Abies, Larix*	EH, WH	R	WR
344.	*Junghunia nitida*	Resupinate	*Pinus, Picea*	WH	R	WR
		STEREACEAE				
345.	*Amylostereum chailletii*	ERf, Pileate	*Cedrus, Abies*	EH, WH	VC	WR

	Name	Habit	Host	Dist.	Status	Rot
346.	*Cystostereum murraii*	Resupinate, ERf.	*Picea, Abies*	EH, WH	C	WR
347.	*Lopharia cinerascens*	Resupinate, ERf.	AW, CW	EH, WH	VC	WPR
348.	*Lopharia fulva*	Resupinate, Pileate	AW, CW	WH	R	WPR
349.	*Stereopsis mussooriensis*	Pileate, stip.	CW, HW	WH	R	WPR
350.	*Stereopsis sparassoides*	Pileate, stip.	MF, gr.	EH, WH	C	RN
351.	*Stereum acanthophysatum*	ERf., Pileate	*Cedrus, Abies*	WH	R	WR
352.	*Stereum gausapatum*	ERf., Pileate	*Quercus, Rhododendron, Pyrus, Berberis*	EH, WH	VC	WSHR
353.	*Stereum hirsutum*	ERf., Pileate	*Quercus, Abies, Pinus*	EH, WH	VC	WR
354.	*Stereum ostrea*	ERf., Pileate	*Cedrus, Quercus, Abies, Juglans*	EH, WH	VC	WR
355.	*Stereum rugosum*	ERf.	*Quercus*	WH	VR	WR
356.	*Stereum sanguinolentum*	ERf., Pileate	*Cedrus, Abies*	EH, WH	VC	WR
357.	*Xylobolus ahmadii*	ERf., resupinate	*Quercus, Cedrus*	WH	C	WSR
358.	*Xylobolus frustulatus*	Resupinate, ERf.	*Quercus, Cedrus, Abies*	EH, WH	VC	WPR

	Name	Habit	Host	Dist.	Status	Rot
359.	*Xylobolus subpileatus*	ERf., pileate	*Quercus, Juglans, Rhododendron*	EH, WH	VC	WPR
			THELEPHORACEAE			
360.	*Boletopsis subsquamosa*	Pileate, stip.	HW, MF, gr.	EH, WH	C	RN
361.	*Hydnellum auratile*	Pileate, stip.	CF, gr.	WH	C	RN
362.	*Hydnellum caeruleum*	Pileate, stip.	CF, gr.	EH, WH	C	RN
363.	*Hydnellum concrescens*	Pileate, stip.	AW, gr.	EH, WH	R	RN
364.	*Hydnellum crustulinum*	Pileate, stip.	CF, gr.	WH	R	RN
365.	*Hydnellum earlianum*	Pileate, stip.	CF, gr.	WH	R	RN
366.	*Pseudotomentella mucidula*	Resupinate	slash of *Pinus*	EH, WH	R	RN
367.	*Sarcodon scabrosus*	Pileate, stip.	CF, gr.	EH, WH	C	RN
368.	*Thelephora palmata*	Clavarioid	CF, gr.	EH, WH	C	RN
369.	*Tomentella botryoides*	Resupinate	*Abies*	EH, WH	C	RN
370.	*Tomentella bryophila*	Resupinate	*Quercus*, CW	EH, WH	C	RN
371.	*Tomentella calcicola*	Resupinate	CW	EH, WH	R	RN

	Name	Habit	Host	Dist.	Status	Rot
372.	*Tomentella chlorina*	Resupinate	*Abies, Picea*	EH, WH	C	RN
373.	*Tomentella cinerascens*	Resupinate	*Abies*	WH	R	RN
374.	*Tomentella coerulea*	Resupinate	AW	WH	C	RN
375.	*Tomentella crinalis*	Resupinate	*Cedrus*	EH, WH	C	RN
376.	*Tomentella ferruginea*	Resupinate	*Cedrus, Pinus, Abies, Picea*	EH, WH	C	RN
377.	*Tomentella fimbriate*	Resupinate	*Pinus*, AW	WH	C	RN
378.	*Tomentella griseoumbrina*	Resupinate	*Cedrus, Abies*	WH	R	RN
379.	*Tomentella himalayana*	Resupinate	*Cedrus, Abies*	EH, WH	C	RN
380.	*Tomentella indica*	Resupinate	*Abies, Picea, Pinus, Cedrus*	EH, WH	VC	RN
381.	*Tomentella lateritia*	Resupinate	B, Conif.	WH	R	RN
382.	*Tomentella ochracea*	Resupinate	CW	WH	R	RN
383.	*Tomentella pannosa*	Resupinate	*Abies, Picea*	EH, WH	C	RN
384.	*Tomentella pilosa*	Resupinate	*Abies*	EH, WH	C	RN

	Name	Habit	Host	Dist.	Status	Rot
385.	*Tomentella puniceа*	Resupinate	*Quercus*, CW	EH, WH	C	RN
386.	*Tomentella ruttneri*	Resupinate	*Pinus, Abies*	EH, WH	C	RN
387.	*Tomentella subcorticioides*	Resupinate	*Cedrus, Abies*	EH, WH	R	RN
388.	*Tomentella umbrinospora*	Resupinate	CW	EH, WH	R	RN

AF - Angiospermic forest; angio. - angiosperms; AW - Angiospermic woods; B - Bark; BR - Brown rot; BHR - Brown heartrot; BCR - Brown cuboidal rot; C - Common; Caesp. - Caespitose; CF - Coniferous forests; Conif. - Conifers; CW - Coniferous woods; Dist. - Distribution; ERf. - Effused - reflexed; EH - Eastern Himalaya; fil. - filiform; gr.- ground; MC - Most common; MF - Mixed forests; R - Rare; RN - Rot unknown; stip. - Stipitate; VC - very common; VR - Very rare; WH - Western Himalaya; WR - White laminated rot; WMR - White mottled rot; WPR - White pocket rot; WR - White rot; WSR - White saprot; WSR - White pocket rot; WR - White rot; WSR - White saprot; WSR - White stringy rot; WSHR - White sap & heartrot; WHR - White heart rot.

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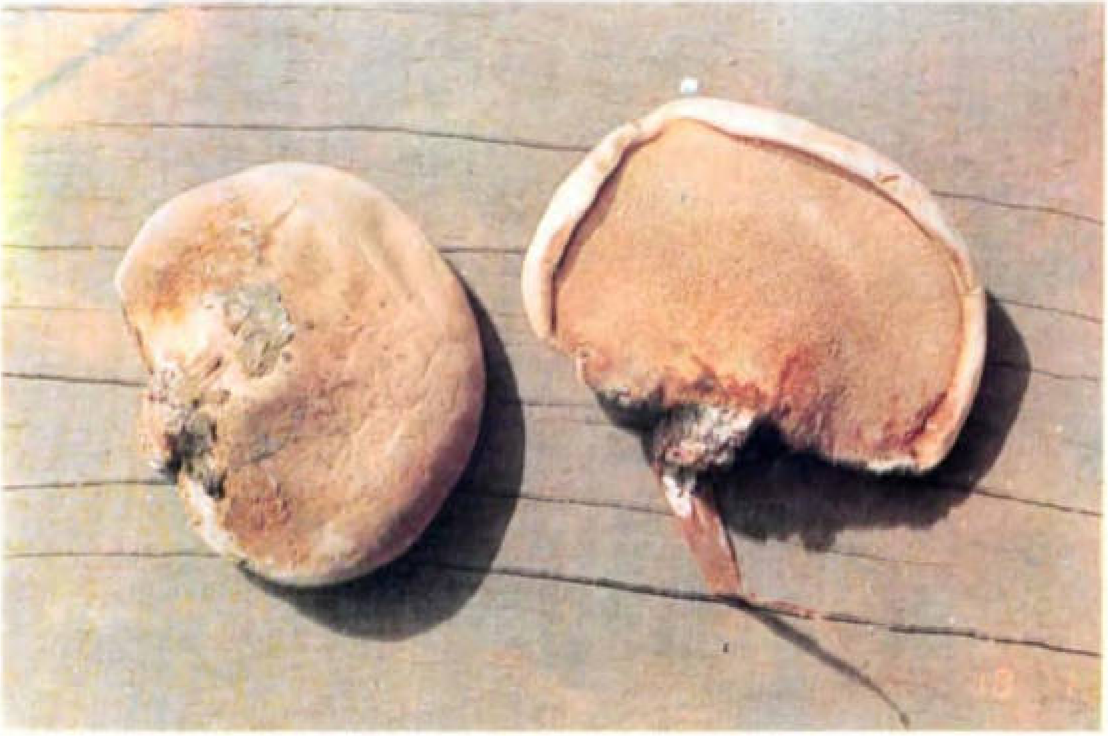
Fomitopsis rosea - A species growing exclusively on coniferous woods near timberline in Himalayas

Phellinus laevigatus - A polypore growing exclusively on *Betula utilis* and causing serious heartrots.



Piptoporus betulinus - A polypore growing only on *Betula utilis* near timberline in Himalayas.

Inonotus tenuicarnis - A serious heartwood rotting polypore on Oaks near timberline

Pleurotus ostreatus - A common edible mushroom species growing on hardwoods between temperate and timberline zone.

Phellinus pectinatus - A serious parasitic species usually on *Pyrus pashia*.

LICHENS

K.P. Singh
G.P. Sinha

Lichens represent a symbiotic association between two different groups of plants, namely, fungi and algae. In other words, certain species of fungi have developed mutualistic relationship with a number of algal taxa. Such a relationship between the two has been so successful that a large number of fungi (*ca* 13,500 species - Groombridge, 1992) have opted for this symbiotic way of life. The lichen thallus is thus a composite structure, consisting of two components, the mycobiont belonging predominantly to inoperculate ascomycetes; and the photobiont that includes taxa of algae and/or cyanobacteria. This association is not just a random mixture of any fungal taxa and any algal species but seems to be manifestation of an extremely selective process, that has undergone evolution through ages and has developed in many directions. In absence of authentic fossil records of lichens, coupled with drastic modification of the thallus in appearance, lichens had been treated as a separate group of plants in the past. Although, universally considered as part of overall fungal domain now, mycologists and lichenologists have not been able to fully integrate the two because of certain unsurmountable barriers in this regard. And hence the lichens are still treated as a separate entity for all practical purposes. Such a situation has, therefore, necessitated consideration of diversity and conservation of this group separately form non-lichenized fungi.

Lichens are universally present and are distributed to different environmental habitats in the world. Many species are of large size and great beauty. In some cases they form dominant components of the epiphytic and ground vegetation. From India, about 2021 species of lichens within 248 genera have been reported. As ours is a vast country, it enjoys a wide range of topographical and climatological diversity. As a consequence, it is bestowed upon rich vegetation and diverse flora. Unfortunately, Indian lichens received much less attention as compared to other groups of plants. Poor reporting of lichens from here can be understood in this light. However, later researches starting from fifties or sixties of this century have considerably swelled the number of species. It is felt that many more will come to light with futher explorations.

Initial plant studies in India were carried out by European workers. Lichens are no exception to this general trend. Some of the earlier lichen collections made in 19th century are those of Belanger from Peninsular India, Perrottet from Nilgiri hills, Wallich from Himalayas, Strachey and Winterbottom from Kumaun hills, Hooker and Thomson from Eastern Himalayas, Kurz from Bengal and Andaman Islands, J. Thomson from Assam, and G. Watt from Manipur. Subsequently, these collections were worked out by lichenologists like C. Montagne, T. Taylor, C. Babington, W. Nylander, J. Stirton, J. Mueller Arg., etc. These historical developments have been discussed in detail by Awasthi (1965) and need no repetition. Studies carried out by contemporary workers during 1966-77 were reviewed by A. Singh (1980). More recently, Awasthi (1988, 1991) has keyed out all Indian, macro and micro-lichen taxa based on his own studies as well as on that of other lichenologists. We have thus, a much better understanding of the Indian lichen flora now, which can provide a base to a somewhat detailed discussion on the topic of diversity of Indian lichens.

VEGETATION

Lichen vegetation in India is rich both in luxuriance and variety. It is found on various substarata wherever suitable conditions are available for its growth. Lichens may be saxicolous, corticolous, terricolous, ramulicolous or muscicolous. They may also grow on walls, decaying woods, iron pipes, etc. The nature of lichen vegetation of an area is determined mainly by the variations in the altitude and climate. Keeping this aspect in view, the lichen vegetation of India can broadly be classified into 3 major types viz. (1) tropical and subtropical lichen vegetation, (2) temperate lichen vegetation, and (3) alpine lichen vegetation. For the discussion of vegetation, the localities mostly explored by the authors in different states are taken into consideration.

Tropical and subtropical lichen vegetation

This type of lichen vegetation is usually found below an altitude of 1500 m. The so far explored areas from this type of climate are Andaman and Nicobar islands; Manipur; Meghalaya; Assam; Nagaland; Arunachal Pradesh; Sunderbans, Howrah, 24-Parganas and Darjeeling districts in West Bengal; Pachmarhi hills in Madhya Pradesh; Mount Abu in Rajasthan; parts of Himachal Pradesh; Mussoorie, Dehradun, Chakrata, Nainital in

Uttar Pradesh; Some specific localities like parts of Nilgiri and Palni hills, South Canara, Coorg, Cardamom hills, Agastiar hills and Silent valley etc. For a better knowledge of tropical lichens, however, more areas need exploration.

The arboreal elements, rocks, boulders, etc. provide suitable habitats for growth of lichens. The foot hills below an altitude of 700 m usually have fewer lichens except in moist areas, such as Andaman and Nicrobar islands, Kerala, etc. where luxuriant growth of lichen is encountered even at sea level. The lichen vegetation changes as the altitude increases. The evergreen moist forests have more luxuriant vegetation than dry deciduous forests. The tree trunks of *Terminalia, Dipterocarpus, Elaeocarpus, Pterocarpus, Meliosma, Eurya, Mallotus, Trema, Schima, Pinus, Quercus, Michelia, Albizia,* etc. are covered usually by the crustose genera of families Pyrenocarpaceae, Caliciaceae, Graphidaceae, Thelotremataceae, Arthoniaceae, Cyphelliaceae, etc. It is observed that smooth bark of *Citrus, Artocarpus heterophyllus, Cocos nucifera, Areca catechu, Hevea brasiliensis,* etc. is much preferred by many crustose species of *Graphina, Arthonia, Cryptothecia, Thelotrema,* etc.

The foliose forms of *Physcia, Dirinaria, Parmotrema* and *Heterodermia* also grow in moist places in association with crustose forms. In more moist places *Collema, Leptogium, Coccocarpia, Sticta,* etc. grow on stones, trees or on the ground. In interior portions of dense forests, lichens are confined to the fringes of forests or on upper portions of trees, where enough light and wind currents are available. The roadside trees and exposed road cuttings also possess many species of foliose forms. The fruticose forms are very few except few cosmopolitan species of *Usnea* and *Ramalina* which usually occur on upper portions of trees or on exposed rocks. Cosmopolitan species of fruticose *Cladonia* spp. usually grow on the ground in shady places. Species of *Roccella* are confined to coastal areas, growing on trees and stones. Certain lime loving lichens of genera *Endocarpon, Peltula* and *Arthopyrenia* still thrive well in the polluted atmosphere of the cities of Uttar Pradesh plains (A. Singh and Upreti, 1984). They can withstand extreme xeric conditions. Similarly in drier zones of Rajasthan, the cyanophilous members of families Heppiaceae, Lichinaceae, Collemataceae and Pyrenopsidaceae grow abundantly in association with Teloschistaceae, Lecideaceae, Lecanoraceae and Physciaceae. Another rich area of tropical lichens is Mangrove forests in Sunderbans, the biggest Gangetic delta between the river Hoogly on the west and the Meghna river on the east. The crustose forms dominate here and thrive well on trees of

Avicennia alba, Sonneratia apetala, Mangifera indica, Phoenix paludosa, Heritiera minor, Coccus nucifera, Nipa fruticans, etc. The Sholas (evergreen patches of forests) which are present here and there on the rolling down of hills occupying sheltered folds of streams or hollows or depressions in Western Ghats, exhibit luxuriant growth of lichen vegetation. Foliose forms are usually present on the outer edges of Shola trees.

Tropical vegetation is also chracterised by the presence of many foliicolous species, which thrive in moist, warm and shady places along the banks of streams, lakes, rivulets or ravines on the leaves of lower branches of evergreen herbs, shrubs and under-trees. Usually more than one species grow on the same leaf or on different leaves of the same plant. The common genera of these lichens are *Aulaxina, Byssoloma, Calopadia, Echinoplaca, Fellhanera, Gyalectidium, Mazosia, Porina, Strigula, Tricharia,* etc.

Temperate lichen vegetation

The temperate vegetation is found between 1500 - 3600 m, in Western and Eastern Himalayas, higher reaches of North-Eastern states, and hills of South India. The temperate climate offfers the optimum conditions for luxuriant growth of foliose and fruticose forms. The forests in temperate zone are not dense and are exposed to rain, open to sun light and wind currents. These factors usually promote the rich growth of lichens. The tree trunks of *Magnolia campbelii, Castenopsis indica,* different species of *Rhododendron* and *Quercus, Acer, Symplocos, Asculus indica, Cornus capitata, Abies spectabilis, Cupressus* species, *Tsuga* species, *Pinus roxburghii, Pinus kesiya, Cedrus deodara* etc. provide suitable habitat for growth of different species of *Parmotrema, Lasallia, Collema, Leptogium.* (*Mallotium* group), *Physcia, Physconia, Lobaria, Pseudocyphellaria, Hypogymnia, Menegazzia, Cetrelia, Bryoria,* etc. The Crustose forms of *Rinodina, Diplotomma, Aspicilia, Acarospora, Pertusaria, Caloplaca, Diploschistes, Ochrolechia, Lecania, Buellia,* etc. are prevalent on exposed rocks, boulders, on bark of trees and on the ground. Certain crustose species are endolithic or endophloedal according to the development of their thallus. Thus, their presence can be detected only when they produce fruiting bodies. The fruticose forms of *Usnea, Ramalina, Bryoria,* and *Teloschistes* hang from the coniferous trees. Fruticose genera *Stereocaulon* and *Cladonia* grow abundantly on the ground as well as on exposed rocks in moist shady places. Similarly species of *Peltigera, Sticta* and a few *Lobaria* species are well represented in this region and grow on the ground or on stones, inside forests in association with mosses along the streams and rivulets. Temperate lichens are also found growing in abundance in high level Shola (1600 to 2400 m) trees in south Indian hills.

Alpine lichen vegetation

This type of lichen vegetation usually occurs at an altitude of about 3600 m and above in the areas like Gomukh, Pindari glacier, Kedarnath, etc. in Western Himalayas; Nathula pass, Jelepla in Sikkim, Sela pass, Pangeteng Show, Bumla, Womingla, Nagula pass, higher ridges of Dichu and Dallai valleys, Taluk pass, Jachup, etc. in Arunachal Pradesh and Saramati hill ranges in Nagaland. Generic composition of alpine lichen vegetation is almost the same as found in higher temperate areas but the species components are different. Large trees are altogether absent, but species of bushy *Rhododendrons, Cotoneaster, Juniperus, Caranga,* etc. provide suitable substrata for growth of lichens. A majority of alpine lichens are saxicolous or terricolous. On exposed rocks big patches of Crustose genera *Acarospora, Diplotomma, Lecidea, Lecanora, Rinodina, Rhizocarpon,* etc. are a common sight. The species of *Rhizocarpon* and *Lecidea* are more common near glacier moraines. Other genera found there, are *Hypogymnia, Candelariella, Cladonia, Cetraria, Umbilicaria, Lethariella, Stereocaulon, Thamnolia,* etc. Lichenologically alpine zone is interesting and needs extensive exploration for its detailed knowledge.

LICHENOGEOGRAPHICAL REGIONS VIS-A-VIS DIVERSITY

Clarke (1898) and Hooker (1907) divided British India into nine different botanical provinces based chiefly on the sudies of vascular plants. While discussing general vegetation, Jain (1990) divided India into nine botanical regions. Pande (1958) recognized nine Bryogeographical units in India based on the studies of Bryophytic flora of India. Recent studies on lichens from various regions similarly show that each region has a somewhat distinct flora of its own. Accordingly, Indian region can be divided into 8 lichenogeographical regions (see map). For each lichenogeographical region, we have taken into account 10 dominant families, 10 largest genera and other interesting features for considering the diversity of the Indian lichen flora. However, this statistics may change gradually in near future when new discoveries, additions and revisions of families and genera are made time to time.

The Western Himalayan Region

It includes Kumaun and Garhwal regions of Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir. The topography of the area is irregular due to valleys and plateaus of various dimensions. The lofty snow clad mountain ranges of this region are far more complex than similar areas of Eastern Himalayan region, and have a general direction from South-West to North-East. Karakoram ranges have several peaks that are more than 7500 m high. Climate varies from place to place. It is mainly tropical below 1500 m, but from 1500 to 3600 m it becomes temperate and above 3600 m it is alpine. Lichen flora has great diversity due to great altitudinal variations coupled with rainfall factor which becomes lesser and lesser from east to west. The lower altitude has less number of species, but their maxium diversity is discernible at altitudes ranging between 1800 to 2600 m. Important contributions on this area are made by C. Babington, A.A. Quraishi, V. Räsänen, R. Schubert and O. Klement, D.D. Awasthi, Mamta Joshi, S.R. Singh, and Krishna Dange. In spite of these studies, many species still remain to be added from unexplored areas of the region. So far, about 550 species under 119 genera are known to occur here and that form about 27.2% of total Indian lichen flora. Of these, *ca* 159 taxa are common with Eastern Himalayan region and *ca* 107 taxa with Western Ghats. Foliose forms are more dominant than crustose and fruticose-forms. The ratio of crustose foliose and fruticose species is 2.21 : 2.56 : 0.73. Considering the species diversity, we find that family Parmeliaceae is largest and represented by 86 species and 17 genera, followed by Physciaceae (81 species, 12 genera), Collemataceae (44 spp., 3 genera), Lecanoraceae (42 spp., 5 genera), Teloschistaceae (34 spp., 3 genera), Usneaceae (32 spp., 6 genera), Ramalinaceae (15 spp., 1 genus), Lecideaceae (14 spp., 3 genera), Pertusariaceae (14 spp., 2 genera), and Peltigeraceae (13 spp., 1 genus). Out of 11 species of *Acarospora* known from India, 9 species occur in temperate and alpine areas of Western Himalayan region. Similarly out of 17 species of *Rhizocarpon*, 12 species occur here. The largest genus Lecanora comprises 32 species, followed by *Caloplaca* (26 spp.), *Leptogium* (22 spp.), *Collema* (21 spp.), *Usnea* (21 spp.), *Heterodermia* (20 spp.), *Ramalina* (15 spp.), *Parmotrema* (14 spp.), *Buellia* (13 spp.), *Cetraria* (13 spp.). Besides about 22 genera viz. *Anaptychia, Aspicilia, Candelariella, Carbonea, Coniocybe, Cornicularia, Dimelaena, Eiglera, Evernia, Glypholechia, Lempholemma, Melanolecia, Peccania, Physconia, Placodium, Placynthium, Psilolechia, Rhizoplaca, Thelenella, Thelediopsis, Toninia, Xylographa* are confined only to this region.

An analysis of species diversity in Western Himalayan region leads to the following categorization.

number of genera with 1 species	=	46
number of genera with 2 species	=	21
number of genera with 3 species	=	10
number of genera with 4 species	=	7
number of genera with 5 species	=	6
number of genera with 6 - 10 species	=	11
number of genera with 11 15 species	=	12
number of genera with 16 - 35 species	=	6

Thus, it is interesting to note that maximum number of genera belong to 1 or 2 species categories, while maximum species diversity occurs in the genera belonging to 11 15 and 16 - 35 species categories. The species having restricted distribution confined to this region are *Aspicilia alphoplaca, Anaptychia ciliaris, A. fusca, Cornicularia aculeata, C. odontella, Cetraria islandica, Collema callibotrys, Dermatocarpon miniatum, Evernia divaricata, E. prunastri, Hypogymnia alpina, Hypotrachyna pluriformis, Leptogium bullatum, Lobaria quercizans, Melanelia glabratula, M. sorediosa, Nephroma expallidum, Parmotrema melanothrix, Peltigera venosa, Physconia muscigena, Stereocaulon macrocephallum, Xanthoria candelaria,* etc.

The Eastern Himalayan Region

It includes Sikkim, Darjeeling district of West Bengal, states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. Phytogeographically, these areas fall under two botanical regions (Jain 1983, 1990), the Eastern Himalaya and the Eastern India. However, for the purpose of lichenological discussions both regions are considered under one lichenogeographical region, namely the Eastern Himalayan region. Compared with the Western Himalayan region, the Eastern Himalayan region has higher rainfall and warmer conditions. The tree line and snow line are at higher altitude by about 300 m. The region consists of high mountains as well as small to large sized valleys with varied climatic conditions. The majority of peaks average 1800 to 3000 m and some peaks even rise upto 7500 m. The special horse-shoe-shaped arrangement of the fold of mountains coupled with moisture laden monsoon winds, blowing across the Bay of Bengal, ensure plenty of rain in most of the places. This creates high humid climate, conducive for great diversity in the lichen flora.

So far, only a few areas in the states of Arunachal Pradesh, Manipur, Nagaland, Sikkim and Darjeeling district of West Bengal have been explored and studied, while major part of the region remains to be explored yet. The main contributions made from this region are by J. Stirton, Mueller Arg., G.L. Chopra, S. Kurokawa, D.D. Awasthi, M. Agarwal, P.G. Patwardhan, M.B. Nagarkar, K.P. Singh, and G.P. Sinha. The flora comprises a total of *ca* 759 species disposed in 147 genera, that constitute about 37.5% of total Indian lichen flora. The ratio of crustose, foliose and fruticose species is 4.18 : 2.15 : 1.26. The flora closely resembles Western Ghats as evidenced by 224 species that are common to both the regions. The flora shows great diversity in its constituent elements. The largest family is Parmeliaceae, represented by 95 species and 15 genera, followed by Graphidaceae (90 spp., 8 genera), Usneaceae (45 spp., 4 genera), Pyrenulaceae (40 spp., 2 genera), Collemataceae (25 spp., 2 genera), Arthoniaceae (24 spp., 4 genera), Lecanoraceae (22 spp., 2 genera) and Pertusariaceae (23 spp., 2 genera). Genuswise, the diversity is different. Genus *Cladonia* is the largest with 48 species, followed by *Graphis* (36 spp.), *Usnea* (34 spp.), *Heterodermia* (29 spp.), *Graphina* (26 spp.), *Lecanora* (21 spp.), *Buellia* (20 spp.), *Parmotrema* (19 spp.), *Leptogium* (19 spp.), and *Anthracothecium* (18 spp.).

About 16 genera including a monotypic *Awasthiella* are confined only to this region. They are *Acroschyphus, Asterothyrium, Echinoplaca, Gyalideopsis, Gymnoderma, Hymenelia, Lasallia, Leprocaulon, Mycocalicium, Mycoporum, Mycoblastus, Phlyctis, Pilophorus, Platismatia,* and *Siphula.* An analysis of species diversity in Eastern Himalayan region leads to the following categorisation.

number of genera with 1 species	=	61
number of genera with 2 species	=	20
number of genera with 3 species	=	20
number of genera with 4 species	=	6
number of genera with 5 species	=	3
number of genera with 6 - 10 species	=	19
number of genera with 11 - 20 species	=	12
number of genera with 21 - 30 species	=	3
number of genera with 31 - 50 species	=	3

Thus, it is interesting to note that majority of the genera belong to 1, 2, 3 and 6-10 species category while maximum species diversity occurs in the genera belonging to last two categories. Some characteristic crustose taxa occur only in this region are *Anthracothecium assamiense*, *A. maculatum*, *Arthonia translucens*, *Awasthiella indica*, *Aulaxina uniseptata*, *Cryptothecia candida*, *Cetraria delavayi*, *C. isidiophora*, *Coenogonium himalayense*, *Graphina acharii*. The foliose species are *Heterodermia lutescens*, *Hypogymnia wattiana*, *Hypotrachyna rigidula*, *H. scytodes*, *Parmotrema zollingeri*, *Peltigera malacea*, *Platismatia erosa*, *Sticta platyphylloides*, *Umbilicaria yunana*, etc. and fruticose species are *Acroscyphus sphaerophoroides*, *Bryoria confusa*, *B. himalayana*, *Baeomyces pachypus*, *Cladonia farinacea*, *Pilophorus awasthianum*, *Ramalina himalayensis*, *Stereocaulon togashii*, *Usnea pectinata*, etc.

The Western Dry Region

It covers the states of Punjab and Rajasthan. Lichen reports are not known from the Punjab area. In Rajasthan, the Aravalli hills lie across the state, but have not been well explored lichenologically except a sporadic collection from a plateau, Mt. Abu. The low and irregular rainfall and extremes of temperatures both during summer and winter months give rise a somewhat entirely different climate for growth of a different kind of lichen flora in comparison to other regions of the country. Saxicolous cyanophilous lichens belonging to genera *Collema*, *Leptogium*, *Peltula*, *Phylliscum*, etc. are more dominant here. So far, 39 species disposed in 24 genera are recorded. In terms of lichen diversity, the area is interesting as certain genera viz. *Anema*, *Astroplaca*, *Heppia*, *Placolecis*, *Zahlbrucknerella*, etc. occur only in this region. However, more explorations from other ranges of Aravalli hills may unfold the existence of many more taxa.

The Gangetic Plains

Gangetic Plains stretch from eastern Rajasthan through plains of Uttar Pradesh to Bihar and Bengal. The lichen flora of this region has also not been worked out thoroughly. The Upper Gangetic Plain has only few species of crustose genera viz. *Lecanora*, *Endocarpon*, *Lecidea*, etc. here and there on the walls as well as on stones where some humidity is available. The lichen flora in Lower Gangetic Plains particularly in 24-Perganas of West Bengal, show a great diversity due to high humid conditions. The islet forests of Sunderbans are full of crustose forms. A total of *ca* 224 species, distributed in 63 genera are reported from this region. Of these 208 species are crustose, 8 are foliose and remaining 8 are fruticose species. Some statistics about the species diversity show that family Graphidaceae is the largest with *ca* 29 species, followed by Opegraphaceae with *ca* 24 species, Trypetheliaceae again with 24 species, Physciaceae and Pyrenulaceae both with 18 species each. Amongst the genera *Opegrapha* is the largest genus with about 13 species, followed by *Arthonia* with *ca* 12 species, *Anthracothecium* with 11 species, *Bacidia* and *Trypethelium* with 9 species in each. Besides, 3 genera *Cryptolechia, Enterographa, Gyrostomum* are known to grow only in this region.

The Central India

The Central India comprises Madhya Pradesh, parts of Orissa, Andhra Pradesh and Gujarat. The lichen flora of this area is also not fully known. Only Pachmarhi, a summer hill station in Madhya Pradesh, has been investigated by S.R. Singh and D.D. Awasthi. About 48 species, distributed in 23 genera are known to occur here. There is not much diversity in the flora. The common species of common genera viz. *Bacidia, Buellia, Caloplaca, Diplotomma, Graphis, Graphina, Parmotrema, Pyxine*, etc. grow on the stones as well as on trees.

The Western Ghats

The Western Ghats cover a distance of about 1600 km., extending from the Tapti Valley in the north of Gujarat to Kanyakumari in Tamil Nadu, and consist of series of hill ranges running north-south along the west coast traversing the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamilnadu. These hill ranges are more or less continuous with a major discontinuity in the Palghat gap separating the Nilgiri ranges from the Anamalais. The exact boundaries of Western Ghats are not sharp, as many spurs of Western Ghats enter into Deccan and merge with the mountains of Eastern Ghats.

However, for boundary delimitations, the concept of Subramaniam and Nayar (1974) and Nair and Daniel (1986) has been adopted. The climate is mainly tropical with annual rainfall varying from 2350 mm in the north to 7450 mm in the south. These conditions help to sustain luxuriant and diverse lichen flora. Lichens grow profusely in evergreen forests called Sholas, as mentioned earlier. The low hill ranges of Western Ghats have comparatively poor lichen diversity in drier places, but in moist shady places macrolichen forms of Physciaceae, Parmeliaceae grow in association with microlichen forms of Arthoniaceae, Physciaceae, Lecideaceae, etc. The optimum growth of lichen diversity is found between 1000 to 2400 m in the high hill ranges of the south Western Ghats. The crustose forms of families Graphidaceae, Lecanoraceae, Thelotremataceae, Pyrenulaceae and foliose and fruiticose forms of Parmeliaceae, Lobariaceae, Usneaceae, Cladoniaceae, Stereocaulaceae, etc. predominate in most of the places. The lichen diversity may be evident from the fact that *ca* 800 species disposed in 519 crustose, 220 foliose and 61 fruticose forms within 140 genera, are known to occur in Western Ghats, and that is the highest estimate recordced so far for any lichenogeographical region in India. The flora of this region comprises *ca* 39.5% of the total Indian lichen flora. The flora of Palni Hills comprises about 318 species in 75 genera and that of Nilgiri hills, 117 species within 21 genera of macrolichens. A small collection of lichens from the rain forests of Silent Valley revealed 77 species. During the last two decades D.D. Awasthi, K. P. Singh, P.G. Patwardhan, C.R. Kulkarni, A.V. Prabhu, and U. Makhija also added numerous taxa to the flora of Western Ghats. If we see the diversity of species at family and generic level we find that the largest family in this region is Graphidaceae with about 97 species and 5 genera ranks first in order of dominance. It is followed by Parmeliaceae with about 95 species and 12 genera; Physciaceae with about 76 species and 10 genera; Pyrenulaceae with about 57 species and 6 genera; Thelotremataceae with about 51 species and 4 genera; Trypetheliaceae with about 42 species and 6 genera; Collemataceae with about 40 species and 3 genera; Usneaceae with about 28 species and 1 genus; Pertusariaceae with about 26 species and 2 genera; Arthoniaceae with about 20 species and 4 genera. *Graphis* is the largest genus with about 38 species, followed by *Ocellularia* and *Parmotrema* with about 31 species each; *Thelotrema* with about 30 species; *Usnea* with about 29 species; *Leptogium* with about 26 species; *Graphina* with about 25 species; and *Peltigera* with about 23 species. An analysis of species diversity in this region leads to the following categorisation:

number of genera with 1 species	=	67
number of genera with 2 species	=	15
number of genera with 3 species	=	11
number of genera with 4 species	=	7
number of genera with 5 species	=	6
number of genera with 6 - 10 species	=	9
number of genera with 11 - 20 species	=	15
number of genera with 21 - 30 species	=	7
number of genera with 31 - 40 species	=	3

Thus, it is interesting to note that maximum number of genera belong to 1, 2, 3, 6-10, 11-20 species categories. The diversity of this region is further enriched by the occurrence of numerous genera viz. *Byssophragmia, Catapyrenium, Catinaria, Conotrema, Cyphelium, Dendriscocaulon, Diploicia, Heppsora (monotypic), Heterocyphelium, Leioderma, Leptorhapis, Physcidia, Physma, Pyrgillocarpon, Pyrgillus, Relicina, Thelocarpon*, etc. and characteristic species viz. *Brigantiaea ionexcipula, Bulbothrix bulbochaeta, Candelaria indica, Catillaria nilgiriensis, Gyalecta tropica, Hypotrachyna revoluta, Pannaria stylophora, Parmelina indica, P. simplicior, Pseudocyphellaria argyracea, Physcidia cylindrophora, Pyxine nilgiriensis, Sticta cyphellulata, Stereocaulon austroindicum, Thelotrema thelotremoides*, etc. which are confined to this region only.

The Eastern Ghats and Deccan Plateau

Unlike the Western Ghats, this region has not high ranges of mountains and consists of much broken isolated hills. The lichen flora of this area has not been extensively worked out. However, from the data available, this region has about 31 species distributed in 23 genera. An economically important genus *Roccella* is widely distributed here.

Andaman and Nicobar Islands

Oceanic islands have always been interesting for botanical studies. They have contributed much to our knowledge on speciation, adaptability, colonisation, evolution, extinction and conservation of endemic species. Andaman and Nicobar archipelago in Bay of Bengal form an arched string of about 300 islands, covering an area of about 8300 sq. kms. The lichen flora of these places is typically a tropical one and starts right from the beach forests. The unique feature of the lichen flora is the occurrence of numerous endemic species. This uniqueness and diversity of the flora is due to heavy mist over the forests during morning hours, high rainfall from May to November and constant sea currents on accounts of high winds that keep the forests moist throughout the year. These factors help in colonization of the various corticolous and foliicolous communities belonging to crustose families Arthoniaceae, Pyrenulaceae, Thelotremataceae, Graphidaceae, etc. and few foliose forms of Physciaceae. In fact, these small islands are the store houses of various novelties and need to be explored thoroughly to uncover the hidden lichen wealth. The diversity of lichens in these islands is so high that a small collection of Sulpiz Kurz, made during 1867, revealed 63 species. Foliicolous taxa also occur in variety and abundance. Important contributions made from this area are by Ajay Singh, P.G. Patwardhan, U. Makhija, M.B. Nagarkar and P.K. Sethy. Crustose forms are the dominant component of the forests of these islands. So far, a total of about 307 species distributed in 66 genera are known to occur here. Of these 283 species are crustose and 24 species are foliose forms. About 66 taxa are common in distribution with Western Ghats. Some statistics on the diversity of lichens in this region show that family Pyrenulaceae is the largest with 44 species distributed in 5 genera. This is followed by Thelotremataceae (38 spp., 5 genera), Graphidaceae (36 spp., 4 genera), Trichotheliaceae (36 spp., 4 genera), Trypetheliaceae (35 spp., 6 genera), Opegraphaceae (16 spp., 5 genera), Arthoniaceae (15 spp., 5 genera), Physciaceae (10 spp., 2 genera), Collemataceae (9 spp., 3 genera), Ectolechiaceae (9 spp., 4 genera), etc. Amongst the genera, *Porina* is the largest genus with about 32 species, followed by *Pyrenula* (24 spp.), *Ocellularia* (19 spp.), *Graphina* and *Thelotrema* (17 spp. each), *Trypethelium* (14 spp.), *Myreotrema* (12 spp.), *Opegrapha* (11 spp.), *Graphis* (10 spp.), *Anthracothecium* (10 spp.), *Cryptothecia* (8 spp.), *Parmentaria* (8 spp.), *Laurera* (7 spp.), etc. A look on the species diversity leads to the following categorisation:

number of genera with 1 species	=	28
number of genera with 2 species	=	11
number of genera with 3 species	=	6
number of genera with 4 species	=	5
number of genera with 5 species	=	5
number of genera with 6 - 10 species	=	5
number of genera with 11 - 25 species	=	6

Thus, it is evident that maximum number of genera of the region belong to 1 and 2 species category. This diversity is further enriched by the occurrence of numerous species of genera viz. *Aspidothelium, Bottaria, Chroodiscus, Cryptothelium, Laisoloma, Lofflammia, Melampylidium, Minksia, Nadvornikia, Phylloblastia, Raciborskiella*, etc. which are confined here only.

PHYTOGEOGRAPHICAL AFFINITIES

Like higher plants, lichens also show significant affinities with the flora of adjacent and distant regions. This has contributed much to the richness and diversity of the flora. There are many lichen species in Indian flora that have fairly widespread distribution on the global level, while on the other hand some species have limited distribution in India and adjoining regions. In the absence of a complete knowledge of the flora, in general, we can say that the Eastern Himalayan lichens show closer affinity with the lichens of Sino-Japanese and South-East Asian countries. Some of the lichens common to India and China are : *Caloplaca handelii, Bulbothrix setschwanensis, Cetraria delavayi, Leptogium pedicellatum, Sticta henryana, S. nylanderiana, S. platyphylloides,* etc. Similarly taxa common with Japan are : *Bacidia hakonensis, Collema japonicum, Icmadophylla coronata, Lobaria kurokawae, Pyrenula impressa, Sulcaria virens, Usnea orientalis, Parmelina rhytidodes,* etc. Resemblance with South-East Asian elements is exhibited by : *Cetraria lateflava, Cetrelia sanguinea, Hypotrachyna koyaensis, H. physcioides, Phlyctella himalayensis, Parmelina expallida, P. perisidians,* etc. The lichens from the Western Himalayas show a closer affinity to the European elements. This is indicated by the species : *Catraria laureri, Dermatocarpon hepaticum, Aspicilia caesiocinerea, Peltigera horizontalis, Collema auriculatum, C. subnigrescens, Evernia divaricata, Leptogium subtile, L. tenuissimum, Chrysothrix chlorina,* etc. African elements are also common among the lichens found in our country, particularly in Western Ghats. *Cryptothecia stirtonii, Hypotrachyna degelii, Parmelina wallichiana, Parmotrema pseudonilgherrense, P. cooperi, P. direagens, Pseudoparmelia malaccensis, P. pustulescens,* etc. are some selected examples of such species.

Certain species show disjunct distribution. *Glypholechia scabra, Lecanora peltata,* which occur in the dry Western Himalayas, Central Asia and rocky mountains of America and Peru in South America; *Hypotrachyna dactylifera* in Meghalaya (India) and South America; *Leptogium papillosum* in Western Ghats and Central America; *Haematomma leprarioides* in Darjeeling and Brazil; *Parmotrema margaritatum* in Western Ghats and North America; *Parmelina mulleri* in Himachal Pradesh and South America; *Thelotrema velatum* in Andamans and Central America, etc. can be cited as examples for this.

Besides, there are numerous pantropical, cosmopolitan and temperate circumpolar elements in the flora. Cosmopolitan elements which occur widely in Europe, Asia, Africa and America are *Calicium abietinum, Caloplaca citrina, Candelaria concolor, Cladonia bacillaris, C. grayi, Collema subflaccidum, Heterodermia obscurata, Nephroma helveticum, Parmelia sulcata, Parmotrema reticulatum, Peltigera spuria, Phaeographis inusta, Phaeophyscia hispidula, P. orbicularis, Physcia* *aipolia, Physconia enteroxantha, Punctelia rudecta, P. borreri, Ramalina pacifica, Teloschistes flavicans, Thelotrema lepadinum, Umbilicaria polyphylla,* etc. *Bulbothrix goebelii, B. isidiza, Dirinaria picta, Parmotrema subtinctorum, P. mellissii, Phaeophyscia endococcinoides, Strigula elegans* and *Thelotrema lepadodes* are some species with pantropical distribution. The temperate elements met in the flora are represented by *Cetraria ocullata, Leptogiun saturninum, Parmelina aurulenta, Heterodermia comosa, Menegazzia terebrata, Pseudoparmelia caperata, Punctelia rudecta, Dermatocarpon hepaticum,* etc.

The above examples of taxa are based on the studies made in the past.. Howevere, extensive survey and a detailed study of the distributional pattern of individual species are required for a better understanding of the phytogeographical affinities of the Indian lichens.

ENDEMISM

Endemism is the phenomenon of confinement of species, genera or other groups to a particular area or habitat beyond which they do not exist. The significance of flora of any region or country is enhanced by the presence of its endemic elements. The concept and importance of endemism pertaining to South Indian flowering plants have already been discussed by Ahmedullah and Nayar (1987) in detail. However for Indian lichens, no data are yet available. In general, lichens do not show high degree of endemism as compared to flowering plants, because their spores and vegetative propagules that can withstand extreme conditions for a long periods are easily blown off to distant places. They can easily germinate and start colonisation even if minimum favourable conditions are available. That is probably the reason why lichens are found even at very high altitudes, where other plants generally do not grow.

It will be premature to discuss endemism in lichens at a greater extent, because large tracts of the country still lie unexplored. The exact distribution of many species is not known. Many species are known only by a single gathering or from a single habitat only. However, some data gathered are presented here on which future studies can be based.

The diverse climatic and habitat conditions in our country provide favourable conditions for speciation. The probable factors that contribute to high degree of endemism in Indian flora, as mentioned by Jain (1983) are : (a) the barrier of high mountain region in the north; (b) separation of southern region of the country by large water mass of the Arabian Sea, Bay of Bengal and Indian Ocean; (c) the extremely arid conditions in the Western region blocking colonisation of propagules coming through westerly winds from middle-eastern regions and (d) humid tropical conditions in Western Ghats and North-Eastern region. An analysis of endemic taxa shows that out of the estimated about 2021 species of Indian lichens, 23%, which means about 466 species seems to be endemic within Indian boundaries. High degree of endemism is observed amongst the crustose genera, probably because of the simple nature of their thallus. The distribution and concentration of endemic species in a particular region is an index to the overall biogeography of the area. A large number of endemic species occur in moist tropical and subtropical forests and have restricted distribution in a particular lichenogeographical region. However, certain species show extended distribution and grow in more than one lichenogeographical zone, therefore, increasing the number of endemic species in a particular lichenographical zone. A region wise distribution of endemic taxa in each lichenogeographical region is listed below :

	Name of the Lichenogeographical region	Total No. of species in India	No. of Endemic species	Percentage of endemism
1.	Western Himalayan Region	550	22	4
2.	Eastern Himalayan Region	759	133	17.5
3.	Western Dry Region	39	6	15.3
4.	Gangetic Plain	224	14	6.2
5.	Central India	48	4	8.3
6.	Western Ghats	800	161	20.1
7.	Eastern Ghats & Deccan Plateau	31	4	12.9
8.	Andaman & Nicobar Islands	307	73	23.7

Thus, it is interesting to note that the highest number of endemic species occur in Western Ghats, followed by Eastern Himalayan region, Andaman and Nicobar Islands, Western Himalayan region, etc., and therefore, these regions can be considered as centres of rich lichen endemism. The first ten lichen families showing high degree of endemism according to their number of species on all India level are Graphidaceae with 70 species, followed by Trypetheliaceae (45 spp.), Pyrenulaceae (44 spp.), Arthoniaceae (40 spp.), Thelotremataceae (39 spp.), Physciaceae (34 spp.), Trichotheliaceae (34 spp.), Parmeliaceae (24 spp.), Opegraphaceae (15 spp.), and Pertusariaceae (9 spp.).

At the generic level, lichens show little endemism. There are only two monotypic genera viz. *Awasthiella* and *Heppsora,* occurring in Eastern Himalayan region and Western Ghats respectively. An analysis of the first ten genera showing high degree of endemism according to their number of species on all India basis are *Graphina* (26 spp.), *Trypethelium* (19 spp.), *Graphis* and *Porina* (18 spp. each), *Laurera* (17 spp.), *Ocellularia* (17 spp.), *Buellia* (16 spp.), *Cryptothecia* (15 spp.), *Ditremis* and *Parmentaria* (15 spp. each).

Some of the genera containing high number of endemic species and individual endemic species occurring in differnet lichenogeographical regions are listed below :

Western Himalayan Region

Genera : *Lecanora* (4 spp.), *Caloplaca* (2 spp.).

Species : *Anaptychia pseudoromeri, Aspicilia almorensis, Caloplaca almorensis, C. pindarensis, Hypogymnia alpina, Lecanora dwaliensis, Parmelia mussooriensis, Physcia gomukhensis, Stereocaulon himalayanse, Umbilicaria jingralensis.*

Eastern Himalayan Region

Genera : Graphina (12 spp.), *Graphis* (12 spp.), *Arthonia* (5 spp.), *Lecidea* (4 spp.), *Arthothelium, Bacidia, Buellia, Cetraria, Cryptothecia* and *Hypogymnia* all with 3 species each.

Species *: Acarospora indica, Anthracothecium cristatellum, A. pustuliferum, Arthonia collectiva, A. recedens, Aulaxina uniseptata, Baeomyces pachypus, Buellia pinicola, Cetraria isidioidea, C. melaloma, Coenogonium himalayense, Collema hookeri, Graphis assamensis, Heterodermia indica, H. togashii, Hypogymnia thomsoniana, Hypotrac-*

hyna rigidula, Nephroma sikkimense, Parmelina manipurensis, Phaeographis indica, Usnea mekista, etc.

Western Dry Region

Species : *Heppia trichophora, Phylliscum abuense, Physcia abuensis, Thyrea indica, Zahlbrucknerella indica.*

Gengetic Plain

Species : *Buellia diorista, Endocarpon nigrozonatum, E. rosettum, E. subrosettum.*

Central India

Species : *Buellia quartziana, B. subgalaziouana, Diplotomma egasporum, Rinodina makenziei.*

Western Ghats

Genera : *Ocellularia* (12 spp.), *Parmentaria* (9 spp.), *Ditremis* (8 spp.), *Laurera* (8 spp.), *Usnea* (8 spp.), *Phaeographis* (7 spp.), *Buellia* (6 spp.), *Cryptothecia* (6 spp.), *Pertusaria* (6 spp.), *Graphina* (5 spp.).

Species : *Anthracothecium awasthii, A. nanosporum, Arthonia inconspicua, Arthothelium awasthii, Brigantiaea nigra, Bulbothrix bulbochaeta, Catillaria nilgiriensis, C. obscura, Heppsora indica, Hypotrachyna coorgiana, Lethothelium indicum, Leptogium indicum, Parmelina simplicior, P. dodapetta, Parmotrema kamatii, Usnea nilgirica, U. austroindica, Stereocaulon indicum,* etc.

Eastern Ghats and Deccan Plateau

Species : *Buellia hemispherica, Caloplaca orissensis, Naevia pandani, Roccella belangeriana.*

Andaman and Nicobar Islands

Genera : *Pyrenula,* (8 spp.), *Cryptothecia* and *Ditremis* (6 spp. each), *Stirtonia, Thelotrema, Ocellularia* and *Parmentaria,* (4 spp. each), *Pleurotrema, Laurera* and *Myreotrema,* (3 spp. each), etc.

Species : *Arthonia catenatula, Arthothelium bessale, Astrothelium subvariolosum, Bottaria awasthii, Clathroporina duplicans, Ditremis andamanica, Laurera alboverruca, Minksia alba, Ocellularia guptei, Pleurotrema corticola, Pyrenula andamanica, P. mestophoriza, Thelotrema rugetulum.*

RARE LICHENS

Our knowledge on the rare lichens is indeed poor. This is because of inadequate knowledge on the full flora of the country. We do not have complete data on exact location and distribution of individual species. Population studies on Indian lichens are also completely lacking. We have also not analysed fully even the available data from literature and collections in herbaria. In spite of all these lacunae, some informations on rare and interesting lichens of India are available. Patwardhan (1983) has already made some observations on the rare and endemic lichens from Western Ghats, South Western India. Similar type of studies are needed on other regions of the country also. What is required in the present situation is concerted efforts by individuals and institutions to make vigorous searches for specific lichens and to confirm whether they are really rare. According to the present estimation about 20% species, that is about 404 species are rare in Indian flora. Most of these are neoendemics having restricted distribution in a small area in a lichenogeographic region, while certain other species have a wide distribution in India. Some of the rare lichens are listed below, alongwith an indication of their presently known distribution.

Acroscyphus sphaerophoroides, Corticolous; alpine region of Sikkim.

Anaptychia pseudoromeri, Terricolous; Uttar Kashi (Uttar Pradesh).

Anthracothecium assamiense, Corticolous; Assam, Kerala and Tamil Nadu.

Arthonia arctata, Corticolous; Assam.

Aspicilia almorensis, Saxicolous; Almora (Uttar Pradesh).

Aulaxina uniseptata, Foliicolous; Barduar Reserve forest, Kamrup (Assam).

Awasthiella indica, Saxicolous; Manipur and Nagaland.

Buellia indica, Saxicolous; Palni hills (Tamil Nadu) and Manipur.

Bulbothrix bulbochaeta, Corticolous; Shembaganur, Kodaikanal (Tamil Nadu).

Calenia conspersa, Follicolous; Manipur and Nagaland.

Caloplaca pindarensis, Saxicolous; Pindari glacier (Uttar Pradesh).

Cetraria hypotrachyna, Corticolous; Manipur.

C. isidioidea, Corticolous; Darjeeling (West Bengal).

Collema hookeri, Corticolous; Lachen (Sikkim).

Diplotomma manipurense, Saxicolous; Manipur and Nagaland.

Glyphis duriscula, Corticolous; Assam.

Heppsora indica, Saxicolous; Palni hills (Tamil Nadu).

Heterodermia togashi, Corticolous; Sikkim.

Hypogymnia thomsoniana, Corticolous; Sikkim.

H. wattiana, Corticolous; Manipur.

Hypotrachyna rigidula, Corticolous; Nagaland; Lachen (Sikkim) and Darjeeling (West Bengal).

H. scytodes, Corticolous; Darjeeling (West Bengal).

Maronea manipurensis, Rhamnicolous; Manipur.

Melanotheca coactella, Corticolous; Assam.

Melaspilea insitiva, Parasitic on Pertusaria; Assam.

Mycobilimbia calcuttensis, Corticolous; Calcutta (West Bengal).

Nephroma sikkimense, Terricolous & Corticolous; Sikkim.

Parmelina manipurensis, Saxicolous and corticolous; Manipur.

P. simplicior, Corticolous; Maharashtra.

Parmotrema latissima, Corticolous; Calcutta (West Bengal).

P. zollingeri, Saxicolous; Manipur.

Peltigera pindarensis, Saxicolous; Phurkia, Pindari glacier (Uttar Pradesh).

Phaeographis manipurensis, Corticolous; Manipur.

Physcia abuensis, Corticolous; Mount Abu (Rajasthan).

P. gomukhensis, Saxicolous; Uttar Kashi (Uttar Pradesh).

Pilophorus awasthianum, Saxicolous; Darjeeling (West Bengal).

Pyxine palniensis, Saxicolous; Palni hills (Tamil Nadu).

Rhizocarpon alpicola, Saxicolous; Himachal Pradesh.

Usnea pictoides, Corticolous; Nilgiri hills (Tamil Nadu).

ECONOMIC USES

The economic uses of lichens are well known since time immemorial. These varies from place to place. Lichens and the lichen substances derived from them have great economic value as food, antibiotics, UV absorbers, antioxidants, anti-cancer agents, dye stuffs, fodder, perfumes, etc. In India, they are mainly used in dyeing, flavouring, smoking tobacco and cigars, sambar masala, scenting soaps and cosmetics and the manufacture of 'Dhoop' and 'Hawan Samagri'. Besides, a large number of tribal population in Madhya Pradesh, Andhra Pradesh, Santhal Parganas in West Bengal, and Chotanagpur in Bihar, use many species such as *Heterodermia tremulans, Everniastrum cirrhatum. Parmotrema reticulatum, P. tinctorum, Ramalina subcomplanata. Usnea longissima, Roccella montagnei, R. belangeriana*, etc. as spices and flavouring agents to increase the taste and fragrance of non-vegetarian preparations, pulses and other vegetables. It is also interesting to note that a large number of tribal population (Brij Lal *et al.*, 1985) of Baiya, Bhil, Bhielala, Gond, Korka and Muria communities inhabiting Bastar, Bilaspur, Dhar, Jhabua, Mandla, Shahdol and Surguja districts of Madhya Pradesh, bring lichens to their local markets for sale to earn money for their livelihood. It is also reported (Saklani and Upreti, 1992) that the Lepchas and Nepalese in certain localities in Sikkim state use lichens in many ways. The thalli of *Heterodermia diademata* and *Peltigera polydactyla* are used for cuts and injuries to stop bleeding and also as antiseptic. The thallus of *Everniastrum cirrhatum* is boiled, fried and eaten as vegetable. Similarly thalli of *Stereocaulon himalayense* are widely used for curing the blisters of the tongue and urinary trouble. Lichens are also used in industry because they contain aromatic resinoids (Sarin and Atal ,1976). The bulk of Indian lichens for this purpose, commercially known as 'Charilla' or 'Jhoola'. 'Salaj phool' and 'Haraphool' are transported from Western and Central Himalayas and are sold in the market at a rate of about Rupees 2500 to 4000 per tonne. About 1000 tonnes of lichen material are collected from the nature to meet the industrial requirements every year. 'Charilla' consists of *Everniastrum nepalense* and *E. cirrhatum* and is utilized by the manufacturers of smoking tobacco, kitchen masalas and 'dhoop' *Parmotrema nilgherrense* popularly known as 'Salajphool' is used in leather industry. The 'Haraphool' which is a mixture of *Usnea lucea* and *Ramalina subcomplanata* is used as an adulterant of 'Charilla' or as an ingredient in 'dhoop' mixtures. In the folklores also, the medicinal uses of lichens are often mentioned. *Peltigera canina* is eaten as a remedy for liver ailments. Lichens have also been used as bio-indicators of air pollution. Apart from these, there are many lichen species in India, which have minor uses. A list (Anonymous, 1962) of some such lichens along with their distribution, chemical composition and uses are appended below in tabular form.

Name of species	Distribution	Chemical components	Uses
Anaptychia ciliaris	Kashmir	*Atranorin, arabitol and* mannitol.	As scent and for cleansing and whitening hair.
Aspicilia calcarea	Kumaun (Uttar Pradesh)	Erythrin	Red brown dye.
Caloplaca saxicola	Pindari Glacier (Uttar Pradesh)	Emodin, Parietin and Teloschistin.	Yellow dye
Candelariella vitellina	Jammu & Kashmir.	Calycin & Pulvic anhydride	Yellow dye.
Cetraria islandica	Almora and Uttarkashi (Uttar Pradesh)	Fumarprotocetraric acid, protocetraric acid and protolichesterinic acid.	Used as human food in Scandinavian countries and Iceland in mixture with cereals and mashed potatoes.
C. pinastri	Uttarkashi (Uttar Pradesh)	Pinastric acid, Usnic acid and vulpinic acid.	Green dye; for poisoning in Northern Europe.
Chrysothrix chlorina	Himachal Pradesh	Leprapinic acid, calycin, arabitol and mannitol.	Brown dye.
Cladonia arbuscula	Sikkim	Fumarprotocetratric acid.	Fodder for reindeer; hot aqueous solutions used in Finland for Tuberculosis.

Name of species	Distribution	Chemical components	Uses
Cladonia pyxidata	Darjeeling (West	Fumarprotocetraric acid.	Ash green dye; expectorant, used Bengal) & Uttar Pradesh. for whooping cough.
Dermatocarpon villereum	Mt. Abu (Rajasthan), Himachal Pradesh, Jammu & Kashmir, Tamil Nadu and Uttar Pradesh.	Ergosterol.	Thallus used as cork substitute for lining insect collection boxes.
Diploschistis scruposus	Widely distributed.	Diploschistic acid.	Brown dye for calico printing.
Evernia prunastri	Jammu & Kashmir	Evernic acid.	For scenting soaps and in preparation of perfumes.
Hypogymnia physodes	Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh	Atranorin, physodic acid, physodalic acid, arabitol and mannitol in traces.	Brown dye; mucilage used as substitute for gum arabic in dyeing and in parchment and cardboard.
Lasallia pustulata	Himachal Pradesh, and Nagaland.	Gyrophoric acid.	Red brown dye.

Name of species	Distribution	Chemical components	Uses
Parmotrema abessinicum	Tamilnadu	Atranorin, norlobaridone, loxodin and protolichesterinic acid.	Used as food material and condiments; source of orcinol and litmus.
Physconia pulverulenta	North-West & Western Himalayas.	Atranorin	Yellow dye.
Pseudocyphellaria crocata	Arunachal Pradesh, Tamilnadu, Uttar Pradesh and Nagaland.	Calycin and pulvic dilactone.	Source of gambose; brown dye.
Pseudoparmelia caperata	Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Nagaland, Tamilnadu & Uttar Pradesh.	Caperatic acid, protocetraric acid, usnic acid, arabitol and mannitol.	Brown orange to lemon yellow dye.
Punctelia saxatilis	Sikkim and Uttar Pradesh	Atranorin and salacinic acid.	Orange yellow and red brown dye; in calico printing.
Ramalina farinacea	Manipur, Tamilnadu, Uttar Pradesh and West Bengal	Usnic acid, sekikaic acid, norstictic acid and mannitol.	Light brown dye; in perfumes and cosmetics.

Name of species	Distribution	Chemical components	Uses
R. fraxinea	Coromandal, Himachal Pradesh, Manipur and West Bengal.	usnic acid and arabitol.	Grey white dye; in perfumes and cosmetics; mucilage used as substitute for gum arabic.
R. subcomplanata	Assam, Himachal Pradesh, Nagaland and Uttar Pradesh.	Salacinic acid and usnic acid.	As spices.
Solorina crocea	Western Himalaya.	Solorinic acid.	Yellow dye.
Teloschistes flavicans	Karnataka and Tamilnadu.	Parietin and vicanicin.	Source of gambose; yellow dye.
Umbilicaria cylindrica	Darjeeling (West Bengal)	Arabitol and mannitol.	Green brown dye.
Usnea longissima	Arunachal Pradesh, Himachal Pradesh, Sikkim and West Bengal.	Usnic, Barbatic, Barbatolic, diffractic, squamatic, fumarprotocetraric and evernic acids.	In smoking tobacco; as dhoop and spices; for filling cushions; source of antibiotics.
U. lucea	Tamilnadu.	Stictic acid.	As spices.
Xanthoria parietina	Kashmir.	Physcion, mannitol, lichenin, isolichenin and parietinic acid.	Yellow dye.

VULNERABILITY AND MAJOR THREATS

Like other group of plants, the lichens are also under various types of threats. But at present we do not have sufficient data on the subject. The threats to lichens can be grouped into two categories viz. (i) natural and (ii) man made or biotic. The main natural causes include landslides, floods, forest fires, etc. During rainy season landslides are frequent in hilly areas particularly in the Himalayas and north-eastern states.These cause great damage to the plant communities as a whole and the lichen communities in particular. Continuous landslides and floods do not allow lichens to establish themselves on the soil. In this way many terricolous species of *Diploschistes, Cladonia, Pyxine, Lecidea, Lecanora,* etc. become vulnerable. However, a proper study of this aspect is lacking. The forest fires often destroy trees and virgin forests, resulting in the elimination of many corticolous species of *Parmelia, Hypogymnia, Usnea, Ramalina,* etc. Regeneration of other trees also is affected thereby reducing the chances of growth of lichen communities in general.

The man-made threats are very apparent particularly because the traditional life in hilly and forest areas is closely associated with the vegetation, domesticated animals and wildlife. Lichens have very limited ability to adapt themselves to abrupt environmental changes. Consequently in any particular habitat they show abundance and diversity only when various conditions are stable over a long period of time. The major threat caused by man is the destruction of habitats brought about by various anthropogenic activities such as construction of roads and dams in the hills, industrial set ups, urbanisation, agriculture, mineral extraction, etc. As a result of these many terricolous habitats especially at lowland areas appear to be at a greater risk. Recent surveys have shown that the forests in and around Ukhrul, Kongpokmpi and Churachandpur in Manipur; Bomdila, Tawang, Seppa, New Itanagar, Along and Yingkiong in Arunachal Pradesh; Kohima, Kephire, Zunheboto, Wokha, etc. in Nagaland and Kolasib in Mizoram, which were once dense and possessed with rich lichen diversity have now been eliminated for various reasons. There are records of certain trees harbouring up to 30 lichen species on their trunks and twigs. A leaf of *Musa* or *Palm* may have up to 12 species of foliicolous lichens growing on it. The cutting or removal of such plants will naturally invite the risk of depletion of the species growing on them.

The shifting cultivation, a common practice adopted by tribal societies in certain parts of the country is another cause responsible for depletion of many rich lichen habitats. This causes great threat to corticolous and foliicolous lichen communities in general, particularly in tropical and subtropical areas. The foliicolous species of *Strigula, Porina, Fellhanera, Mazosia* etc. becoming rarer day by day due to burning of virgin forests and loss of habitats.

Besides, excessive use of fire-wood in hilly regions, preparation of charcoal by burning of trees (a practice common in the hill of Meghalaya) and stone quarrying for construction purposes specially in hills, are the other factors that lead to deforestation and resultant habitat destruction of species leading to degradation, depletion and disappearance of lichen deversity in general.

Environmental pollution caused by the thermal power stations, industries, etc. is also another threat which affect the lichen vegetation in certain areas. Its increased quantum is responsible for creating unfavourable conditions for lichen growth. The Indian Botanic Garden at Howrah and suburban areas of Calcutta, Bangalore and Lucknow were once richly inhabited by corticolous communities, but now due to atmospheric pollution, the number of such species has decreased in Lucknow (A. Singh & Upreti, 1984), and the growth of lichens is greatly affected in the Indian Botanic Garden, Howrah (Das *et al.*, 1986). However, for a detailed knowledge on the impact of pollution on lichen flora, much more work has to be carried out.

The over exploitation of many economically important species such as *Parmotrema reticulatum, P. nilgherrense, Everniastrum nepalense, E. cirrhatum, Usnea, Ramalina* species, etc. in Sikkim Himalaya and recently from Arunachal Pradesh for various industrial purpose is another major cause of threat to these species. According to an estimate, about 1000 tonnes of lichen material is collected every year from the Western and Central Himalayas.

CONSERVATION

Lichen conservation has not received any attention in India, though we discuss much about the conservation of biodiversity of different plant groups from various platforms. This is regrettable in view of their role in ecosystem function and other similar values like pollution indicators, etc.

At present, probably, it is premature to discuss the lichen conservation at a greater length because we have no full data on the composition of lichen flora of any particular area, its general distribution and similar other aspects. However, some observations are made here so as to help formulation of future conservation strategies.

The total reported species of Indian lichens stands just above 2000. Of these about 60% are crustose forms, most of which have not been collected a second time. A great majority are corticolous ones occurring in tropical and subtropical forests. Many species are rare and endemic. It is expected that the total number of lichen species in India would be around 3500, if unexplored regions are explored thoroughly. Recent surveys have shown that many lichen rich habitats are depleting due to various threats as mentioned earlier, thus necessitating proper attention of this group for conservation. Like higher group of plants, lichens can be conserved in two ways - '*in situ*' and '*ex situ*' methods.

In situ conservation of lichens can be effected by ensuring the protection of selected lichen rich habitats in the form of 'lichen sites' or 'lichen reserves' at different elevations in a particular region. These sites should be of smaller dimensions, easily manipulated, have widest range of interest like maximum number of species including interesting, rare and threatened ones and least disturbed biotically. There are many such sites observed during our survey work in North-eastern states and can be considered for conservation of foliicolous, corticolous, saxicolous and terricolous lichen communities in general. Some such sites are as follows :

Name of the state	Name of the site	Nature of the lichen community
Arunachal Pradesh	Deban and 40th mile in Namdapha proposed biosphere reserve	Foliicolous
	Bomdila and Thungrai forests	Foliose, terricolous and saxicolous
	Melinja, Simbi forests	*Cladonia, Lobaria, Sticta, Usnea, Peltigera Stereocaulon species*

Name of the state	Name of the site	Nature of the lichen community
	Shergaon forests	Foliose and Fruticose forms particularly of *Lobaria* species
	Jung and Bomdir forests	Usneaceae
	Yingkiyong forests	Foliicolous
Manipur	Ukhrul, Sirohi	Foliose
Meghalaya	Shoraraim and old Cherapunjee	Crustose and foliose (saxicolous)
Mizoram	Ngengpui	Foliose and foliicolous
Nagaland	Japho hills, Thanamere, Saramati forests.	Foliose and fruticose

Similarly more lichen rich habitats can be identified throughout the country for conservation.

In situ conservation can also be effected by further demarcation of lichenologically rich areas as `lichen sites' within earlier demarcated boundaries of Biosphere Reserves or National Parks in the country. While preparing inventories of species of such areas, lower plants should also be taken into account for conservation strategies.

Ex situ conservation of lichens has no base line in our country. This is a difficult task because lichens can not be easily multiplied or regenerated. However, to some extent the bark inhabiting communities can be grown in Botanical Gardens under suitable environmental conditions in different climatic zones. In these gardens, rare, interesting or otherwise threatened species from disturbed habitats can be rehabilitated by means of transplantation method for which detailed ecological studies are required. Transplantation of saxicolous communities appears to be simple and some success has already been achieved (Richardson, 1967) in case of foliose species. A technique to transplant intact saxicolous communities is already known (Seaward, 1976). Recently some reseaches have been carried out (Yamamoto 1991) in the field of tissue culture through which *in vitro* culture can be developed and maintained for preserving the diverse gene bank in lichens.

The excessive collection of lichens can be regulated by making some legislations. This provision is known to be available in some European countries like Britain and Poland.

Besides there are many other aspects of conservation which need not be emphasised except most important one is to create public awareness about lower plants in general by giving wide publicity through available media. Lastly, a judicious planning and use of resources would help long way to conserve biodiversity for posterity.

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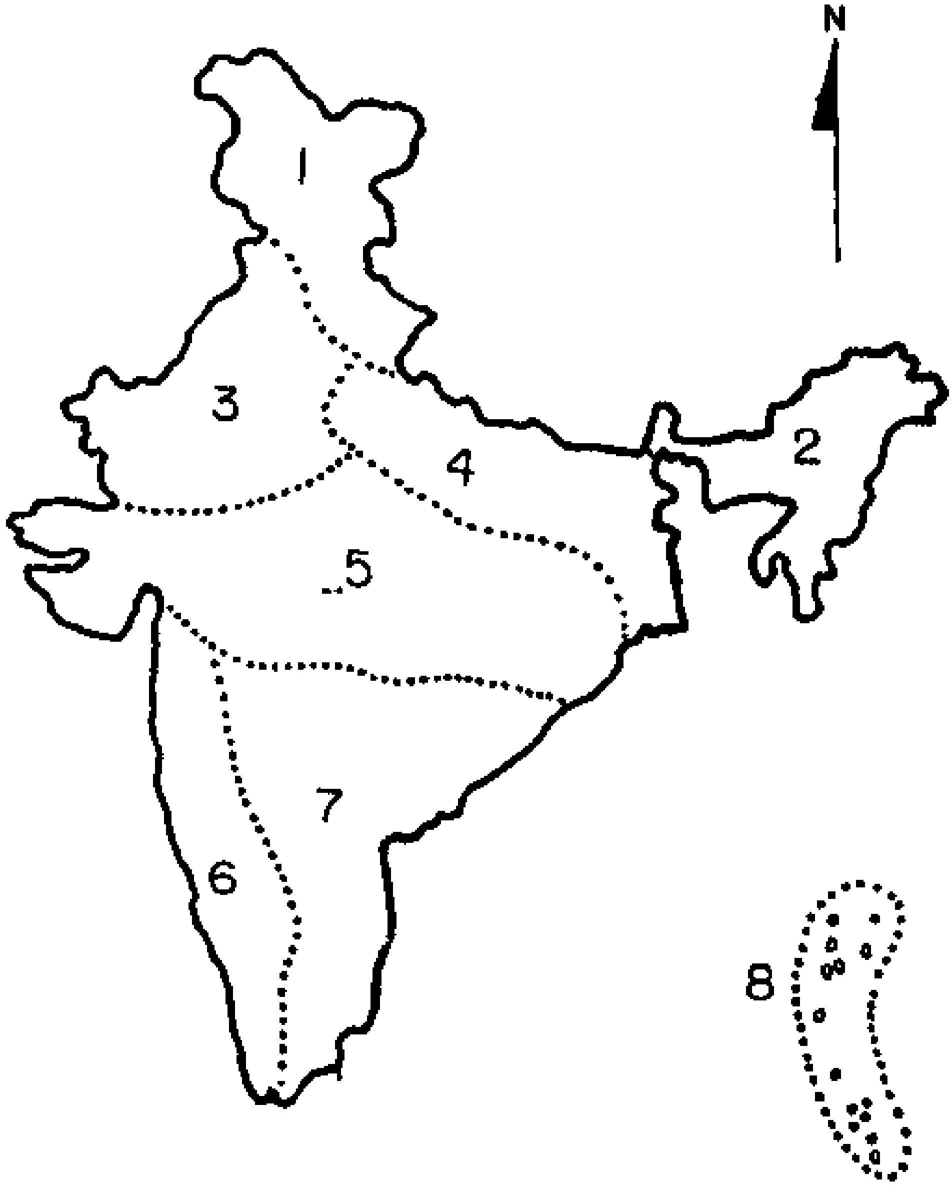
LICHENOGEOGRAPHICAL REGIONS OF INDIA

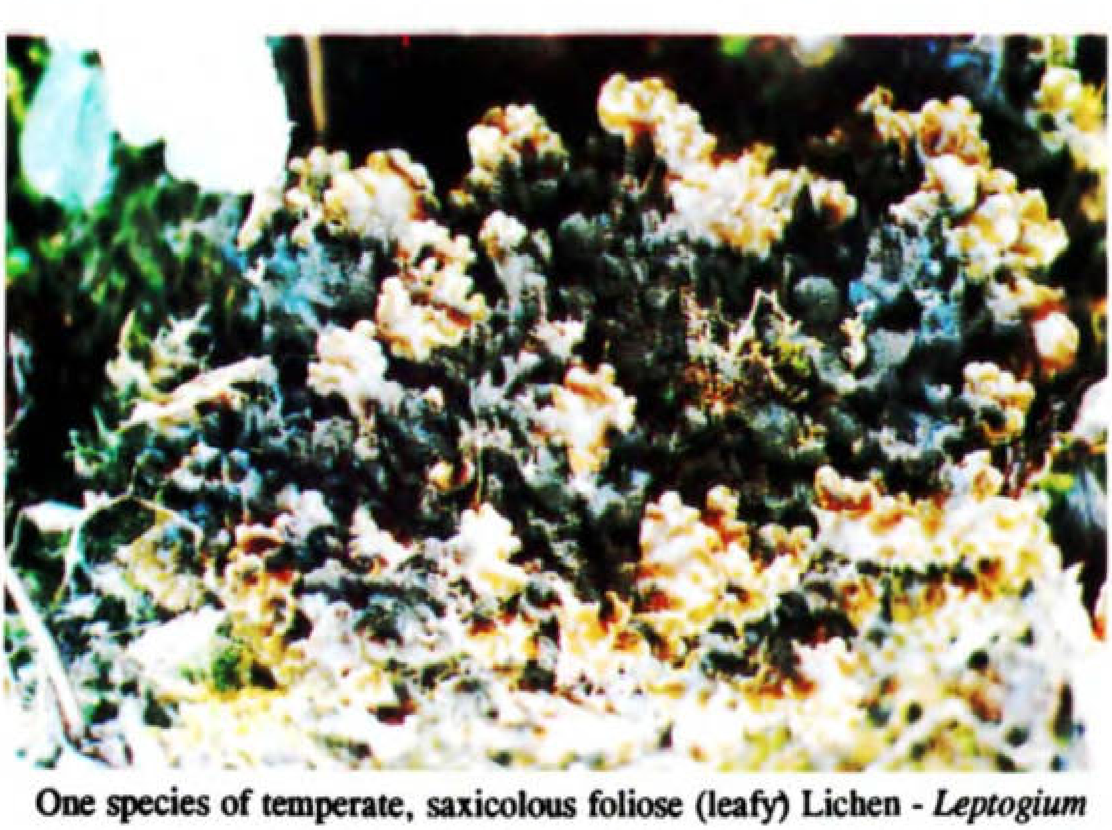


1. WEST HIMALAYAN REGION
2. EAST - HIMALAYAN REGION
3. WESTERN DRY REGION
4. GANGETIC PLAIN
5. CENTRAL INDIA
6. WEASTERN GHATS
7. EAST RN GHATS & DECCAN PLATEAU
8. ANDAMAN & NICOBAR ISLANDS

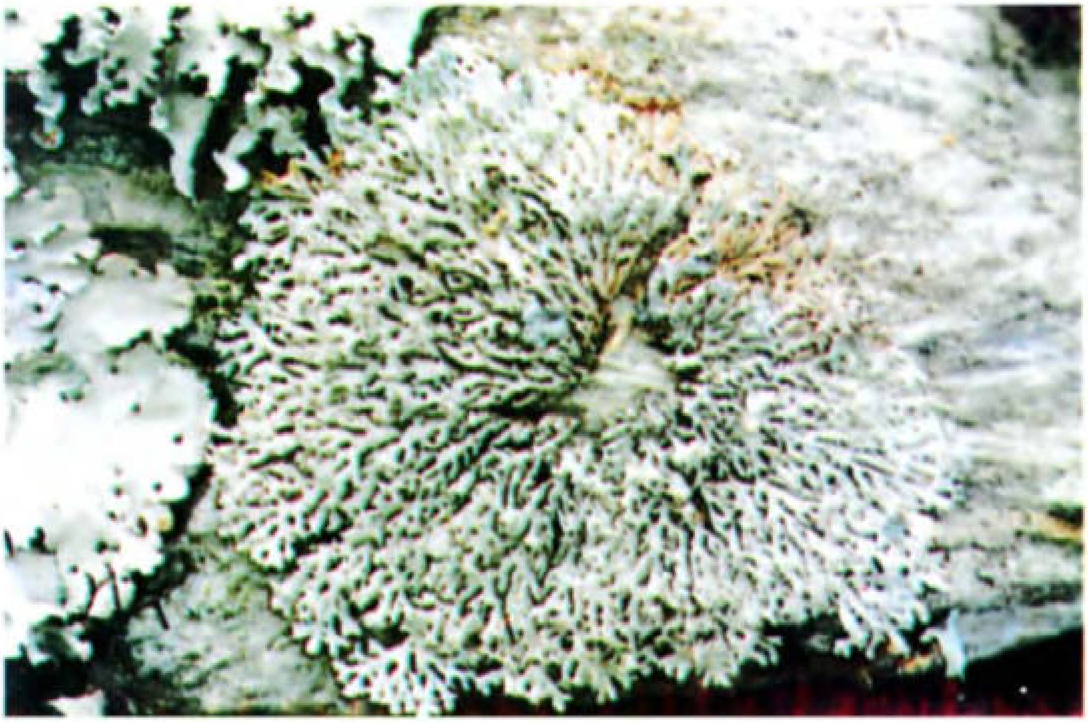
Hiterodermia diademata - A Tropical, Saxicolous foliose (leafy) Lichen

Dirineria picta -A Tropical, Saxicolous foliose (leafy) Lichen

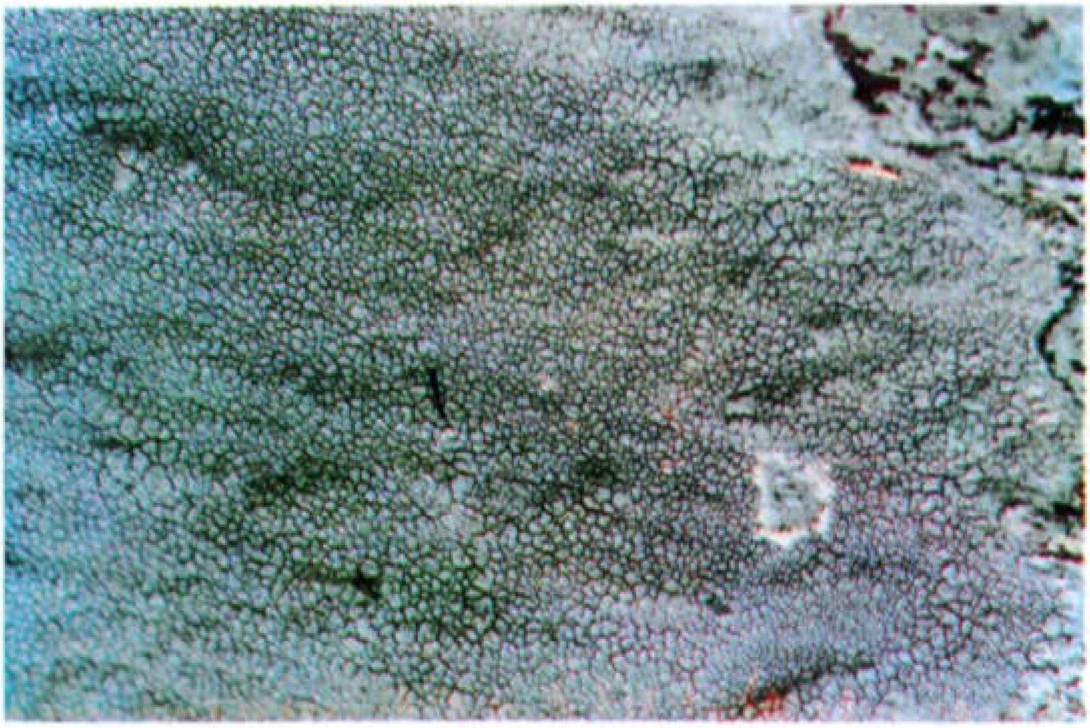
Species of corticolous - *Ramalina*



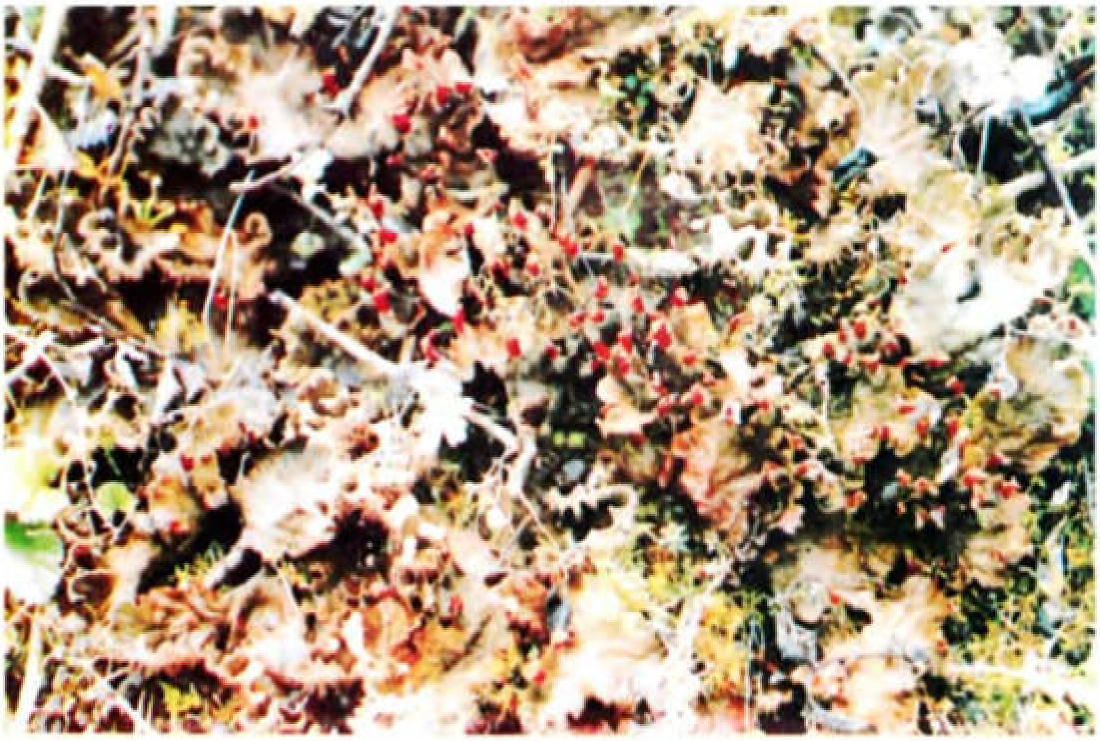
One species of temperate, saxicolous foliose (leafy) Lichen - *Leptogium*



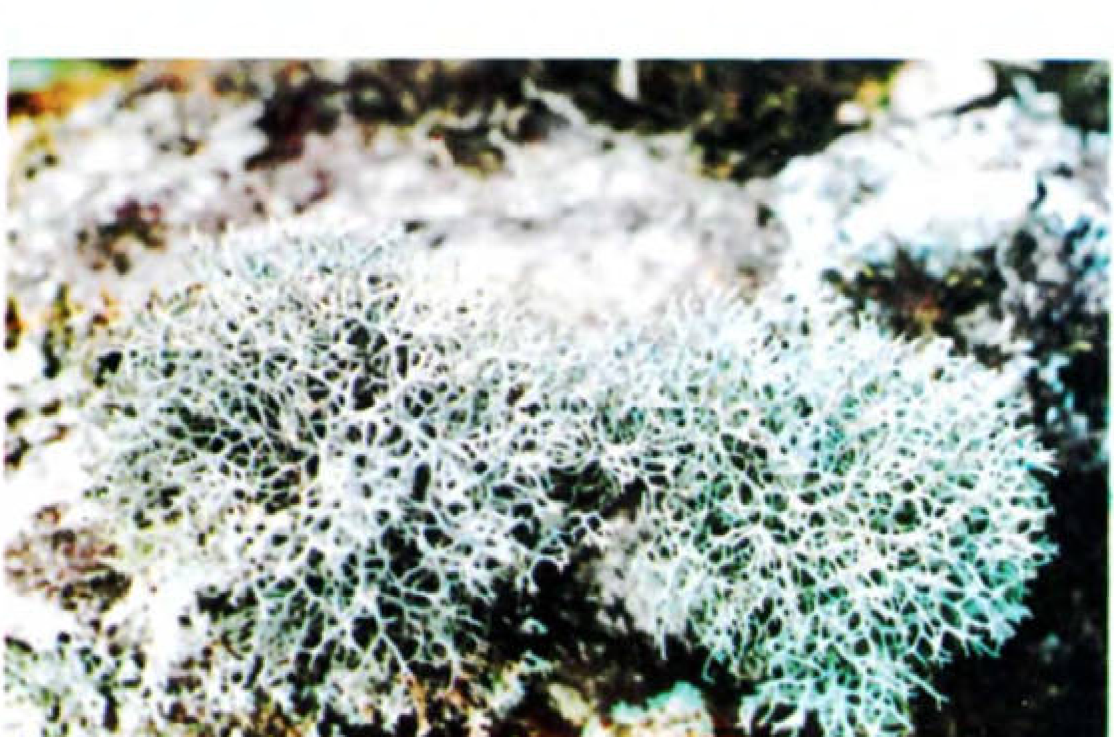
Menegazzia tereprata - A Temperate, Saxicolous foliose (leafy) Lichen



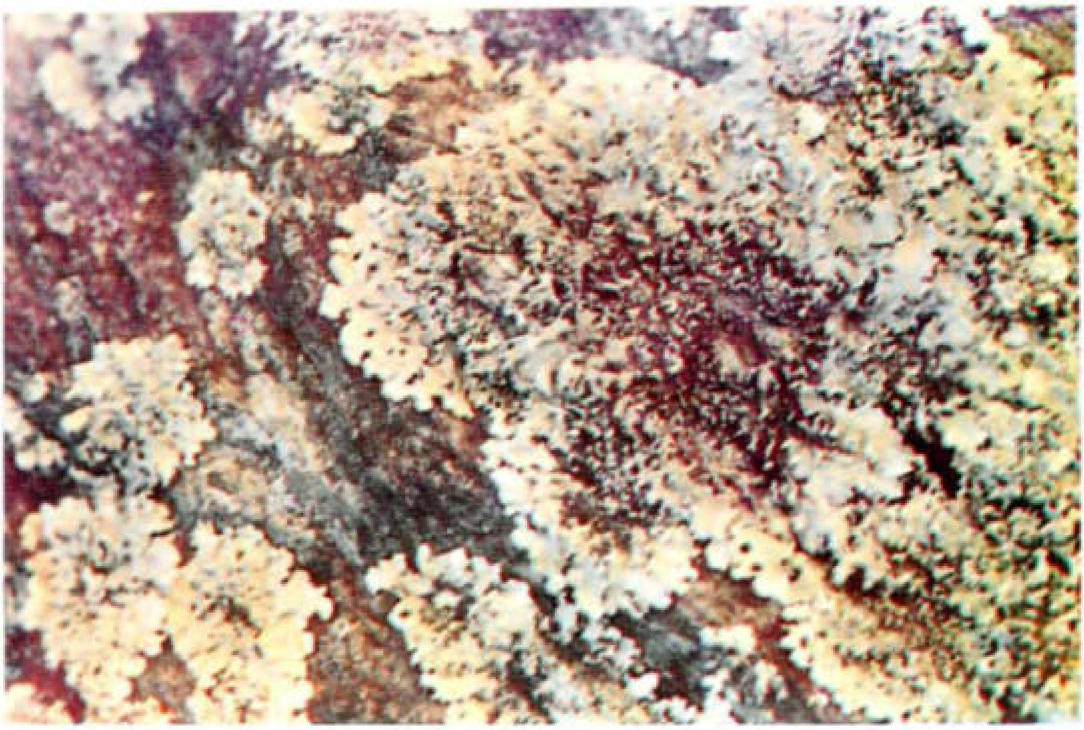
Diploschistus actinostomus. Saxicolous, Crustose Lichen



One species of the genus *Peltigera* - A Terricolous (normally on mosses) foliose (leafy) Lichen



Evevniastum cirvhatcum - Useful in the form of spices.



Parmotrema reficulatum - Useful in the form of spices.

Parmelia tenctorum - Useful in the form of spices.

Epiphyllous Lichen - Species of *Strigula* and *Bacidia*

LIVERWORTS

D.K. Singh

The Hepaticae, popularly known as liverworts, taxonomically represent one of the Classes of Bryophyta the first colonisers of the terrestrial habit which occupy an intermediate position between the Pteridophytes on one hand and the Algae on the other. The Bryophyta as a whole comprise autotrophic, except *Cryptothallus* and *Buxbaumia* (saprophytic liverwort and moss genera respectively), atracheate and archegoniate plants. An interesting feature of the bryophytes is the heteromorphic alternation of generations wherein, unlike other embryophytes, the dominant phase is represented by a haploid gametophyte subtending a short-lived, diploid sporophyte, fully or partially dependent on it. Based on the structure and characteristics of these two generations, the bryophytes have been broadly grouped into liverworts (Hepaticae) and mosses (Musci). Sometimes, however, because of their heterogenous assemblage, order Anthocerotales is segregated from the liverworts and treated as separate Class Anthocerotae by some school of thoughts. In the present paper, however, the first view has been followed.

The term 'liverwort' in fact, is the relict of the superstitious mediaeval belief in the "doctrine of signature" which ascribed curative properties to plants like *Marchantia polymorpha* for liver ailments. The resemblance of these thalloid plants with that of the lobes of the liver (*hepatica* in Greek) eventually lead to their present day scientific name. As the name would suggest, the liverworts are often visualised as thalloid a freely branched, flattened structure of no definite shape and size. On the contrary more than 85 per cent of the total liverwort taxa, especially those representing the subClass Jungermannidae are foliaceous with plant body differentiated into 'stem' (*caulis*) and 'leaves' (*phyllids*) much like 'true' mosses.

The liverworts, considered to have evolved during the late Devonian, are considerably interesting because of their extremely archaic nature at all levels (family, genus and species) and exhibit remarkable "conservatism" in speciation, strikingly wide disjunction of taxa and extreme "Somatic plasticity" in several species (Schuster, 1996). Probably because of these reasons the liverworts have considerably small number of species, ranging between 5,500-6,000 (Anon., 1992; Schuster, 1996) to approximately 8,500 (Singh & Hajra, 1996). Paradoxically, however, there are genera like

Cololejeunea, Frullania, Plagiochila, Porella, Radula, etc., which are characterised by enormous "species explosion".

The bryophytes usually inhabit microclimatic niches. They are equally adapted to moist tropical-tropical mountain forests to arctic tundra, and are amongst the very few plants which grow in antipodal regions. In India they reach an altitude of over 5000 m above the mean sea level in the Himalayas. Though they usually grow in groups and patches, their small size disables them to compete with vascular plants for light and space. As such they tend to grow on such surface where normally no other plants would grow. Sometimes they even grow on such unusual surface as animal carcases; abandoned articles like shoes, etc.; humified faecal material, etc. On the other hand, in certain habitats like grasslands they are totally excluded by competition. Their dependence on sufficient moisture for vigorous vegetative growth and effective fertilisation has further impaired their elaboration and proliferation. The majority of them, therefore, are damp loving, predominantly terrestrial and favour shaded conditions, whereas number of taxa are also epiphytic and epiphyllous. While plants like *Dumortiera, Pallavicinia, Pellia, Makinoa,* etc. are hygrophilous in nature, a few of them, viz. *Riccia fluitans, Ricciocarpus natans* and *Riella* have adapted to fully aquatic mode of life, the last one being the sole liverwort that completes its entire life cycle under water. Still fewer taxa, like *Plagiochasma appendiculatum, Targionia hypophylla, Asterella angusta,* etc. are usually xeromorphic in nature capable of enduring drought and may even grow under arid conditions.

Though the studies in Indian Hepaticology, as reviewed from time to time (Udar, 1976; Singh, 1984, 1992; Srivastava, 1994), dates back to early nineteenth century, our knowledge about the Indian liverworts is still inadequate and remains largely abridged. A considerable part of the country, especially the North-eastern India and the Andaman and Nicobar Islands, supposedly richest in the country, hepaticologically still remains *terra incognita* (Singh, 1982; 1992). As such, in the present state of our knowledge approximately 850 taxa, spreading over to 140 genera and 52 families are known to occur within the present political boundary of our country (Singh, 1992, 1995; Singh & Semwal, 1995; Parihar, 1994). Interestingly this accounts for *ca* 10 per cent of the total liverwort flora of the world, in just about 2 per cent of the global landmass.

VEGETATION

India, with a very significant topographical variations, from sea-level to world's highest mountain ranges, coupled with varied climatic conditions, ranging from humid tropical to both hot as well as cold arid conditions, harbours a rich liverwort vegetation, both in luxuriance and diversity. Based on the altitude, rainfall, humidity and the species composition the liverwort vegetation of the country may be broadly categorised into tropical-subtropical, temperate and alpine. Outside Himalayas, however, plants do not exhibit any distinct altitudinal zonation. Unlike other plant groups, the liverworts usually prefer higher elevations, showing their best manifestation between the altitudinal range of 1000-3500 m above mean sea level.

The Tropical-Subtropical liverworts

The tropical subtropical liverwort vegetation extends up to 1500 m in the Western Himalaya, 1800 m in Eastern Himalaya, including the North-Eastern region, and 2000 m in the Western ghats. The occurrence of certain taxa like *Anthoceros erectus, Chandonanthus hirtellus, Plagiochasma articulatum, Reboulia hemisphaerica, Riccia crystallina, R. melanospora,* etc., however, does not conform to any altitudinal barrier. In the regions with comparatively higher temperature and low humidity, the vegetation is usually composed of terrestrial elements like *Anthoceros punctatus, Asterella angusta, A. blumeana, A. pathankotensis, Aneura indica, Cyathodium cavernarum, C. smaragdinum, Cephalozia andreana, Fossombronia himalayensis, Jungermannia purpurata, J. Humilis, Mannia indica, Marchantia nepalensis, M. palmata, Notothylas anaporata, N. dissecta, N. indica, N. pfleidereri, Plagiochasma appendiculatum, Riccardia santapauii, Riccia billardieri, R. cruciata, R. discolor, R. gangetica, R. melanospora, R. sanguinea,* etc. along with a few epiphytic taxa mostly belonging to families Lepidoziaceae, Radulaceae, Porellaceae, Jubulaceae, Lejeuneaceae. At relatively higher and more humid locations the vegetation comprises all the three liverwort communities, viz. terrestrial, epiphytic and the epiphyllous. The prominent amongst the terrestrial forms are : *Phaeoceros laevis* subsp. *laevis, Plagiochasma intermedium, Folioceros dixitianus, F. paliformis, F. appendiculatus, Notothylas himalayensis, Petalophyllum indicum, Plagiochasma japonicum, Marchantia paleacea, Plagiochila alata, Jungermannia appressifolia, J. tetragona, J. truncata, Jamesoniella elongella, Notoschyphus lutescens, N. paroicus, Chiloscyphus polyanthos, Heteroscyphus* *argutus, Cylindrocolea tagawae,* etc. The epiphytic vegetation in this region comprise *Radula pandei, Caudalejeunea* spp., *Lopholejeunea gradsteinii, L. sikkimensis, Archilejeunea apiculaifolia* var. *dentifolia, Cheilolejeunea khasiana, Lejeunea flava, L. tuberculosa, Leucolejeunea turgida, Mastigolejeunea humilis, Frullania arecae, F. ericoides, F. evelynae, F. nepalensis, Porella* spp., *Trichocolea udarii,* etc. The conducive conditions prevailing in the Eastern Himalayas, including the North-eastern region, the Western ghats and in the Andaman and Nicobar Islands, support a luxuriant epiphyllous community. In the humid, tropical rain forests of these regions, the leaf surface of Angiosperms and ferns (like *Asplenium, Cyathea, Dipteris,* etc.) form a sort of "Phyllosphere" in which Algae, Fungi, Lichens and Bryophytes (especially liverworts) thrive successfully (Pocs, 1982). While lichen may often form hypophyllous populations, the algae and the bryophytes are strictly epiphyllous. The prominent among them are *Radula assamica, R. accuminata, R. tjibodensis, Cololejeunea cardiocarpa, C. dentifolia, C. farmosana, C. foliicola, C. jelineckii, C. lanciloba, C. mizutaniana, C. pandei, C. sigmoidea, C. kashyapii, Colura acroloba, C. ari, Leptolejeunea foliicola, L. balansae, L. himalayensis, L. schiffneri, L. subacuta, Rectolejeunea aloba, Taxilejeunea tenerrima, Raphidolejeunea yunnanensis, Pycnolejeunea ceylanica, Frullania* spp., etc. In congenial situations, nevertheless, the habitat preferences are not obligatory for some of the foliaceous taxa.

The Temperate Liverworts

The temperate liverwort vegetation extendes up to 3500 m above sea level in Himalayas and to lesser extent is confined only to upper most ridges of Doddabeta (2636 m), Makurti (2554 m), Anaimudi (2760 m), Vembadi (2505 m) in the Western ghats, and Saramati (3826 m), Yakko (2700 m), Siruhi Kashong (2568m), and Phawngpui Tlang (2300 m), etc. in the North-eastern region. So far as the luxuriance and the diversity of liverworts is concerned, this is the richest vegetational zone. The cool and humid climatic conditions met in this zone facilitates rich growth of liverworts on cliffs, ridges, moss-covered rocks, logs, tree trunks and occasionally on leaf surface of Ferns and Angiosperms. The terrestrial liverwort community usually comprise *Anthoceros crispulus, A. angustus, Folioceros glandulosus, Megaceros tjibodensis, Notothylas levieri, Phaeoceros laevis* subsp. *carolinianus, Calypogeia trichomanis, C. lunata, Cephalozia gollani, C. siamensis, Jamesoniella nipponica, Jungermannia gollani, J. polyrhizoides, J. pseudocyclops, J.*

subrubra, J. rubripunctata, Lophozia setosa, Scapania griffithii, S. orinthopodioides, Lophocolea bidentata, L. muricata, Heteroscyphus tener, Chiloscyphus spp., *Plagiochilla* spp., *Fossombronia cristula, F. foreaui, F. wondraczekii, Pellia epiphylla, Metzgeria decipiens, Aneura indica, Riccardia sikkimensis, R. tenuicostata, R. villosa, Cyathodium* spp., *Conocephalum conicum, C. supradecompositum, Asterella reticulata, Marchantia polymorpha, M. nitida, Preissia quadrata, Riccia hirta, R. pandei, R. sorocarpa,* etc. The epiphytic elements in this zone are ; *Trichocolea indica, T. tenera, T. tomentella, Lepidozia reptans, L., setacea, Bazzania tricrenata, Cephaloziella microphylla, Plagiochila semidecurrens, Radula obscura, R. tabularis, Porella madagascariensis, Frullania tamarisci, F. hattoriantha, F. sharpantha, Acrolejeunea recurvata, Archilejeunea apiculifolia, Trocholejeunea sandvicensis, Drepanolejeunea ternatensis, Metzgeria* spp., etc. This zone, however, harbours fewer foliicolous elements, like *Frullania grevilleana, Cololejeunea longifolia, C. minutissima, C. obliqua, Leptolejeunea elliptica,* etc. Besides, a considerable mixiing of tropical-subtropical elements, like *Notoscyphus darjeelingeniss, N. pandei, Marchantia hartlessiana, M. papillata, M. subintegra, Asterella khasiana, A. leptophylla, A. mussuriensis, Targionia hypophylla, Mannia indica* (terrestrial); *Radula javanica, Porella campylophylla, P. densifolia, P. hattorii, Frullania retusa, F. physantha, Archilejeunea minutilobula, Microlejeunea punctiformis, Mastigolejeunea repleta, Ptychanthus striatus* (epiphytic); and *Lopholejeunea abortiva* (foliicolous) are also noticeable in more or less identical niches. It is interesting to note that a number of taxa, particularly those belonging to families Plagiochilaceae, Porellaceae and Lejeuneaceae often show both terricolous as well corticolous habitation in congenial environs.

The Alpine Liverworts

The alpine liverwort vegetation is confined only to the Himalayas beyond 3500 m altitude and consists mostly of terrestrial and epiphytic communities. Comparatively dry, colder conditions apparently do not support the epiphyllous communities in this zone. The terrestrial vegetation is mostly represented by *Anthoceros alpinus, Lepidozia brevifolia, L. robusta, Bazzania imbricata, B. deflexa, Anthelia julacea, Chandonanthus filiformis, C. setiformis, Anastrophyllum* spp., *Jamesoniella nipponica, Jungermannia atrata, J. atrobrunnea, J. rubida, Lophozia alpestris, L. incisa, Tritomaria exsecta, Lophocolea* *sikkimensis, Sauchia spongiosa, Sauteria alpina, Mannia dichotoma, M. perssonii, Marchantia polymorpha, Riccia crystallina,* etc. which grow under exposed as well as inside *Abies, Betula, Juniperus, Quercus, Rhododendron, Tsuga* forests. The liverworts colonising the tree trunks, twigs and sometimes the moss-ladden logs comprise the taxa like *Herbertus dicrana, H. kurzii, Blepharostoma trichophyllum, Kurzia makinoana, Bazzania pearsonii, Pleurozia purpurea, Radula lindbergiana, R. auriculata, Mastigophora woodsii, Frullania muscicola, Acrolejeunea sikkimensis, Lejeunea discreta, L. wallichiana,* etc. Besides, some of the temperate elements like *Anastrepta orcadensis, Anastrophyllum assimile, Apometzgeria pubescens, Frullania yunnanensis, Geocalyx graveolens, Metacalypogeia alternifolia, Plagiochila semidecurrens, Scapania ciliata, S. ciliatospinosa, S. ferruginea,* etc. are also found growing luxuriantly in this zone.

DIVERSITY

The large size of the country, variety of phytoclimatic conditions met within its different biogeographic zones and the incidence of floristic elements of neighbouring and far off regions have together contributed to a great diversity of Indian liverwort flora comprising about 850 species, including infraspecific categories, belonging to over 140 genera and 52 families. While Jungermanniales with *ca* 99 genera and 630 species is the largest liverwort Order in the country, Treubiales represents the other end of spectrum with just a single genus and species only. The other Orders represented in Indian bryoflora are : Calobryales (2 genera and 6 species); Metzgeriales (12 genera and 59 species); Sphaerocarples (1 genus and 3 species); Marchantiales (22 genera and 116 species) and Anthocerotales (5 genera and 36 species). At a lower taxonomic level, Lejeuneaceae with *ca* 36 genera and 155 species and *Plagiochila* with *ca* 114 species are the largest liverwort family and the genus respectively, whereas 15 families, with 9 monogeneric (Jackiellaceae, Antheliaceae, Chonecoleaceae, Radulaceae, Mastigophoraceae, Ptilidiaceae, Riellaceae, Conocephalaceae and Notothylaceae) and 6 monotypics (Delavayellaceae, Makinoaceae, Blasiaceae, Aitchisoniellaceae, Lunulariaceae and Monoseleniaceae), and 55 genera, inclusive of monotypics, like (*Schiffneria, Gerhildiella, Diplocolea, Delavayella, Monoselenium, Lunularia, Cryptomitrium Sewardiella, Makinoa, Blasia, Aitchisoniella, Stephensoniella*, etc. are represented by just a single species in Indian bryoflora (Kashyap, 1929, 1932; Chopra, 1943; Kachroo, 1969, 1970, 1970a, 1973; Kachroo *et al.* 1977; Srivastava, 1979; Asthana & Srivastava 1991; Singh, 1992, 1995, Parihar, 1994; Asthana, G., 1995). Table I and II show the ten dominant families and genera, by virtue of number of species, respectively in India. While the major families together account for *ca* 71.2 per cent of the total liverwort flora of the country, the ten largest genera have a share of *ca* 45.6 per cent.

Table I
Dominant families of liverworts in India

Sl. No.	Family	Genera	Species*	Percentage of flora
1.	Lejeuneaceae	36	155	18.2
2.	Plagiochilaceae	4	119	14.0
3.	Jungermanniaceae	15	76	8.9
4.	Jubulaceae	2	57	6.7
5.	Rebouliaceae	5	40	4.7
6.	Geocalycaceae	4	37	4.4
7.	Ricciaceae	2	37	4.4
8.	Lepidoziaceae	4	36	4.2
9.	Metzgeriaceae	2	25	2.9
10.	Scapaniaceae	2	24	2.8

* Including infraspecific categories.

Table II
Dominant genera of liverworts in India.

Sl. No.	Genus	Species	Percentage of flora
1.	**Plagiochila**	114	13.4
2.	**Frullania**	54	6.4
3.	**Jungermannia**	38	4.5
4.	**Riccia**	36	4.2
5.	**Cololejeunea**	30	3.5
6.	**Porella**	26	3.0
7.	**Asterella**	24	2.8
8.	**Metzgeria**	23	2.7
9.	**Scapania**	22	2.6
10.	**Lejeunea**	21	2.5

A perusal of literature and analysis of the species in each family presents an interesting data as presented below :

Families with		1	species	15
Families with	2	5	species	13
Families with	6	10	species	4
Families with	11	15	species	6
Families with	16	25	species	5
Families with	26	50	species	5
Families with	51	100	species	2
Families with	above	101	species	2

An equally interesting data emerges following the analysis for genera of the Indian liverworts :

Genera with			1	species	55
Genera with	2		5	species	51
Genera with	6	-	10	species	15
Genera with	11		15	species	5
Genera with	16		25	species	8
Genera with	26		50	species	4
Genera with	51		100	species	1
Genera with	above		101	species	1

The data presented above clearly highlights the conservatism in speciation, at both the taxonomic level, so characteristic of the group.

An interesting aspect of the Indian liverworts is the fact that such phylogenetically interesting taxa as family Haplomitriaceae [with 6 out of 14 species in the world (Chandra, *et al.* 1987)] and genera *Cyathodium* , [with 9 out of 12 species in the world (Singh, 1983)], and *Notothylas* [with 8 out of 18 species in the world (Singh, 1995a,b)] have their maximum representation in India, which is also highest for any geographical region in the world. The Indian liverwort flora is also characterised by the presence of such phylogenetically significant taxa as *Fossombronia, Petalophyllum, Sewardiella, Stephensoniella, Monoselenium, Calobryum* and *Haplomitrium*. The family Haplomitriaceae, apart from being phylogenetically significant, is also remarkable because of its 'stenotypic' nature (Schuster, 1966).

Apart from that, the discovery of certain fossil liverworts like *Hepaticites pantii, Hepaticites* sp., *Shuklanites deccanii, Sporangioceros nippanica,* etc. (see Singh, 1992; Srivastava, 1994) which, together with considerably high endemism, is indicative of the uniqueness of the liverwort flora of India.

The geomorphological as well as the climatological variations have quite discernibly shaped the pattern of floristic composition of liverworts in different part of the country. The Himalayas and the peninsular India have vast areas rich in hepatics, with the greatest number of species occurring in the regions with abundant precipitation and high humidity. On the other hand the conditions at the Vindhya, Satpura and Aravalli mountains, Pchmarhi plateau and Mahabaleshwar are comparatively less congenial for the growth of liverworts. The large plains, stretching over the greater part of the country, offer still less congenial conditions to support their growth and only few liverworts in favourable niches are available. It has been experimentally demonstrated that the relative humidity has a profound bearing on the overall growth and distribution of liverworts (Clausen, 1952). Mahabale and Chavan (1954), also recognised well demarcated floristic regions of liverworts in Gujrat depending up on the prevailing arid or humid conditions.

A distributional analysis of the liverwort flora of India shows that the Eastern Himalaya, with *ca* 548 reported species, account for over 64 per cent of the total liverwort flora of the country. This is followed by the Western ghats with 280 species (*ca* 33 per cent) and the Western Himalaya with 235 species (*ca* 28 per cent). The rest of the country together account for just 135 species. It is rather interesting that the number of liverwort taxa common to the Eastern Himalaya and the peninsular India is greater than that between the Eastern and the Western Himalaya. An interesting aspect of the distribution of liverworts in the Himalayas is that, vertically, its luxuriance and diversity increases up to 3,000 m beyond which it declines. The most luxuriant hepatic vegetation occurs between 2000-2800 m in the Western Himalaya, whereas in the Eastern Himalaya the optimum richness is encountered at a comparatively lower altitude. In Arunachal Pradesh, for instance, the maximum luxuriance and species diversity is observed between the altitudes of 1000 and 3200 m. Secondly, the number of species and its frequency, at a particular altitude in the outer Himalaya decreases from Darjeeling in the East to Kashmir in the West. The floristic characteristics shown by the Himalayan region (both East and West) and the Western ghats, suggest that these territories represent three distinct and richest diversity centres of liverworts in India. It should, however, be stressed that large parts of such bryologically rich areas as the North-east Indian states, Western ghats and the Andaman & Nicobar Islands still remain to be thoroughly investigated for their liverwort vegetation. As such any generalisation, with regard to the total number of species occurring in these parts of the country and their distributional relationship, at this stage would at best be only tentative.

Based on a careful analysis of liverwort vegetation in different regions Pande (1958) proposed seven bryogeographic units of India, viz. the Western Himalaya; the Eastern Himalaya; the Panjab & West Rajasthan; the Gangetic Plains; the Central India; the Western Ghats and the Eastern Ghats & Deccan Plateau, each with its more or less characteristic liverwort flora. Later Singh (1992) and Singh and Semwal (1995) proposed an eighth bryogeographical territory, as also endorsed by Joshi (1995), to include the oceanic islands of Andaman & Nicobar in the Bay of Bengal (Map-I).

Table III
Distributional Analysis of the liverworts in different bryogeographical regions.

Bryogeographical regions	Taxa*		
	Family	Genus	Species
India	52*	140*	850*
Eastern Himalaya	44(7)	111(32)	548(363)
Western Himalaya	40(3)	77(9)	235(75)
Panjab & W. Rajasthan	13(0)	17(0)	34(5)
Gangetic Plains	9(0)	11(0)	18(3)
Central India	21(0)	32(0)	61(7)
Western Ghats	32(2)	79(9)	280(121)
Eastern Ghats & the Deccan Plateau	14(0)	14(0)	33(0)
Andaman & Nicobar	12(0)	40(1)	53(19)

* Approximate. Figures in parenthesis indicate the approximate number of taxa confined to respective bryogeographical regions in Indian bryoflora.

The West Himalayan Territory

The Himalayas hold a unique status in the Geography of the world and offers most enchanting area that fascinates all, the tourists, naturalists and the botanists, alike. The West Himalayan region, forms a link between the flora of India and that of the West Asian and Mediterranean countries. Extending from the Western boundaries of Nepal, through hills of Uttar Pradesh, Himachal Pradesh, to Kashmir, it is a zone with comparatively less rainfall and low humidity, and with the several peaks rising upto more than 7600 m. With respect to the hepatic flora, which shows maximum diversity between the altitudes of 1800-3000 m, this territory has been worked out rather intensively in Indian bryology (Kashyap, 1929, 1932; Udar & Singh, 1977, 1978, 1981; Srivastava, 1979; A. Kumar & Udar, 1985; Srivastava & P. Singh, 1988; Udar & D. Kumar, 1984; Srivastava & A. Srivastava, 1989; Srivastava & Anshu Srivastava, 1993; Parihar, 1994, Srivastava, 1994; Asthana & Nath, 1994; Negi *et al.* 1995).

The Western Himalaya host about 235 species of liverworts, belonging to 40 families and 77 genera (Table III), which accounts for *ca* 28 per cent of the total Indian liverworts. Of these three families, viz. Aitchisoniellaceae, Antheliaceae and Arnelliaceae, 9 genera and 75 species are confined to this region alone in Indian bryoflora. The details of the ten largest families and genera of liverworts in this territory are tabulated below. It is rather interesting that Rebouliaceae, essentially a xeric family, with 5 genera and 29 species, dominates the region.

Family	Genera/specis	Genus	Species
Rebouliaceae	5/29	**Plagiochila**	19
Jungermanniaceae	7/23	**Asterella**	17
Plagiochilaceae	1/19	**Porella**	14
Ricciaceae	2/18	**Jungermannia**	14
Jubulaceae	2/15	**Frullania**	14
Scapaniaceae	1/10	**Scapania**	10
Anthocerotaceae	2/7	**Riccia**	9
Metzgeriaceae	2/7	**Plagiochasma**	7
Phaeocerotaceae	2/6	**Rudula**	6
Radulaceae	1/6	**Metzgeria**	5

The liverworts of this territory are further characterised by the presence of four endemic, monotypic genera, viz. *Aitchisoniella, Sewardiella, Sauchia* and *Stephensoniella,* and an endemic family Aitchisoniellaceae. Besides, this territory hosts, *ca* 54 endemic taxa, of which 34 species, such as *Anthoceros alpinus, Athalamia pinguis, A. pusilla, Cephalozia udarii, Cephaloziella magna, Cyathodium indicum, Cryptomitrium himalayense, Fossombronia kashyapii, Frullania subclavata, Jubula himalayensis, Mannia perssonii, Phaeoceros kashyapii, Plagiochasma pauriana, Riccia indica,* etc. are restricted to this region only, (Table IV). The rest are common with other bryogeographical regions of the country, except the Central Indian territory and the Andaman & Nicobar Islands, with the East Himalayan territory sharing a maximum of 12 species. The West Himalayan region is also endowed with certain arctic elements like *Pressia quadrata, Sauteria alpina, S. spongiosa, Aneura pinguis, Apometzgeria pubescens,* and ubiquitous taxa like *conocephalum conicum, Dumortiera hirsuta, Fossombronia pusilla, Gymnomitrion concinnatum, Lophocolea* spp., *Lunularia cruciata, Marchantia polymorpha, Pallavicinia lyellii, Reboulia hemisphaerica, Riccia hirta, R. crystallina, R. sorocarpa, Ricciocarpus natans,* etc. This territory is further characterised by the occurrence of such phytogeographically interesting taxa as *Anthoceros crispulus, A. punctatus, Blasia pusilla, Delavayella serrata, geocalyx graveolens, Haplomitrium hookeri, Jamesoniella nipponica, Nowellia indica, Phaeoceros laevis, Radula complanata,* etc. (Table V).

The Western Himalaya are also considered to be the centre of origin for the family Rebouliaceae (Kachroo, 1954), which, because of its "xerogeophytic" habitat, is quite prolific between 1600-2300 m altitudes in this territory. It is also interesting to note that out of 36 species of the family Ricciaceae, hitherto known to occur in the country, 18 grow in this region alone.

The East Himalayan Territory

The East Himalayan region comprises the mountanous territory east of Nepal and also includes the "Seven sister states" of the North-Eastern India, i.e. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram and Tripura. Wedged between Tibet, China and Burma, the region is strategically located from the phytogeographical point of view. The wide range of physiographical and ecoclimatic conditions met in this territory, have adequately expressed itself by supporting a vast and luxuriant vegetation which accounts for over 60 per cent of the total liverwort flora of the country (Chopra, 1938; Udar 1976; Udar & A. Kumar, 1981; Udar & Awasthi 1982; Udar & Kumar, 1976; Udar & D. Kumar, 1982; Udar & Singh, 1976, 1977, 1981a; Singh, 1981, 1982, 1983, 1983a, 1984, 1987, 1992; Srivastava *et al.* 1988; 1991; 1994; Sharma & Srivastava, 1993; Asthana *et al.* 1994; Srivastava & Anshu Srivastava, 1994; Parihar, 1994; Srivastava, 1994; Srivastava & P. Singh, 1995). The Eastern Himalaya harbour about 548 taxa of liverworts spreading over to 111 genera and 44 families (Table III) which account for almost 65 per cent of the total Indian liverwort flora. As many as 7 families (Balantiopsidaceae, Chonecoleaceae, Makinoaceae, Mastigophoraceae, Pleuroziaceae, Ptilididiaceae, and Treubiaceae), 32 genera and 363 species are confined to this bryogeographical region alone in the India bryoflora. Family Plagiochilaceae, with 4 genera and about 90 species (including infraspecific categories), and the genus *Plagiochila*, with 85 species, excluding subspecies, varieties, etc., predominate the liverwort flora of this territory. The other dominant families and genera of the region are tabulated below. It is rather interesting that about 40 per cent of the taxa known from this bryogeographical region are considered endemic to the Eastern Himalaya (Srivastava, 1994).

Family	Genera/species	Genus	Species
Plagiochilaceae	4/90	**Plagiochila**	85
Lejeuneaceae	25/85	**Frullania**	39
Jungermanniaceae	15/71	**Jungermannia**	37
Jubulaceae	2/40	**Lejeunea**	17
Lepidoziaceae	4/32	**Cololejeunea**	17
Geocalycaceae	4/28	**Metzgeria**	17
Metzgeriaceae	2/19	**Herbertus**	16
Scapaniaceae	2/8	**Scapania**	16
Rebouliaceae	4/17	**Bazannia**	15
Herbertaceae	1/16	**Riccia**	13

The East Himalayan liverwort flora exhibits a remarkable admixture of species from China, Japan and Indo-Malayan region and is characterised by some extremely rare and interesting plants, such as *Calobryum dentatum, C. indicum, Haplomitrium grollei, H. kashyapii,* *Lophochaete trollii, Cylindrocolea reticulata, Isotachis indica, Metzgeria crispula, M. madagassa, Cyathodium denticulatum, C. mehranum, C. tuberculatum, Notothylas khasiana, Folioceros assamicus, F. physocladus,* curiously confined to this territory.

The East Himalayan region exhibits the highest endemism in Indian flora with *ca* 150 taxa known to occur in the territory. Of these, while 90 taxa are strictly confined to this region alone, the rests are common with the other parts of the country as well except the bryogeographical territories of Gangetic plain, Central India and the Andaman & Nicobar Islands (Table IV). A striking feature of the endemism in the East Himalayan territory is that all the endemic taxa (including species and infraspecific categories) belonging to family Balantiopsidaceae, Blepharostomataceae, Haplomitriaceae, Herbertaceae, Lepidoziaceae, Pallaviciniaceae and Trichocoleaceae, besides a majority of Scapaniaceae, Jungermanniaceae, Plagiochilaceae and Jubulaceae, are restricted to this region only. It is also interesging to note that this region hosts six out of fourteen species of the family Haplomitriaceae, viz. *Calobryum blumii, C. dentatum, C. indicum, Haplomitrium grollei, H. hookeri, H. kashyapii,* a phylogenetically as well as phytogeographically important taxon, which is the highest for any geographic region in the world (Chandra *et al.*, 1987). It is highly significant that except for *Calobryum blumii,* which is known from Khasi & Jaintia hills of Meghalaya, and *Haplomitrium hookeri,* also known from the Western Himalaya and Arunachal Pradesh, all the other species are confined to Darjeeling only.

The liverwort flora of the Eastern Himalaya is further characterised by the presence of such monotypic taxa as *Gerhildiella rossneriana, Schiffneria hyalina, Blasia pusila, Monoselenium tenerum, Lunularia cruciata, Diplocolea sikkimensis,* etc. of which the last one is endemic to this territory. The region also abounds in a number of temperate and alpine taxa, such as *Acrobolbus ciliatus, Anastrepta orcadensis, Anastrophyllum assimile, A. donnianum, A. joergensenii, Cololejeunea longifolia, C. obliqua, Conocephalum supradecompositum, Diplophyllum trollii, Drepanolejeunea angustifolia, Folioceros glandulosus, Horikawaella albula, Kurzia makinoana, Lejeunea curviloba, Lophozia incisa, Marsupella revoluta, Megaceros tjibodensis, Metahygrobiella albula, Metzgeria decipiens, M. sanguinea, Mylia taylori, Ptilidium ciliare, Riccia beyrichiana, R. huebeneriana, Southbya grollei, Tritomaria exsecta, Xenochila integrifolia,* which exhibit an interesting range of distribution (Table V).

Apart from that, this region also abounds in a number of ubiquitous elements like *Chiloscyphus polyanthos, Cololejeunea minutissima, Frullania ericoides, Lejeunea flava, Targionia hypophylla,* etc. An interesting aspect of the flora of this territory is the occurrence of two species of *Colura* Dum. (*C. calyptrifolia* and *C. tenuicornis*), a genus recently added to the Indian bryoflora from Darjeeling (Lal, 1977). It is rather significant to note that the only other two species, viz. *C. acroloba* and *C. ari,* reported from this country, are restricted to Andaman islands in Indian bryology ((Singh, 1992).

These noteworthy aspects of the liverwort flora of this territory notwithstanding, the East Himalayan region, especially the major parts of North-east India, still remains hepaticologically one of the lesser studied parts of our country. If the discovery of new species and new records from the region, every now and then, are any indication, once thoroughly worked out, this territory is expected to add many more floristic marvels to the liverwort flora of India.

The Panjab & West Rajasthan Plains

This area with a low and irregular annual precipitation, ranging between 40-100 cm, in most parts is rather not well suited for the growth of liverworts. As such mostly xeromorphic forms, such as *Asterella, Mannia, Plagiochasma, Riccia,* etc. (Kashyap, 1929, 1932) occur in this region, mostly showing a closer affinity to the West Himalayan flora. In the South-western parts of Rajasthan, especially in the Aravali hills, where the growth conditions are comparatively more congenial, taxa like *Anthoceros erectus, Aneura pinguis, Asterella angusta, A. blumeana, Calycularia crispula, Marchantia polymorpha, Metzgeria himalayensis, Notothylas himalayensis, N. levieri, Pellia epiphylla, Riccia billardieri, R. frostii, R. gangetica, R. plana, Targionia hypophylla,* etc. are more commonly seen (Bapna & Vyas, 1962; Udar & Singh, 1981).

This bryogeographic territory of the country is host to about 34 species belonging to 17 genera and 13 families (Table III) of which 5 species are confined to this region alone. Ricciaceae, with 13 species, is the largest family in the territory followed by Rebouliaceae (7) Targioniaceae (3) and Fossombroniaceae (2). The rest are represented by just a single species only. Similarly, *Riccia* with 13 species is the largest geneus, distantly followed by *Plagiochasma* (3), *Asterella* (2), *Mannia*

(2) and *Cyathodium* (2). The region is also characterised by the presence of about 12 endemic taxa (Table IV) of which three, viz. *Riccia abuensis, R. jodhpurensis* and *R. reticulata* are confined to this territory alone. The others are common with rest of the country except the Andaman & Nicobar islands. It is rather significant that so far no foliaceous liverwort has been recorded from this region (Singh, 1992), which forms a sort of meeting ground for the flora of Western ghats and the Western Himalayas. It is further credited with the occurrence of a phylogenetically significant taxon *Petalophyllum indicum*, which it also shares with above two bryogeographical regions.

The Gangetic Plains

The territory, which stretches through the plains of Uttar Pradesh, Bihar and the West Bengal, like the Panjab & West Rajasthan plains, is unsuited for the growth of liverworts. So far only about 18 species, belonging to 9 families and 11 genera, have been recorded from this region 3 of which, including *Riella affinis* are confined to this territory alone in Indian bryoflora (Table III). Interestingly *Riccia* with 10 species is the largest genus in this territory also followed by *Cyathodium* with just 2 species. Only Lucknow appears to have been thoroughly worked out in this region from where *ca* 15 species of liverworts, including 8 species of *Riccia*, are recorded. The notable among them are the species of *Asterella, Plagiochasma, Cyathodium cavernarum, Notothylas indica, Anthoceros crispulus, Riccia cruciata, R. curtisii, R. gangetica, R. pimodii* and *Riella affinis* (Singh, 1992). This territory is also characterised by the occurrence of about 5 endemic species of which *Frullania inflata* var. *dioica* and *Riccia pimodii* are confined only to this region (Table IV).

The Central Indian Territory

The Central Indian zone, encompassing the states of Orissa, Madhya Pradesh, Gujarat and parts of Maharashtra and Rajasthan, has received better attention, with respect to the study of liverworts, as compared to the previous two bryogeographical regions (Udar, 1976; Singh, 1984, 1992. Srivastava, 1994; Kaul, 1995). Though the region experiences a moderate rainfall, the hepatic vegetation here is comparatively more luxuriant. In all 61 taxa of liverworts belonging to 21 families and 32 genera are so far been recorded from this territory (Table III). While the family Ricciaceae, with 12 species, predominates the territory followed by Lejeuneaceae and

Rebouliacieae, with 7 each, Radulaceae (5), Aneuraceae (4), Jungermanniaceae and Targioniaceae, with 3 each, and Anthocorotaceae, Phaeocerotaceae, Notothylaceae and Cephaloziellaceae with 2 each, *Riccia* (12) is the largest genus followed by *Radula* (5), *Jungermannia, Plagiochasma, Asterella* and *Riccardia,* with 3 species each, and *Frullania, Lejeunea, Phaeoceros* and *Notothylas* with 2 species each, showing affinity mostly to Himalayan and the Western ghat's flora. Broadly speaking the Central Indian territory, together with the territories of Panjab & West Rajasthan and the Gangetic plains, apparently forms a connecting link between the liverwort flora of the Himalayas and that of the Peninsular India (Singh, 1992).

The hepatic flora of the Central India is further characterised by the presence of 6 endemic taxa of which, *Riccardia santapaui,* and *Folioceros satpurensis* are confined to this territory only (Table IV).

The Western Ghats

This bryogeographical territory virtually comprises two distinct physiographic regions; (a) The West Coast Plain, which stretches from the mouth of Tapti to Kanyakumari, between the hilly Western ghats and the sea, and is invariably less than 65 km in width anywhere, and abounds in several epiphytic taxa occurring at sea level, and (b) The Western ghats - the mountainous terrain formed by North-South oriented hill ranges that rise abruptly from the coastal plain. These hill ranges, that run almost parallel to the coastal plain, average between 700-1300 m in height, with the few isolated peaks, such as Doddabetta (2636 m) and Makurti (2554 m) in Nilgiris; Anaimudi (2639 m) in the Anamalais and Vembadi Shola (2505 m) in the Palni hills, rising higher obtaining almost temperate climes. The entire territory receives heavy annual precipitation of over 400 cm and fosters one of the richest liverwort flora in the country next only to the Eastern Himalaya. The bryogeographical region of the West coast and the Western Ghats together host about 280 taxa spreading over to about 32 families and 79 genera (Table III), which accounts for about 35 per cent of the total liverwort flora of the country. Of these, family Chonecoleaceae and Schistochilaceae, 9 genera and about 121 species are confined to this region alone in Indian bryoflora (Chopra, 1938a; Udar & Singh, 1979, 1979a; Awasthi & Udar, 1984, Udar & A. Kumar, 1985; Udar & G. Srivastava, 1982, 1983, 1985; Udar & Gupta, 1983a; Udar *et al.* 1982a, 1983; Udar & Jain, 1984; Awasthi & Srivastava, 1988; Srivastava & G. Srivastava, 1989; Asthana & Srivastava, 1991; Singh, 1992; Parihar, 1994; Srivastava 1994). It is rather significant that while family Chonecoleaceae is essentially a South American taxon interestingly represented in Indian bryoflora, the family Schistochilaceae is largely distributed in antipodal region.

Lejeuneaceae, with 85 taxa is the largest family in this territory, whereas *Cololejeunea* (23) is the largest genus. The table below provides the details of the dominant family and genera of the region.

Family	Genera/species	Genus	Species
Lejeuneaceae	26/85	**Cololejeunea**	23
Ricciaceae	2/18	**Frullania**	17
Jubulaceae	1/17	**Riccia**	17
Rebouliaceae	3/15	**Radula**	14
Jungermanniaceae	3/13	**Plagiochila**	13
Plagiochilaceae	1/13	**Metzgeria**	9
Radulaceae	1/10	**Porella**	9
Anthocerotaceae	2/9	**Asterella**	9
Metzgeriaceae	1/9	**Jungermannia**	8
Geocalycaceae	3/8	**Lejeunea**	7

The Western ghats, as a whole, are endowed with an interesting hepatic flora that shows striking similarity with that of Africa, Indo-Malaya and the East Himalayan territory. The region is characterised by the occurrence of such phytogeographically interesting species as *Cephaloziella kiaeri, Ceratolejeunea singapurensis, Cololejeunea auriculata, C. marginata, C. minutissima, C. ocellata, Dicranolejeunea yoshinagana, Exormotheca ceylonensis, Gottschelia schizopleura, Jackiella ceylanica, Jungermannia pusilla, Lopholejeunea abortiva, Lunularia cruciata, Mastigolejeunea flavescens, Notothylas dissecta, Porella caespitans* var. *setigera, Radula onraedtii, R. protensa,* etc. (Table V). Besides, the genus *Archilejeunea* (with 3 species), *Caudalejeunea* (3 species) and *Schiffneriolejeunea* (4 species) are confined only to this territory as well as the Andaman & Nicobar Islands in the Indian bryology. Further, the genus *Acrolejeunea* shows maximum differentiation in Western ghats with four, viz. *A. fertilis, A. parvula, A. pycnoclada* and *A. sikkimensis,* out of five Indian species growing in this territory. Apart from that, all the Indian species belonging to genera *Dicranolejeunea, Mastigolejeunea* and *Spruceanthus* are represented in this zone.

These territoreis are further characterised by the presence of 65 endemic species, including infraspecific taxa (Table IV). Of these 41 taxa such as *Anthoceros macrosporus, Asterella mysorensis, Chonecolea schusteri, Folioceros dixitianus. F. mangaloreus, F. udarii, Frullania pyriflora, Herbertus nilgiriensis, H. pinnata, Heteroscyphus perfoliatus. Jungermannia incurvifolia, J. kashyapii, J. pfleidereri, Lethocolea indica, Metzgeria lutescens, M. pandei, Notothylas anaporata, N. pandei, N. pfleiderei,* etc. are confined to these regions only, whereas others are common with the rest of the country. The genera *Archilejeunea, Cololejeunea, Fossombronia, Metzgeria,* and *Notothylas* show higher endemism in these territories as compared to any other bryogeographical region of the country. It is significant to note that the Western ghats are considered to be the centre of origin and diversity for the genus *Notothylas* because of the number and the phylogenetic status of its species represented in the region, (Singh, 1995a).

The Eastern Ghats & the Deccan Plateau

Like the Western ghats, this region too presents two discernible physiographic areas : (i) The Deccan plateau, and (ii) The Eastern ghats, comprising a series of detached hill ranges stretching intermittently from the northern border of Orissa, through the costal regions of Andhra Pradesh turning towards the west to meet the Western ghats. These areas have almost never been investigated in Indian hepaticology. Nevertheless, the available data (Chopra, 1938a; Pande, 1958; Singh, 1992; Singh & Semwal, 1995) reveals that *ca* 33 species of liverworts, belonging to 14 families, and almost equal number of genera (Table III), none of which are confined exclusively to these territories, have so far been recorded from the region.

The region has no distinctive liverwort flora of its own. It shows elements common to the Western ghats and the Andaman & Nicobar Islands on one hand, and to Indo-Malayan countries like Java, Farmosa, Sumatra, Philippines, Luzon, Borneo, Thailand Caroline Islands, etc. on the other. *Anthoceros bharadwajii* is the only endemic species known from this zone, but it also occurs in other bryogeographical regions (Table IV). Some of the liverworts recorded from this region are *Bazzania tridens, Cephalozia andreana, Cyathodium cavernarum, Exormotheca ceylanica, Frullania arecae, F. nodulosa, F. recurvata, F. subinflata, F. wallichiana, Jungermannia purpurata, Lunularia cruciata, Mastigolejeunea repleta, Porella acutifolia, Radula foreauana Reboulia hemisphaerica, Riccia fluitans,* etc.

The Andaman & Nicobar Islands

The bryogeographical region of Andaman & Nicobar Islands as proposed by Singh (1992, see also Singh & Semwal, 1995) lies within 6°25' 14°5' N latitudes and 92°25' 94°12' E longitudes, in the South-eastern Bay of Bengal and comprise over 300 islands. Both the Andaman and Nicobar are said to be geomorphologically distinct group of islands (Renvoize, 1979) with the former representing the continental fragments, whereas the latter are volcanic in nature.

The flora of oceanic islands are considered to be of considerable phytogeographical significance as it usually show a high degree of endemism. However, the liverwort flora of Andaman & Nicobar is virtually unknown, with no concerted attempt being made so far to systematically work out the hepatics of these islands. Nonetheless, as per the available informations through sporadic publications (Kachroo, 1970; Udar, 1976; Lal, 1980; Udar & A. Kumar, 1983, Udar & Awasthi, 1982a; Awasthi & Udar, 1984; Long & Grolle, 1990; Asthana & Srivastava, 1991; Parihar, 1994; Joshi, 1995; Chavan & Joshi, 1995) about 53 taxa belongings to 12 families and 40 genera have so far been recorded from these islands (Table III). This include mostly cortiicolous or foliicolous Jungermannioid taxa, such as *Acrolejeunea cumingiana, A. fertilis, A. parvula, A. pycnoclada, Bazzania* sp , *Caudalejeunea cristiloba, C. reniloba, Cephaloziella kiaeri, Ceratolejeunea singapurensis, Cheilolejeunea intertexta, C. orientalis, C. trifaria, Cololejeunea appressa, C. longifolia, C. obliqua, Colura acroloba, C. ari, Jungermannia tetragona, Lejeunea wallichiana, Leptolejeunea balansae, Lopholejeunea eulopha, Mastigolejeunea humilis, M. repleta, Plagiochila* sp., *Ptychanthus striatus, Radula kurzii, R. sandei, Schiffneriolejeunea tumida, S. pulopenangensis, Thysananthus gottschei, T. spathulistipus,* in the tropical wet evergreen, semi-evergreen and moist deciduous forests of *Dipterocarpus, Pterocarpus, Endospermum, Terminalia, Canarium, Chuckrasia, Calophyllum, Miliusa, Alstonia, Hopea,* etc., in these islands. The genus *Hygrolejeunea* and about 19 species are confined to this bryogeographical region alone in Indian bryology. In the present state of our knowledge, Lejeuneaceae with about 33 taxa, is the largest family in these islands followed by Jubulaceae (3), and Jungermanniaceae, Radulaceae and Notothylaceae (with 2 species each), whereas *Acrolejeunea* with 4 species is the largest genus, followed by *Frullania, Cheilolejeunea, Leptolejeunea, Cololejeunea* (with 3 species each) and *Jungermannia, Radula, Caudalejeunea, Mastigolejeunea,* *Schiffneriolejeunea, Archilejeunea, Thysananthus, Colura, Notothylas* (with 2 species each). The only thalloid liverwort so far recorded from these territories are *Folioceros spinisporns, Notothylas dissecta, N. pfleidereri* and *Cyathodium* sp. (Singh, 1992; Joshi, 1995). The liverwort flora in these islands, as a whole, has a greater resemblance with that of the peninsular India, Sri Lanka and the countries in Indian Archipelago.

The territory is so far known to have about eight endemic taxa (Table IV) of which six, viz. *Frullania manii, F. nicobarica, Porella densifolia* subsp. *andamana, Pycnolejeunea nicobarica, Taxilejeunea laxiretis* are confined to these territories only (Bonner, 1965; Kachroo, 1970). Of these, while *Hygrolejeunea, Pycnolejeunea, Taxilejeunea* and *Frullania nicobarica* are restricted to Nicobar islands, the remaining two have been recorded from Andaman only.

ENDEMISM

The endemism in a country or in a geographical region provides an insight into the biogeography, centres of diversity, vicariance and the adaptive evolution of the biological components of that particular country or the region, and highlights the indigenous nature of its biological diversity. It may evolve either by selective biotic extinction of the biological components, once widespread, over most of its range of distribution during the millions of years, or through speciation triggered by the selection pressure consequent to physical isolation of their habitat, normally associated with climatological influences during the Pleistocene glaciation (Pande, 1958; Schuster, 1982; Singh, 1993).

The combined factors like (i) the aftermath of the Pleistocene glaciation, (ii) the diverse climatic conditions and the physiography so congenial for the growth of vast variety of liverworts, and (iii) the physical barriers like the high mountain ranges in the North, the great oceanic barriers in the South and the hot arid conditions in the West, have all contributed to considerably high endemism of liverworts in India. Besides, the conducive conditions, prevailing particularly in the peninsular and the Himalayan region, including the North-eastern India, apparently, have also resulted into speciation and proliferation in several genera, thereby adding to the endemism in the hepatic flora of the country. A perusal of literature shows that over 260 taxa or about 30 per cent of the total liverwort flora, including one family (Aitchisoniellaceae) and five genera (*Aitchisoniella* Kash., *Sewardiella* Kash., *Stephensoniella* Kash. *Sauchia* Kash. and

Diplocolea Amak.). are endemic to different regions of the country with their maximum representation in the Eastern Himalaya followed by the Western ghats and the Western Himalaya, much like the pattern exhibited by the angiospermic flora (Chatterjee, 1940; Jain & Mehrotra, 1980; Ahmedullah & Nayar 1987). Table IV shows some endemic liverworts and their distribution in the country.

Table IV
Some endemic liverworts and hornworts of India and their distribution in different bryogeographical regions

Name of the taxa	Distribution	Remarks
HAPLOMITRIACEAE		
Calobryum dentatum	EH	Rare, confined only to Darjeeling
C. indicum	EH	Rare, confined only to Darjeeling
Haplomitrium grollei	EH	Rare, confined only to Ghoom area
H. kashyapii	EH	Rare, confined only to Darjeeling
HERBERTACEAE		
Herbertus nilgerriensis	WG	
H. pinnata	WG	
H. lonchobasis	EH	Rare
H. mastigophoroides	EH	Rare
H. nicholsonii	EH	Rare
H. darjeelingensis	EH	
BLEPHAROSTOMATACEAE		
Pseudolepicolea trollii var. *darjeelingensis*	EH	
Lophochaete trollii	EH	Extremely rare

Name of the taxa	Distribution	Remarks
TRICHOCOLEACEAE		
Ttrichocolea indica	EH	
T. tenera	EH	Rare
T. udarii	EH	
LEPIDOZIACEAE		
Bazzania amplicata	EH	
Lepidozia plicatistipula	EH	
L. udarii	EH	
CEPHALOZIACEAE		
Cephalozia kashyapii	EH	Rare
C. pandei	EH	Rare
C. udarii	WH	Rare
Nowellia indica	WH	Rare
Pleuroclada albula	EH	Rare
CEPHALOZIELLACEAE		
Çephaloziella dentifolia	EH; WH	
C. indica	EH	
C. magna	WH	
C. meghalayensis	EH	
Cylindrocolea reticulata	EH	Rare
JUNGERMANNIACEAE		
Anastrophyllum revolvens	EH	
A. subacutum	EH	
Cuspidatula nicholsonii	EH	
Diplocolea sikkimensis	EH	An endemic, monotypic taxon; rare
Jungermannia appressifolia	EH	
J. atrobrunea	EH	
J. limbatifolia	EH	
J. pfleidereri	WG	
J. pseudodecolyana	EH	
J. purpurata	EH	
J. schauliana	EH	

Name of the taxa	Distribution	Remarks
J. subrubra	EH	Rare
J. udarii	EH	
Nardia assamica	EH	
Notoscyphus darjeelingensis	EH; WG	
N. pandei	EH; WG	
SCAPANIACEAE		
Scapania angusta	EH; WH	
S. harae	EH	
S. himalayica	EH	
S. pseudoferruginea	EH	
S. pseudoferruginea	EH	
S. udarii	WH	
GEOCALYCACEAE		
Heteroscyphus perfoliatus	WG	Rare
H. udarii	EH	
PLAGIOCHILACEAE		
Plagiochila flavovirens	WH	
P. forficata	WH; WG	
P. khasiana	EH	
P. luthiana	EH; WG	
P. pseudopoeltii	EH	
P. richteri	WG	Rare, known only through the type collection.
P. runcinata	EH	
P. udarii	WH	
P. woronofii	WG	Rare, known only through the type collection.
CHONECOLEACEAE		
Chonecolea schusterii	WG	Rare, confined only to Bandishola

Name of the taxa	Distribution	Remarks
ACROBOLBACEAE		
Lethocolea indica	WG	Rare
Tylimanthus indicus	WG	Rare
BALANTIOPSIDACEAE		
Isotachis indica	EH; WG	Rare
RADULACEAE		
Radula nilgiriensis	WG	Rare
R. pandei	WG; CI	
PORELLACEAE		
Porella campylophylla var. *ptycantha*	EH; WH	
P. campylophylla subsp. *lancistipula*	WG	
P. chinensis var. *decurrens*	WH	
P. chinensis var. *irregularis*	WG	
P. chinensis f. *hastata*	WH	
P. densifolia subsp. *andamana*	A&N	
P. hattorii	WH; WG	Rare
JUBULACEAE		
Jubula hattorii	EH	
J. himalayensis	WH	
Frullania evelynae	EH	
F. gracilis subsp. *zennoskei*	EH	
F. hattoriantha	EH	Rare, confined only to Darjeeling.
Frullania inflata var. *dioica*	GP	
F. pariharii	EH	Rare, confined only to Darjeeling.

Name of the taxa	Distribution	Remarks
F. pariharii f. *intermedia*	EH	
F. pseudoschensiana	EH	Rare, confined only to Shillong peak.
P. pseudoschensiana var. *darjeelingensis*	EH	
F. retusa	EH	
F. rhytidantha	EH	
F. sharpantha	EH	Rare, confined only to Tanglu
F. sphaerantha	EH	Rare, confined only to Mawphlang
F. subclavata	WH	
F. subpedicellata	EH; WH	
LEJEUNEACEAE		
Acrolejeunea sikkimensis	EH; WH	
Archilejeunea apiculifolia	WG	
A. minutilobula	WG	
Caudalejeunea pluriplicata	WG	
Cololejeunea dentifolia	WG	
C. foliicola	WG	
C. indica	EH	
C. kashyapii	WG	
C. mizutaniana	WG	
C. pandei	WG	
Drepanolejeunea pulla	EH	Rare; no collection after J.D. Hooker
Leucolejeunea turgida	EH	
Lejeunea indica	EH	
Leptolejeunea himalayensis	EH	Rare
L. sikkimensis	EH	Rare
Lopholejeunea acmella	EH	
L. gradsteinii	WG	
Microlejeunea punctiformis	EH; WG	
Pycnolejeunea nicobarica	A&N	

Name of the taxa	Distribution	Remarks
Schiffneriolejeunea indica	WG	
Strepsilejeunea papillata	EH	
Taxilejeunea himalayensis	EH	
FOSSOMBRONIACEAE		
Fossombronia foreaui	WG	Rare
F. himalayensis	WH; WG	
F. indica	WG	Rare
F. kashyapii	WH	Rare
Petalophyllum indicum	P&WR; WG	Rare
Sewardiella tuberifera	WH	an endemic, monotypic taxon; extremely rare.
PALLAVICINIACEAE		
Pallavicinia himalayensis	EH	Rare
ANEURACEAE		
Aneura indica	WH; P&WR	
Riccardia cardotii	EH	Extremely rare, known only through type collection from Sikkim.
Riccardia perssonii	WH	
R. santapaui	CI	
R. sikkimensis	EH; WH	Rare
R. villosa	EH	Extremely rare, only once collected in 1941 since its original collection.
METZGERIACEAE		
Metzgeria assamica	EH	Rare, confined only to Shillong peak

Name of the taxa	Distribution	Remarks
M. crispula	EH	Rare; known only through type collection.
Metzgeria himalayensis	EH; WH;	
M. indica	WG	
M. lutescens	WG	Extremely rare; known only through type collection.
M. madagassa	EH	Extremely rare; known only through type collection
M. nilgiriensis	WG	
M. pandei	WG	Rare
TARGIONIACEAE		
Aitchisoniella himalayensis	WH	An endemic, monotypic taxon; extremely rare.
TARGIONIACEAE		
Cyathodium denticulatum	EH	Rare
C. indicum	WH	Rare
C. mehranum	EH	Extremely rare.
C. samaragdinum	WG	
C. tuberculatum	EH	Rare
Targionia indica	WH	
SAUTERIACEAE		
Athalamia pinguis	WH	Rare
Athalamia pusilla	WH	Extremely rare.
Sauchia spongiosa	WH	An endemic, monotypic taxon; rare
REBOULIACEAE		
Asterella angusta	EH; WH; P&WR; GP; CI	

Name of the taxa	Distribution	Remarks
A. mysorensis	WG	
A. reticulata	WH	
Cryptomitrium himalayense	WH	
Mannia foreaui	WH	Rare
M. indica	WH;	
		P&WR; GP
M. personii	WH	Rare
Plagiochasma pauriana	WH	Rare
Reboulia hemisphaerica var. *pangiensis*	EH; WH	
EXORMOTHECACEAE		
Exormotheca tuberifera	WH; WG;CI	Rare
Stephensoniella brevipedunculata	WH	An endemic, mono-typic taxon; rare.
MARCHANTIACEAE		
Marchantia kashyapii	WH	
RICCIACEAE		
Riccia abuensis	P&WR	
R. aravalliensis	P&WR	
R. grollei	WH; P&WR; CI; WG	
R. indica	WH	Rare
R. jodhpurensis	P&WR	
R. melanospora	P&WR; GP; WG	
R. pandei	WH	
R. pimodii	GP	Rare, known only through type collection from Burdwan.
R. reticulata	P&WR	Rare
NOTOTHYLACEAE		
Notothylas anaporata	WG	Rare
N. himalayensis	WH; P&WR	

Name of the taxa	Distribution	Remarks
N. khasiana	EH	Rare; known only through type collection from Upper Shillong.
N. pandei	WG	Rare
N. pfleidereri	WG; A&N	Rare
PHAEOCEROTACEAE		
Phaeoceros himalayensis	EH; WH	
P. kashyapii	WH	Rare; confined only to Deoban.
P. udarii		
ANTHOCEROTACEAE		
Anthoceros alpinus	WH	Extremely rare; known only through type coll ection from Mussoorie.
A. bharadwajii	EH; WH; WG; EG&DP	
A. erectus	EH; WH; WG	
A. macrosporus	WG	Extremely rare; known only through type collection from Borghat (Khandala).
A. pandei	EH	Rare
Folioceros assamicus	EH	Rare; known only through type collection from Gauhati-Shillong Road (55th - 57th mile).
F. dixitianus	WG	

Name of the taxa	Distribution	Remarks
F. indicus	WH	Rare; known only through type collection from Munsyari-Melam.
Folioceros kashyapii	EH	
F. mangaloreus	WG	Rare; known only through type collection from Mangalore.
F. paliformis	EH	Rare.
F. physocladus	EH	Extremely rare; known only through type collection from Kurseong.
F. satpurensis	CI	Rare; known only through type collection from Chota Mahadeo (Pachmarhi).
F. udarii	WG	

EH : Eastern Himalaya; WH : Western Himalaya; P&WR : Panjab & West Rajasthan Plains; GP : Gangetic Plains; CI: Central India; WG : Western Ghats; EG & DP : Eastern Ghats & the Deccan Plateau; A&N : Andaman & Nicobar Islands.

A brief insight into the endemic liverworts in different bryogeographical region of the country has already been provided in the preceding text. It is highly significant that the order Anthocerotales, considered to be representing a 'relict' taxon (Singh, 1993) exhibits as high as 61 per cent endemism with its 22 out of 36 taxa (Singh, 1993; Asthana & Nath, 1995) being endemic to the country. The Western ghats account for the maximum of 10 species followed by the Eastern Himalaya (8) and the Western Himalaya (7). The Gangetic plain is the only territory which has no endemic hornwort recorded so far.

Some of the other groups with notably high endemism in India are: Exormothecaceae (67 per cent), Haplomitriaceae (67 per cent), Fossombroniaceae (67 per cent), Scapaniaceae (58 per cent), Plagiochilaceae (52 per cent), Targioniaceae (50 per cent), Cephaloziaceae (42 per cent), Cephaloziellaceae (38 per cent), and Metzgeriaceae (33 per cent). At the generic level, while *Folioceros*, with 10 out of 13 hitherto recorded species from India exclusively confined to the country, shows 77 per cent endemism, the other genera (having more than 5 species in India) with more than 50 per cent endemic taxa are : *Scapania* (64 per cent), *Notothylas* (63 per cent), *Anthoceros* (56 per cent), *Cyathodium* (56 per cent), *Plagiochila* (54 per cent), etc.

PHYTOGEOGRAPHICAL AFFINITIES

The territorial contiguity of the Indian land-mass with the Middle East, Eurasia, Central Asia, China and East Asia has resulted into a closer floristic affinity between the liverworts of our country and that of several countries and regions. While the liverworts of western Himalayas show greater affinity with those of Central Asia and Europe, the East Himalayan flora is characterised by the presence of Indo-Malayan and Indo-Chinese elements. On the other end of the spectrum, some elements in the Indian liverwort flora represent the floristic element of such distant places as Africa, America, Australia and New Zealand, and thus show discontinuous or disjunct distribution (Table V). Such disjunct distribution of a particular species or vicariads in the regions now widely separated by vast oceanic barriers is of particular interest, and, as earlier noted by Steere and Inoue (1972), offer suggestive insight into :"..........different episodes in geological and climatological history which have influenced the migration and even survival of floras".

Based on the phytogeographical affinities, the following floristic groups are discernible amongst Indian liverworts (*see* also Kachroo, 1969, Singh, 1992):

Bipolar elements: *Anastrepta orcadensis*, *Blepharostoma tricophyllum*, *Apotreubia pubesence*, etc.

Eastern Asiatic elements: *Asterella sanguinea*, *Bazzania bidentata*, *B. himalayana*, *B. imbricata* *Cheilolejeunea khasiana*, *Cololejeunea* spp., *Conocephalum supradecompositum*, *Delayavela serrata*, *Frullania yuennanensis*, *Herbertus kurzii*, *Jungermannia* *schauliana, Jamesoniella autumnalis, Mannia fragrans, Mastigolejeunea* spp., *Mylia verruculosa, Lophozia setosa, Metacalypogeia alternifolia, Odontoschisma denudatum, Plagiochila flexuosa, Porella densifolia, Scapania* spp., *Spruceanthus semirepandus,* etc.

Subarctic elements: Anastrophyllum joergensenii, Apotreubia nana, Chandonanthus filiformis, Gymnomitrion concinnatum, Jungermannia hyalina, J. sphaerocarpa, Mastigophora woodsii, etc.

Circumboreal elements: *Acrobolbus ciliatus, Anastrophyllum assimile, A.donnianum, Bazzania pearsonii, B. tricrenata, Conocephalum conicum, Frullania tamariscii, Geocalyx graveolens, Lepidozia reptans, Lophozia incisa, Marsupella revoluta, Mylia taylori, Pleurozia purpurea Ptilidium ciliare, Trichocolea tomentella,* etc.

Pantropical elements: *Calycularia crispula, Cololejeunea cardiocarpa, Drepanolejeunea vesiculosa, Schiffneriolejeunea polycarpa, Leucolejeunea xanthocarpa, Lopholejeunea subfusca, Metzgeria consanguinea, Frullania arecae, F. nodulosa, Leptolejeunea elliptica, Notothylas,* etc.,

Palaeotropical elements: *Trocholejeunea sandvicensis, Cololejeunea lancilaoba, C. longifolia, C. obliqua, Colura* spp., *Drepanolejeunea ternatensis, Frullania squarrosa, F. moniliata, Gottschellia schizopleura, Jungermannia pusilla, J. tetragona, Ptychanthus striatus, Cyathodium* spp., etc.

Ubiquitous elements : *Aneura pinguis, Cololejeunea minutissima, Frullania ericoides, Lophocolea bidentata, Metzgeria hamata, Pallavicinia lyelli, Reboulia hemisphaerica, Riccia fluitans, Ricciocarpus natans, Targionia hypophylla, Dumortiera hirsuta, Lunularia cruciata, Marchantia paleacea, M. polymorpha, Phaeoceros laevis,* etc.

Subantarctic elements : *Temnoma setigerum, Lethocolea, Tylimanthus, Schistochila,* etc.

Endemics : The endemic liverworts and hornworts and their distribution in different bryogeographical regions of India are shown in Table IV.

Disjuncts : Some liverworts and hornworts, showing interesting trans-continental or trans-oceanic disjunct distribution are presented in Table V.

Table V
Some disjunct liverworts of India and their phytogeographical affinities

Name	Distribution
HAPLOMITRIACEAE	
Calobryum blumii	India (EH), Java, Sumatra, New Guinea.
Haplomitrium hookeri	India (WH), Europe, N.America.
HERBERTACEAE	
Herbertus dicrana	India, (EH, WG), China, Thailand, Taiwan, E. Africa.
Herbertus kurzii	India, (EH, WH), China, Taiwan.
Herbertus sendtneri	India, (W.H.), China, Taiwan.
BLEPHAROSTOMATACEAE	
Blepharostoma trichophyllum	India, (Himalayas), N., C. & S. America, E. Africa; boreal as well as antipodal.
LEPIDOZIACEAE	
Bazzania pearsonii	India (EH), Sri Lanka, China, Thailand, Japan, Europe, Canada, Alaska.
Bazzania tricrenata	India(EH), Guatemala; circumboreal in Asia,Europe, N. America.
Kurzia makinoana	India (EH), China, Taiwan, Korea, Japan, Philippines, Canada, Alaska.
Lepidozia reptans	India (EH), C. & S. America, common in cool moist parts of northern hemisphere.

Name	Distribution
CEPHALOZIELLACEAE	
Cephaloziella kiaerii	India (WG, A&N), Sri Lanka, Java, Malaya, New Caledonia, Thailand, China, Africa.
Cephaloziella microphylla	India (EH), Japan, China.
Cephaloziella subdentata	India (EH), Germany.
Cylindrocolea chevalieri	India (WG); Africa
ANTHELIACEAE	
Anthelia julacea	India (WH); N. Asia, Europe, N. America.
JUNGERMANNIACEAE	
Anastrepta orcadensis	India (EH), China, Taiwan, Japan, Hawai, Europe, N. America.
Anastrophyllum assimile	India (EH), Arctic-alpine in China, Japan, Indian archipelago, Europe, N. America, Greenland.
Anastrophyllum donnianum	India (EH), China, Czechoslovakia, Canada, Norway.
Anastrophyllum joergensenii	India (EH), China, Norway.
Chandonanthus birmensis	India (EH), Myanmar, Java, Japan, Madagascar.
Chandonanthus filiformis	India (EH), China, Taiwan, Japan, British Columbia, Spain.
Chandonanthus hirtellus	India (EH), Asia-Pacific, Madagascar, Mitt. Africa, Canada.
Gottschelia schizopleura	India (WG), Sri Lanka, New Guinea, Madagascar.
Jamesoniella elongella	India (EHWH), Valley of Flowers), Sri Lanka, China.
Jamesoniella nipponica	India (EH, WH), Japan, Taiwan.
Jungermannia rubripunctata	India (EH), Nepal, Japan.
Jungermannia pyriflora	India (EH), Japan, Korea, Taiwan, N. America.
Jungermannia tetragona	India (EH), Indian archipelago, New Caledonia, Australia, Oceania.

Name	Distribution
Lophozia incisa	India (EH), Temperate-Boreal Asia, Europe, North, C. & S. America.
Mylia taylorii	India (EH), circumboreal in Asia, Europe, N. America.
GYMNOMITRIACEAE	
Cymnomitrion concinnatum	India (WH), Europe, N. America.
Marsupella revoluta	India (EH), China, Taiwan, Japan, Europe, Greenland, N. & S. America.
SCAPANIACEAE	
Scapania orinthopodioides	India (WH, EH), China, Taiwan, Japan, Hawai Europe.
GEOCALYCACEAE	
Geocalyx graveolens	India (EH, WH), Japan, Siberia, Europe, N. America.
Heteroscyphus argutus	India (WH, EH), Indian archipelago, Australia, New Zealand.
Lophocolea bidentata	India (WH, EH), Europe, Middle East, Africa, N. & C., S. America, New Zealand.
Lophocolea minor	India (WH), temperate Aisa, Europe, N. America.
Lophocolea muricata	India (WG), Sri Lanka, Indonesia, New Guinea, Australia, New Zealand, Africa, N. & S. America. Pantropical - temperate antipodal.
PLAGIOCHILACEAE	
Plagiochila flexuosa	India (EH, WG), Sri Lanka, Thailand, Taiwan, Japan.

Name	Distribution
Plagiochila sciophylla	India (EH), S.E. Asia, N. America.
Xenochila integrifolia	India (EH), China, Taiwan, Korea, Japan.
ACROBOLBACEAE	
Acrobolbus ciliatus	India (EH), China, Taiwan, Japan, N. America, Alaska.
PLEUROZIACEAE	
Pleurozia purpurea	Indian (EH), China; Taiwan, Japan, Atlantic Europe, Alaska.
MASTIGOPHORACEAE	
Mastigophora woodsii	India (EH), China, Taiwan, W. Europe, British Columbia.
JUBULACEAE	
Frullania arecae	India (EG & DP), China, Africa. S. America.
Frullania gracillima	India (WH), Australia.
Frullania nodulosa	India (WG), Indo-Malaya, Polynesia, Australia, C. & S. America, Africa.
Frullania sinensis	India (EH), China.
Frullania tuyamae	India (Ukhrul), Laos.
Frullania wallichiana	India (EH, WH), Java, Philippines, Australia.
Jubula hutchinsiae subsp. *javanica*	India (EH), Java, Japan, Taiwan, Madagascar.
LEJEUNEACEAE	
Anomalolejeunea pluriplicata	India (EH), S. Africa
Cheilolejeunea khasiana	India (EH), China, Japan.
Cololejeunea auriculata	India (WG), S. Africa.
Cololejeunea cardiocarpa	India (WG), N., C. & S. America, Africa.
Cololejeunea furcilobulata	India (WG); Nigeria

Name	Distribution
Cololejeunea longifolia	India (EH, A&N), Sri Lanka, China, Java,.S. Africa.
Cololejeunea obliqua	India (A&N), S.E. Asia, Madagascar, Africa.
Colura calyptrifolia	India (EH), Europe, S. America.
Dicranolejeunea yoshinagana	India (WG), Japan.
Drepanolejeunea erecta	India (EH), Nepal, China, Japan.
Drepanolejeunea ternatensis	India (WG), Indo-Malaya, Japan, St. Australia, Norfolk Is.
Drepanolejeunea vesiculosa	India (EH), Indo-Malaya, Tahiti, Norfolk Is.
Frullanoides intuscata	India (WG), Nepal, America, Africa.
Lejeunea curviloba	India (EH), Japan.
Leptolejeunea elliptica	India (EH), S.E. Asia, S. America
Leucolejeunea paroica	India (EH), Japan.
Leucolejeunea xanthocarpa	India (WG), Sri Lanka, Japan, China, Africa, N. & S. America.
Mastigolejeunea flavescens	India (WG), Japan.
Rhaphidolejeunea foliicola	India (EH), Japan.
Rhaphidolejeunea yunnanensis	India (EH, WG), China, Vietnam.
Schiffneriolejeunea polycarpa	India (WG), Sri Lanka, Africa, Puerto Rico, S. America.
TREUBIACEAE	
Apotreubia nana	India (EH), China, Japan, British Columbia.
FOSSOMBRONIACEAE	
Fossombronia cristula	India (EH, WG), Japan, N. America.
Fossombronia pusilla	India (WG), Europe, N.America, Chile.
Fossombronia wondraczekii	India (WG), N. Africa, N. America.

Name	Distribution
ALLISONIACEAE	
Calycularia crispula	India (EH, WH), Myanmar, Thailand, Korea, Taiwan, Japan, Africa, Mexico.
MAKINOACEAE	
Makinoa crispata	India (EH), Japan.
BLASIACEAE	
Blasia pusilla	India (EH, WH), Europe, America.
ANEURACEAE	
Aneura pellioides	India (EH), Japan.
METZGERIACEAE	
Apometzgeria pubescens	India (EH, WH), N. Asia, Europe, N. & S. America.
Metzgeria consanguinea	India (EH), Sri Lanka, New Guinea, Java, Sumatra, Africa, S. America.
Metzgeria decipiens	India (EH), S.E. Asia, Australia, C.& S. America.
TARGIONIACEAE	
Targionia lorbeeriana	India (WG), Africa, Sicilia, Sardinia, Portugal, Morocco, France.
WIESNERELLACEAE	
Wiesnerella denudata	India (WH), China, Papua New Guinea.
CONOCEPHALACEAE	
Conocephalum conicum	India (WH, EH), China, Korea, Japan, Africa, Europe, N. America, Siberia.
Conocephalum supradecompositum	India (EH), China, Japan.

Name	Distribution
REBOULIACEAE	
Asterella leptophylla	India (EH, WG), Russia.
MONOSELENIACEAE	
Monoselenium tenerum	India (EH, WH), China, Japan, Hawai.
RICCIACEAE	
Riccia berychiana	India (EH) Europe, N. America.
Riccia crozalsii	India (WG), Israel, Europe.
Riccia hirta	India (WH), N. America.
NOTOTHYLACEAE	
Notothylas dissecta	India (WG, A&N), Guatemala.
Notothylas levieri	India (EH, WH, P&WR), Brazil.
ANTHOCEROTACEAE	
Anthoceros angustus	India (EH, WH), Japan.
Anthoceros crispulus	India (EH, WH, GP, WG), Europe, U.S.A.
Anthoceros punctatus	India (EH, WH), China, England, N. Europe, N. & S. America, New Caledonia
Folioceros glandulosus	India (EH), Australia.
PHAEOCEROTACEAE	
Phaeoceros laevis subsp. *carolinianus*	India (WH, EH, WG), Myanmar, Guyana, Europe, N. America, Australia.

The species included in different floristic groups may be widespread, or show a discontinous distribution within and even outside their respective floristic zones.

The disjunction of different types is known among all the major groups of plants (see Sharp, 1972). Because of great phytogeographical significance, of such phenomenaon several attempts have been made to explain various distributional patterns, extent of their ranges, and the regional correlations, particularly in case of foliaceous liverworts(see Singh, 1995a). The theory of past land connections has usually been taken into account while explaining the trans-oceanic disjunct distribution. There are also a sizeable number of Angiospermic taxa with North American - East Asian or North American European East Asian disjunct distribution (Asa Gray, 1846, 1860; Hooker, 1878; Fernland, 1931). Similar studies have also been carried out involving moss flora of eastern North America and east Asia. Asa Gray (*l.c.*) regarded most of the disjunct taxa as 'relics' in the sense that they were the remnants of the ancient flora, which had either survived the unfavourable conditions during the Pleistocene glaciation at their original homes, or their migration during the post glaciation period resulted in their present range of distribution. Fernland (1925) demonstrated the present disjunct distribution of arctic elements of once a continuous northern flora of Miocene in temperate and subtemperate regions of northern hemisphere. The common occurrence of several liverwort taxa in almost all the bryogeographical regions of India may, thus, be suggestive of once continuous flora during the preglaciation era which might have changed to its present pattern due to geoclimatological factors (*see* also Joshi & Biradar, 1984).

Based on the strong resemblance of several species of *Cololejeunea, Microlejeunea* and *Rectolejeunea* with their African allies, Pande (1958), discussed the similarities in the hepatic flora of the Western ghats, the North-eastern India and Africa. While discussing an interesting tricentric, trans-oceanic discontinuous distribution pattern exhibited by *Riella affinis,* a North American-North African-South Asian disjunct (occurring only at California in North America, Canary Island in North Africa and Varanasi in India), Pande (*l.c.*) observed: "It is quite possible, however, that these plants had a much wider distribution in the past and due to isolation of land masses, changed topography, ecological segregation or some such overland migratory route now no longer present, the continuity of the vegetation was lost and these plants were subjected to diverse changes. Those with wide adaptability and possibly congenial microhabitats survived in their present homes and disappeared from others......". He (Pande, 1958) further observed: "Possibly also they underwent enough transformations and resulted in the evolution of new species". It is, therefore, apparent that disjunct ranges reflected the involvement of two phenomena: selective biotic extinction over vast areas, during the millions of years that has since elapsed, due to rigors of unfavourable conditions of late Tertiary and Pleistocene, and physical isolation due to breaking up of once continuous land mass, the Wegner's (1924) 'Pangea' In this view the occurrence of the genus *Chonecolea, Lethocolea, Tylimanthus,* etc., is of great phytogeographical significance. It is interesting to note that the genus *Chonecolea* is represented in the world by three species of which two, viz. *C. andina* and *C. doellingeri* are confined to Peru and Brazil, and Florida respectively, whereas *C. schusteri* has been recently described from Nilgiris (see Singh, 1992). Similarly, of the three species of *Lethocolea,* known so far, *L. congesta* reported from East and South Africa, and *L. squamata* from New Zealand (see Singh, 1992). Furthermore, *Tylimanthus,* an essentially antipodal taxon represented in New Zealand, Australia and subantarctic islands, by two species : *T. saccatus* and *T. tenellus* is interestingly represented in Indian bryoflora through *T. indicus* (Chopra, 1943; see also Singh, 1992). Udar and Singh (1979b) have also discussed the central American-peninsular Indian, bicentric, trans-oceanic disjunct distribution shown by *Notothylas dissecta* and Mexican-African- South Asian disjunction exhibited by *Cyathodium cavernarum.* It is rather interesting that both *Notothylas* and *Cyathodium* have been found to prefer more or less identical conditions of growth.

As such the present range of distribution of such widely separated taxa (see also Table V) may be ascribed to both, their relic nature as well as overland migration prior to the physical break up of land-masses. Such distribution pattern strongly supports Wegner's hypothesis of continental drift which has been excellently supported by late Prof. Sahni (1937) on Palaeobotanical context and many others, including Fulford (1963), Hattori (1951) and Schuster (1972), based on the phytogeographical, zoogeographical and geological evidences. The disjunct distribution shown by Bryophytes in general is of particular significance. As these taxa usually inhabit micro-climatic niches, they are subjected to more or less uniform climatic conditions and, as such , offer better resistance to macroenvironmental variations than higher plants. Therefore, their occurrence at different distinct sites, widely separated from each other, indicate the similarities in the climatic conditions of the past as well as present.

ECONOMIC IMPORTANCE

"It is true that the **Hepaticae** have hardly as yet yielded any substance to man capable of stupefying him or of forcing his stomach to empty its contents, nor are they good for food; but if man cannot torture them to his uses or abuses, they are infinitely useful where God has placed them .... and they are, at the least, useful to, and beautiful in themselves - surely the primary motive for every individual existence."

Richard Spruce

Nevertheless, there are instances to believe that bryophytes as a whole may have a substantial and distinctive influence on the ecosystems. The liverworts, together with mosses, often play an important role in various ways, such as modification of habitat, nutrient cycling and the maintenance of nutrient status of the soil, primary production, besides being used, to some extent, as 'Bioaccumulators', 'Biomonitors', etc. (Glime & Saxena, 1991).

Modification of habitat : It is well known that the bryophytes (both liverworts as well as mosses) contribute significantly towards the primary succession of plants on bare rocks. The trapping of wind blown particles within the bryophyte cushions is the most significant factor in soil development as compared to the weathering of rocks induced by these bryophyte communities (see Singh, 1992). These are often found to be abundant in early stages of primary as well as secondary succession on gravels, till and other mineral soils (Longton, 1984). In Arunachal Pradesh, members of Anthocerotales, particularly belonging to genera *Anthoceros* and *Folioceros*, have been observed by the author to be the first colonisers on the exposed earth material following land slips. Even the liverworts have been reported to colonise the ash, almost devoid of nitrogen contents, resulting from volcanic eruption (Griggs & Ready, 1934; Smith, 1984).

Bryophytes considerably influence the composition of other communities by creating a moist environment, available round the year, associated with equable temperature regimes. This not only helps the epiphytic plants, like orchids, ferns, etc., growing in their close association, but also a range of microorganisms and invertebrates termed as 'bryobionts', 'bryophiles' and 'bryoxenes' (Gerson, 1982), which colonise them. Infact the bryophytes possess several attributes with overbearing influence on the abundance and distribution of dependent 'bryofauna'. For example they rapidly absorb large quantities of water (many times more than their body weight), retain it and thus retard the drying out of the underlying substratum. They also muffle sound in the frequency range of 30-50 KHz and serve as insulation to the associated invertebrates, which live within them, against the heat, cold and wind. Therefore, the bryophyte habitat significantly increases the "diversity of both species and trophic relationship in many biotic communities" (Longton, 1984). Besides, both liverwort and moss colonies also serve as a suitable medium for seed germination.

Nutrient cycling and the maintenance of nutrient status: In a terrestrial community regular cycling of nutrients takes place between the living organism and the soil. This is regularly augmented through precipitation, dust, biological nitrogen fixation and losses through leaching and surface run off, etc. In such a system both liverworts and mosses considerably enhance the retention of nutrients, from the precipitation, by partially incorporating the input directly into their tissue. Besides, the absorption of the rainfall into the capillary spaces of their colonies not only helps retention of input in precipitation but also prevents leaching of minerals dissolved in soil moisture. Humus, to which bryophytes in general contribute significantly, too facilitates the maintenance of soil fertility by minimising the drainage and through chemical association with mineral ions (Longton,1984).

There are reports of nitrogen fixation by heterotrophic bacteria and blue-green algae associated with several bryophytes. This is likely to hold good in case of a number of liverworts, such as *Anthoceros, Folioceros, Phaeoceros, Notothylas, Balasia,* etc., which harbour *Nostoc* colonies in their thalli. Besides a number of other liverworts, such as *Calypogeia, Cephalozia, Jackiella,*

Jungermannia, Notoscyphus, etc. harbour mycorrhizal fungus in the bulbous ends of their rhizoids, which is nitrogen fixing in nature. Apart, Bentley and Carpenter (1980) reported significant nitrogen fixation being carried out by the epiphyllous liverwort communities in Costa Rican rain forest. As the tropical evergreen forest of the Western ghats and the Eastern Himalaya abound in rich epiphyllous liverwort vegetation, it would be imperative to initiate studies to assess their contribution towards nitrogen fixation and nutrient cycling in real terms.

Another interesting aspect about the epiphytic bryophytic communities is their great water holding capacity. According to an estimate, they can absorb up to 30,000 litres of water per hectare during a single rain in the canopy of elfin forests in Tanzania (Pocs, 1982). This significantly helps in maintaining the nutrient status of the forest soils, abates erosion, and ensures a steady flow of water that ultimately benefits the local agriculture.

Apart from that liverworts like *Ptychanthus* and *Diplophyllum* have been found to possess antifungal properties (see Singh, 1992). Even some species, like *Dumortiera, Riccia, Marchantia* and *Conocephalum,* have ethnobotanical significance as well. While the *Dumortiera,* together with a host of other plants, is used by Khasi tribals in N.E. region for curing the bronchial asthma, the thallus paste of *Riccia,* and *Marchantia* and *Conocephalum* is used to treat ringworm and boil respectively by the highlanders in Kumaon region of the N.W. Himalaya (Pant, *per lit.*). Besides, the high concentration of flavonoids and turpenoids, in large number of liverworts, enables them to serve as natural 'Antibiotics', 'Fungicide' and 'Pesticide'.

More rational use of bryophytes, however, has been in the field of pollution detection and monitoring. The disappearance of bryophytes as well as lichens, has often been used as an indication of undesirable level of pollution. Certain liverworts, like *Scapania undulata,* have been found as good 'Bioaccumulators' for toxic heavy metals such as Cadmium, Lead and Zinc and may provide biological cleaning system, especially in aquatic ecosystems (*see* Glime & Kleen, 1984). The liverwort was found to absorb Cadmium for over 20 weeks in contrast to aquatic vascular plants which accumulated their highest concentration after 1 or 2 weeks and then released most of it back to the system. It is, therefore, desirable that more liverworts be tested for their capacity to accumulate and withhold the toxic heavy metals. For, these 'Biological Vaccum Cleaners', which are slow to release accumulated substance, can also be utilised for developing an 'environmental specimen bank' (see Singh, 1992). A comparison between such herbarium specimens and a current sample can precisely elucidate the pollution trends for heavy metals. Besides, certain liverworts, as part of a specific bryophyte communities, grow well on mineral enriched substrates, such as *Marchantia palmata, Jungermannia tetragona* (on polymetallic copper); *Jungermannia confertissima* (on Iron Limonite); *Dumortiera hirsuta, Pellia endiviaefolia, Chiloscyphus polyanthos, Plagiochila* spp., *Jungermannia gollanii, Asterella wallichiana, Marchantia palmata, M. polymorpha, Plagiochasma appendiculatum, Aneura indica* (on Calc-tufa deposits), and may serve as important tool in geobotanical prospecting.

Most of these aspects, however, ought to be thoroughly looked into in Indian context to properly assess the role of liverworts, in various ways.

VULNERABILITY, THREATS AND CONSERVATION

As already emphasised, the liverworts have remarkably diversified to suit themselves to a range of climatic and habitat conditions and have greatly succeeded 'within the narrow niches to which their evolutionary limitations have restricted them' (Schuster, 1966). Extensive surveys in several bryologically rich localities, and its comparison with hepaticological studies in the past have, however, revealed different growth and distribution patterns of a number of liverwort taxa in different parts of the country. The studies during the last few decades have not only resulted into the significant additions to Indian liverwort flora (both as new species and new records), but have also revealed an extended range of distribution in case of many taxa such as *Calobryum, Chonecolea, Geocalyx, Gottschelia, Haplomitrium, Jackiella, Lethocolea, Anomalolejeunea, Makinoa, Schifneria,* etc. At the same time, these investigations have also brought to fore alarming shrinkage in both the population as well as the range of occurrence of several other taxa, leading to their loss of diversity.

In certain cases liverworts like *Aitchisoniella himalayensis, Anthelia julacea, Anthoceros alpinus, A. macrosporus, Calobryum blumii, Drepanolejeunea pulla, Folioceros assamicus, F. indicus, F. mangaloreus, F. physocladus, F. satpurensis, Gymnomitrion concinnatum, Metzgeria crispula, M. conjugata, M. furcata, M. lutescens, M. longitexta, Notothylas khasiana, Riccia pimodii, Tylimanthus indicus,* etc., could either not be located again in Indian bryoflora, since their original record, or have been collected after long intervals. For instance, *Monoselenium tenerum,* a monotypic genus described originally from Assam (Udar, 1976; Singh, 1992), could subsequently be collected from Manipur only after about eitht decades (Kashyap, 1923). Eversince, the type locality of this phylogenetically interesting taxon; 'Suddya' and 'Tingrei' in Assam were probably completely destroyed due to several major earth-quakes in the region. The species, though recently reported from the Western Himalaya (Kapila & Kumar, 1995), could never be collected again from Manipur also, possibly because of certain biotic factors.

Usually the natural home of liverworts in India, which include the Himalayas, the eastern and the western ghats, and the hill ranges of central and north-eastern region of the country, also provide considerably good tourist resorts attracting large number of visitors round the year. Thus many liverworts growing in these places are more often than not inadvertently exposed to considerable stress due to various biotic interferences, inevitably causing disturbances in their habitat and threatening them of their very survival. A personal experience, in this regard, would suffice to bring home this point. The author collected some interesting plants of *Notothylas* (which later on proved to be a new species: *N. khasiana*) from a roadside drain near the 3rd Mile area on Shillong-Cherrapunjee highway during October 1975. In April-May 1976, however, when the author again visited the spot, he found, to his dismay, that the entire ridge, along the roadside, was mowed and stripe-painted to beautify the area for the coming tourist season. And, as feared, the plants could never be located again despite several attempts. Thus, as emphasised time and again, in context of usually Angiosperms (Jain & Sastry 1980; Rao, 1977; Singh, 1981 a; Rao & Harja, 1986; Chauhan & Singh, 1990), the biotic factors have overriding effect on the status of floristic diversity.

Recently, Udar and Srivastava (1983), Pant (1983), Pant *et al.* (1994), Singh (1992) and Srivastava, *et al.* (1995) have provided details on endemic and rare liverworts of India including those with narrow ecological range and restricted distribution in the country. A status survey of liverwort taxa, at different levels, reveals that *ca* 100 species are rare in Indian bryoflora, and are vulnerable to various threats, both biotic as well as natural. Amongst the rare hepatic genera the mention may be made of *Acrobolbus, Anastrepta, Anastrophyllum, Apotreubia, Blepharostoma, Calobryum, Ceràtolejeunea, Chonecolea, Cuspidatula, Cylindrocolea, Lethocolea, Geocalyx, Haplomitrium, Isotachis, Lophochaete, Kurzia, Mylia, Pleurozia, Marsupella, Nowellia, Pleuroclada, Stephensoniella, Sauteria, Syzygiella, Tylimanthus,* etc. While Table IV lists some of the endemic rare liverworts, the species that are not confined to India but have highly restricted population within the country and often outside too, are *Haplomitrium hookeri* (E. & W. Himalaya, N. America, Europe, Spitsbergen), *Calobryum blumii* (E. Himalaya, Java, Sumatra, New Guinea), *Gottschelia schizopleura* (W. ghats, Sri Lanka, New Guinea, Madagascar), *Pleurozia purpurea* (E. Himalaya, China, Taiwan, Japan, Atlantic Europe, Alaska), *Mylia taylori* (E. Himalaya, Circumboreal Asia, Europe, N. America), *Ptilidium ciliare* (E. Himalaya, Nepal, Circumboreal Asia, Europe, America, Alaska, Argentiana, New Zealand), *Blepharostoma trichophyllum* (E. & W. Himalaya, N., C. & S. America, E. Africa : Boreal as well as antipodal), *Kurzia makinoana* (E. Himalaya, China, Taiwan, Korea, Japan, Philippines, Canada, Alaska), *Calypogeia* *fissa* (E. Himalaya, Tropical Asia), *Apotreubia nana* (E. Himalaya, Japan, British Columbia), *Wiesnerella denudata* (E. & W. himalaya, Nepal, Sumatra, Java, Formosa, Korea, Japan, Hawai), *Blasia pusilla* (E. & W. Himalaya, Pakistan, Taiwan, Japan, Europe, America, Russia), *Makinoa crispata* (E. Himalaya, Japan), *Pressia quadrata* (W. Himalaya, Nepal, Japan, Russia, Europe, N. America), *Riella affinis* (Gangetic plains, S. Africa, N. America), *Geocalyx graveolens* (E. & W. Himalaya, Russia, Japan, Europe, N. America), *Sauteria alpina* (E. & W. Himalaya, Japan, Russia, Norway, N. America), *Notothylas dissecta* (W. ghats, E. Himalaya, Andaman and Nicobar Is., Guatemala), *Delavayella serrata* (W. Himalaya, Thailand, China); *Exormotheca ceylonensis* (W. ghats, Sri Lanka); *Metzgeria conjugata* (W. Himalaya, Mayanmar, Celebes, Taiwan, Newzealand, Japan, America, Chile, Ireland, Caucasus, Africa, Brazil, Mozambique : known only through its initial record from India); *M. furcata* (W. Himalaya & W. ghats, Europe, N. & S. America, Australia, New Zealand, Africa, China, Japan, Farmosa, Caucasus); *M. longitexta* (E. Himalaya, Insula Dominicia : known only through its initial record from India); *Monoselenum tenerum* (E. & W. Himalaya, China Japan, Hawai, Ryukyu Is.); *Anthelia julacea* (W. Himalaya, Nepal, Europe, America); *Isotachis indica* (Eastern Himalaya, Nepal), *Plagiochilon mayebarae* Hatt. (E. Himalaya, China, Farmosa, Japan), etc.

No immediate data is available on causes of rarity or non-availability of these taxa in their respective localities in India. However, it can be explained if the habitat requirement of the group is fully realised vis-a-vis its destruction in the present era due to several biotic factors. As already emphasised, the habitat condition of the group is highly circumscribed because of its great dependence on external supply of water for completing the life-cycle. Apart from that, different liverwort communities have their own specific requirement. Even different sides of the tree trunk or branch or the leaf surface present different microclimates depending upon three factors: aspect of the substratum in relation to the direction of light source; the same in relation to prevailing wind, and finally the inclination of the substratum. Besides, their existence also depends on the nutritional potentialities of the bark of trees. They are conspicuously absent from the bark of coniferous taxa, especially *Pinus* because of its resin contents, barring few species such as *Cephaloziella microphylla*. Similarly, in case of terrestrial communities, Clausen (1952) demonstrated that on the steep bank of a lane two different taxa, growing few centimetres apart, experienced considerably different relative humidity.

Thus the group, with such a delicate choice for microhabitats,is highly susceptible to the mass habitat destruction. As, in the process not only epiphytic and epiphyllous taxa are directly affected, but the terrestrial communities are also exposed to various environmental rigors and natural calamities.

On the contrary biological imparity has also contributed considerably towards the vulnerability of many liverworts. In case of *Lunuluria cruciata*, a gemmiparous taxon, the male plants are extremely rare and often do not occur in the same population as the female plants (Schuster, 1953; Srivastava, 1967). On the other hand many species of *Trichocolea* (Hatcher, 1957; Singh, 1983a), and *Plagiochila sullivantii* and *P. austinii* (not known from India) are known only through male plants (Longton & Schuster, 1983) thus forcing them to adapt to asexual mode of reproduction. Similarly, plants of such liverworts as *Herbertus* are generally sterile. Though a few species do produce male and female gametangia, yet the production of sporophytes is rare and the plants maintain their growth by vegetative reproduction (Kumar & Manocha, 1995). Secondly, because of dioecism in approximately 80 per cent of liverworts with wide separation of male and female gametophytes, coupled with the limited fertilisation range [according to Richards (1978) the antherozoids in hepatics are capable of swimming just 1 - 2 meters at a speed of *ca* 100-200 μm/sec.], the liverworts are rather forced to take to vegetative or asexual mode of reproduction for maintenance and development of their population (Longton & Schuster, 1983). Besides, such endemic taxa as *Sewardiella tuberifera* and *Stephensoniella brevipedunculata,* though copiously develop sporophytes and produce spores, perennate vegetatively through tubers only. The spores apparently do not germinate, neither *in vivo* nor *in vitro.*

The reliance on asexual reproduction by a large number of Hepaticae, consequent to regression in sexuality, results into genetic stenotypy (Schuster, 1966). The genotypic erosion further takes place because of the tendency of most hepatics to adopt themselves somatically, instead of genetically, to various environmental changes. As such a major shift in the habitat conditions may lead to the elimination of biotypes or the nonadaptive species as a whole. Kashyap (1919) realised the link between the reduction in morphological complexity in the Marchantialean taxa and depletion in the number and significance in the vegetation as a whole and observed "......it would be strange if such forms (were to) perish all of sudden. It would be more likely that a number of them became gradually reduced before their entire disappearance. Many forms, therefore, which.......are apparently perfectly sound and self-supporting to all intents and purposes are really on the downward slope leading to extinction, though some like the Jungermanniales show a flicker before final disappearance". Besides, according to Schuster (1966)," ....As a taxon becomes rarer its evolutionary plasticity appears to decrease, even if there is regular sexual reproduction. It may become what has loosely been called `senescent'". Thus, *Calobryum blumei*, the species of *Haplomitrium*, and *Pleurozia purpurea*, may be regarded as `senescent` species.

It would, therefore, appear that the causes for rarity of, or threat to many liverworts stem from not only biotic factors like wanton destruction of primeval forests for agriculture, mining, urbanisation, industrialisation, etc., but also from natural factors like floods, earth-quakes, landslides and the inherent biological imparities of the species as well. On the other end of the spectrum, the poor knowledge and lack of both intensive and exhaustive bryological explorations in the country have also lead to some erroneous conclusions about the status of certain taxa. The recent discovery of *Monoselenium tenerum* from Western Himalaya, *Blasia pusila* from the Eastern Himalaya, the recollection of *Radula assamica* after its type collection, the extensive populations of *Conocephalum supradecompositum* encountered in the interiors of Arunachal Pradesh are few such examples which clearly highlight this fact.

Before embarking up on any effective conservational strategy it is imperative to have proper understanding of these plants, as the lack of it may pose serious consequences. As already mentioned, the hepatic flora of some of the rich bryogeographical regions of the country still stand to be thoroughly investigated. As such, consequent to the indiscriminate clearance of forests, leading to massive habitat destruction, it is likely that a number of taxa may become extinct even before being brought to the notice of the scientific world. It would be largely because the group has miserably failed to popularise itself mainly for two reasons: small, rather inconspicuous structure of plants that easily escape attention of unaided eyes in the field, and secondly because of prevailing unawareness/apathy amongst the general botanists. However, it can be effectively remedied by having proper representation of Hepaticae in the teaching curricula of various Universities, with judicious choice of the representative taxa, thus inculcating interest in the younger generation about this curious group of plants.

In the meantime, some rich liverwort habitats, together with many interesting taxa are already protected, against biotic interferences, in over five hundred protected sites, spread across the length and breadth of the country covering *ca* 4.6 per cent of its total landmass encompassing various ecosystems. This includes eight Biosphere Reserves; established in different phytogeographical regions of the country, such as Nilgiri B.R., Nanda Devi B.R., Sundarban, B.R., Gulf of Mannar B.R., Great Nicobar, B.R., Nokrek B.R., Simplipal, B.R. and Manas B.R.; *ca* 77 National Parks and *ca* 445 Wildlife Sanctuaries. For, conservation of higher plants is often a pre-requisite to ensure conservation of liverworts. Because these elements not only support epiphytic and epiphyllous liverwort communities but also create congenial conditions for the terrestrial vegetation as well. Certain other areas rich in liverwort vegetation and diversity like Vyas Shikhar and Khadamba (Near Chakrata in Uttar Pradesh), Pachmarhi Plateau (Madhya Pradesh), Purandhar (Maharashtra), Agumbe, Shimoga (Karnataka), Tiger Hill (near Darjeeling in W.B.), Shikar Hills (West Siang district), Tale Valley (Lower Subansiri district), Panga Teng Tso (Tawang district), Simbi-Melinza ridge (Lohit district) and Dri Valley (Dibang Valley district) (all in Arunachal Pradesh) may be protected as 'Bryophyte sanctuary' for *in situ* conservation of unique bryofloristic components met at these sites. Botanical Survey of India, the nodal organisation under the Ministry of Environment & Forests, Government of India, concerned with plant diversity and its conservation in India, may also consider setting up 'Liverwort Gardens' on the pattern of the "Moss-Gardens" developed in Japan, and more recently in the Botany department of the Kumaon University, Nainital (Farooqui & Pant, 1994), initially at Pauri, Shillong and Yercaud, for *ex situ* conservation of some of the rare and vulnerable species. This would also facilitate creation of general awareness amongst the people about these plants. At the same time it is also essential to inventories the rare and vulnerable taxa and intensify the search for them not only in their original home but also in other regions with identical eco-climatic conditions. Efforts have already been initiated to prepare 'Red Data Sheet' on critically threatened or rare species so that special care can be taken for their conservation/rehabilitation.

Recently, Botanical Survey of India has successfully initiated *ex situ* conservation of rare and threatened angiospermic plant species through tissue culture. This programme may be expanded to include *in vitro* conservation of biologically impaired liverworts, such as *Calobryum, Haplomitrium, Pleurozia, Sewardiella Aitchisoniella, Stephensoniella,* etc., as well through biotechnology.

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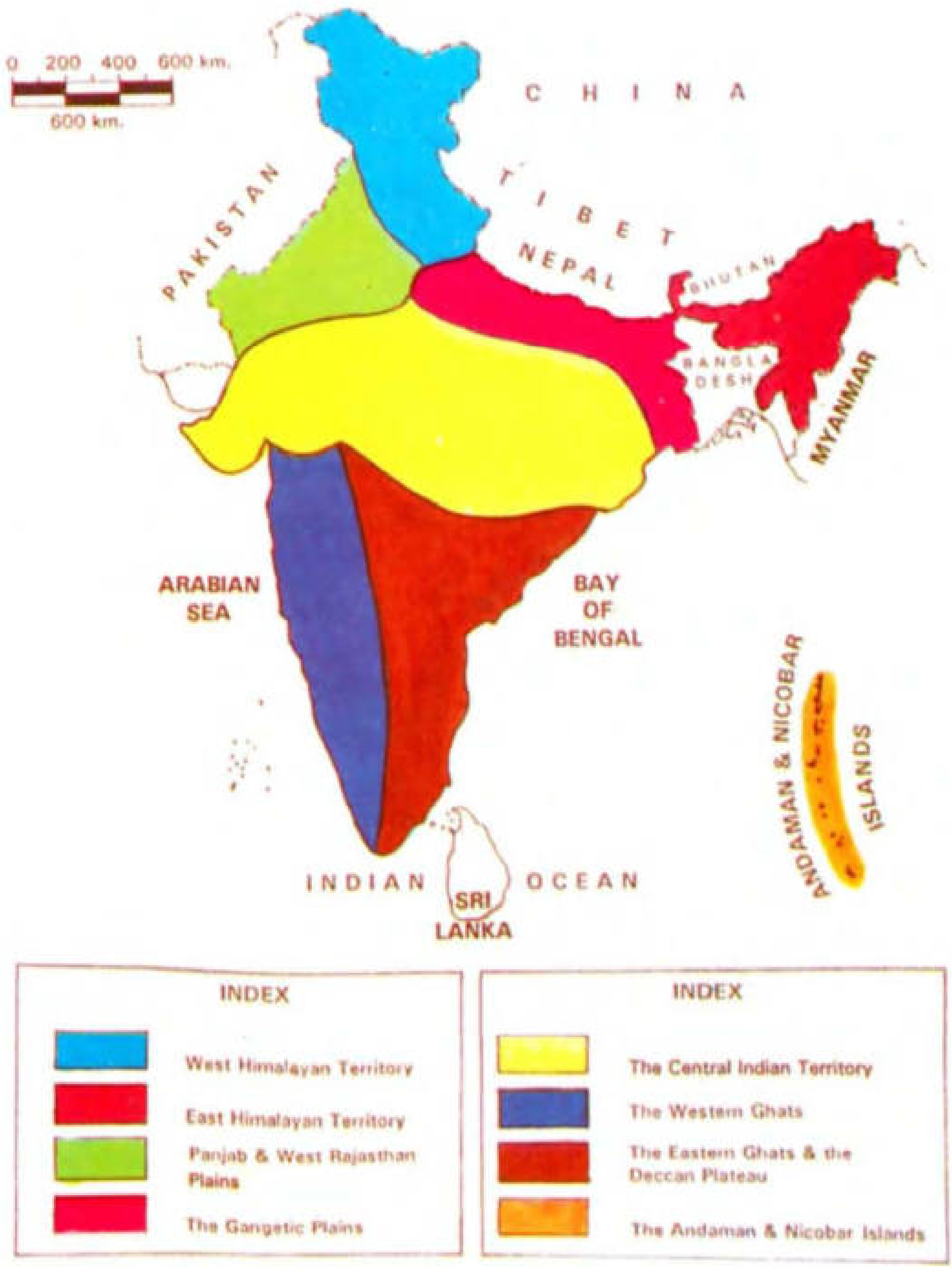
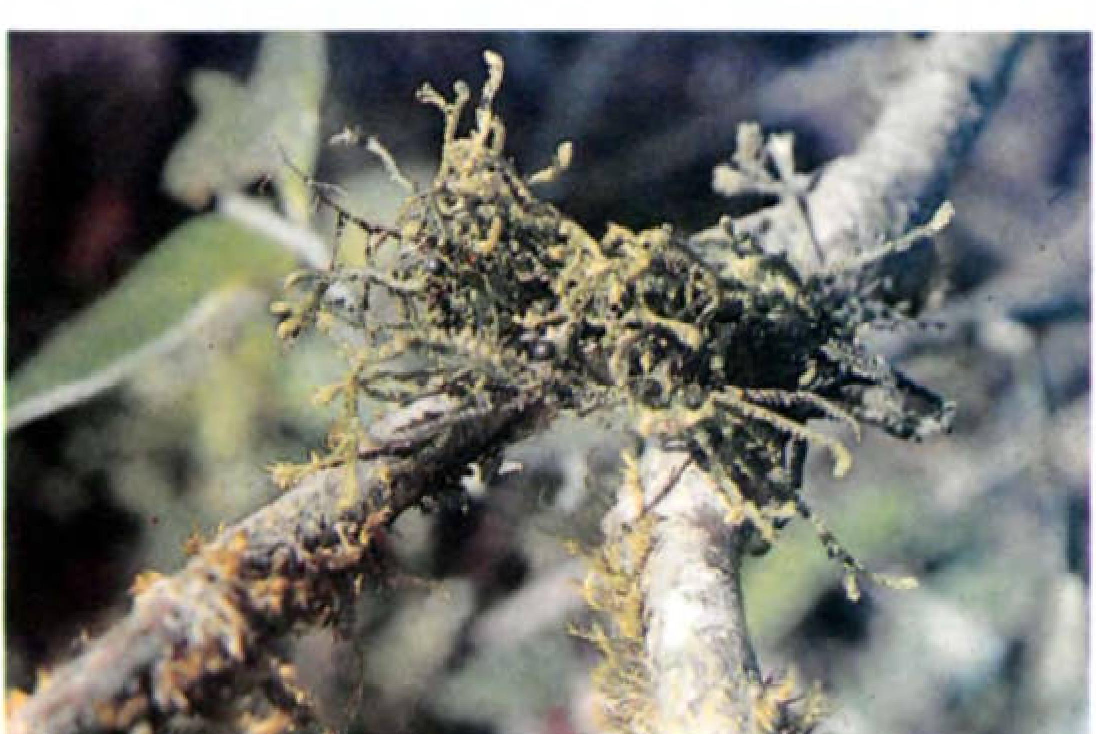
BRYOGEOGRAPHICAL TERRITORIES OF INDIA



Plagiochiasma puriana - A thalloid endemic of Western Himalaya.

Asterella angusta - A thalloid endemic of North India.

Folioceros paliformis - A thalloid endemic of Eastern India.



Plagiochila semidecurrens. - A leafy epiphyte of Himalayan region.

An epiphyllous liverwort group growing on the leaves of *Phrynium* in the evergreen forests of Arunachal Pradesh.

Haplomitrium hookeri - A rare, leafy liverwort.

Cyathodium carernarum - A fluorescent, thalloid liverwort.

An epiphytic assemblage of *Porella* and *Frullania* in the Alpine region.

MOSSES

J.N. Vohra
M.N. Aziz

Mosses are small, diminutive, non flowering plants, belonging to the group bryophyta. They need cool and humid climate for their proper growth and development. They are mostly found in hilly areas; the climate of plains is too harsh for them particularly during summers. Some degree of moisture is always required in their growth and reproduction that is why they are found in greater numbers along streams, water falls and other water sources and at high altitudes near glaciers and melting snow, where there is a constant supply of water. Most species, however, depend on monsoon clouds for their daily needs. They grow on boulders, rocks, soil or are epiphytic on trees, bushes, etc.

They prefer shady places in forests, where moisture can be conserved for longer periods. Those growing in open places develope vigorously during rainy season and shed their spores before the onset of winter. Those occurring in extremely dry conditions in high altitudes sometimes exhibit features such as the development of anthocyanin, which imparts red colouration to the plants. The presence of thickened cell walls, papillae, lamellae, etc. is also considered by some authors as an adaptation to xeric condition (Watson, 1968).

The plants being gametophytes lack root system; instead they are provided with rhizoids which are attached superficially to the substratum. The absorption of fluids can be internal or external. The absence of cuticle helps in the absorption of fluids. However, species of such genera as *Bryum* are provided with a thin layer of cuticle. They are, therefore, slow in absorbing moisture and also take longer time in getting dried up.

The plants being weak several of them grow together for support, forming erect, compact tufts or clumps (Acrocarpic) or may grow prostrate forming mats or carpets (Pleurocarpic).

Apart from endemics which are abundant, many taxa are of wide distribution and are spread over different continents. A fairly large number of them being disjuncts are of phytogeographical interest. Mosses being an ancient group (having evolved during Permian), these disjuncts provide information on the past climates and distribution of plants.

India is endowed with a rich and diversified moss flora. This richness is manifested not only in the number of taxa, but also in their luxurious growth and variety of life forms. This richness of moss flora is largely attributed to the fact that, the various regions of the country, due to differences in their climate and latitudes support a distinctive kind of moss vegetation. Besides, the wide altitudinal range, particularly in the Himalayas, provides suitable habitats to various groups of mosses.

By far the largest repository of mosses in India is the Himalayas. Lying between 30° 50'N, in the North West, and 27°N, in the North East, and stretching for about 2400 km from Kashmir in the North West to Arunachal Pradesh in the North East, with width up to 300 km, the Himalayas, along with other N. Eastern hill states, provide a home to about 1402 species.

The climatic conditions in the Himalayas are highly varied from humid in the North East to cold desert conditions in Ladakh where temperatures drop to 30°C in winter. Though not much explored, the vegetation of cold deserts has similarity to that of the arctic regions of the world. Elsewhere in the Himalayas alpine, temperate, subtropical and tropical areas exist at various altitudes, each inhabited by a different group of genera and species. Besides, there are vast areas in the country about which we have very little or no information at all. One such portion is the humid tropics of Southern Western Ghats. Known for lofty trees, and high rainfall, the area has been only marginally explored and needs special attention. The other such area is the Andaman & Nicobar Islands. Only very recently a collection has been made from Great Nicobars, which is perhaps the first ever made from this place (Vohra & Kar, in Press).

VEGETATION

Western Himalaya

Moss collection in India began in early 19th century. The publication of Species Muscorum (Hedwig 1801) generated a lot of interest in mosses. Several explorers, who were collecting phanerogams, also started picking up mosses. Notable among them are Royle, Falconer, Strachey

& Winterbottom, T. Thomson, etc. who collected in the early part of 19th century from Western Himalaya. Others who subsequently contributed to the bryolgoy of W. Himalaya are Brotherus (1898, 1928), Dixon (1926, 1930, 1942), Dixion and Badhwar (1938), Bartram (1955, 1960). Another important collection is by Walter Koelz, who visited Tehri in 1933. His material is in Michigan University. Some of his collections from Tehri and Mussoorie have been reported by Robinson (1968).

Among the recent collections, Chopra *et al.* (1956) published a list of mosses from Mussoorie. They included 143 species in the list. Subsequently Chopra (1960) enumerated 156 species of mosses from Nainital. Srivastava (1966) published an account of mosses of Kumaun. Vohra and Wadhwa (1964) reported 60 species from North Garhwal. They also reported genus *Andreaea* for the first time from Western Himalaya and *Aloina* for the first time from India (Vohra & Wadhwa, 1963; Wadhwa & Vohra 1963). Both the genera were collected from this region. Vohra (1969, 1970) reported 165 species of mosses which were collected from Tehri, Mussoorie, Chakrata, Dehra Dun, etc. These reports include a large number of species which were so far known only from Eastern Himalaya. These are : *Oxystegus cylindricus, Splachnobryum indicum, Anomobryum auratum, Aerobryidium filamentosum, Plagiothecium denticulatum, Campylium ericoides, Dicranum gymnostomum, Oxystegus stenophyllus, Hydrogonium consanguinium, giganteum, Fleischerobryum longicolle, Macromitrium sulcatum, Thuidium meyenianum* and *Stereophyllum indicum.* Tewari *et al.*, (1982) enumerated 79 species of mosses from Pindari (Kumaun). Pant and Tewari (1984) reported *Distichophyllum schmidttii* and *Thamnobryum latifolium* for the first time from India from Kumaun region.

Some of the novelties published in recent years from U.P. Himalaya include *Mitrobryum koelzii* (Robinson, 1968), *Campylium gollanii* (Vohra, 1970), *Hydrogonium mussoorianum* (Vohra, 1967), *Plagiothecium dehradunense* (Vohra, 1974), *Hygroamblystegium gangulianum, Hygrohypnum nairii, Brachythecium chakratense, Brachythecium grahwalense,* and a number of varieties (Vohra, 1980). Vohra (1969) also reported *Hymenostyliella llanosii* from India. This moss was so far known only from Philippines.

Vohra (1966) reported *Barbula asperifolia* and *Orthotrichum pumillum* for the first time from N.W. Himalaya. While the former was collected from Bhadrawah in Jammu, the latter was collected from Kashmir Valley. Noguchi (1964) enumerated 37 species from Kashmir which included *Bryoerythrophyllum yunnanense,* a species so far known only from China. Robinson (1965) reported 56 species from Kashmir, which included two new taxa, viz. *Theriotia kashmirensis* and *Tortula websteri.* Vohra (1969 a, 1969b) reported 113 species from Kashmir which included *Leptopterigynandrum brevirete,* a species reported for the second time after its type which is from Waziristan, and some new records for India, viz. *Astomum crispum, Brachythecium glareosum, Bryum alpinum, Funaria calcarea* and *Tortula subulata* var. *angustata*. Wadhwa and Vohra (1966) reported *Sphagnum squarrosum* for the first time from India (Kalpa, Himachal Pradesh), and *Pogonatum subperichaetiale* from W. Himalaya (Wadhwa & Vohra, 1965). Other new records from W. Himalaya include *Leucobryum aduncum* and *Platyhypnidium muelleri* (Vohra, 1968) and *Merceyopsis angulosa* (Vohra & Wadhwa ,1966). Aziz and Vohra (1983) published a new species of *Anoectangium*, viz. *A. kashmiriense*. Some new varieties, viz. *Pseudoleskea laevifolia* var. *vasudharensis* and *Thuidium contortulum* var *mussooriense* were also published (Vohra, 1980).

It may be mentioned that all the above work pertains to Kashmir and trans Himalayan region. Except for some collection made by Vohra, the entire Jammu and most districts of Himachal Pradesh still remain unexplored. These areas are extremely rich in species diversity because of the occurrence of a wide range of climates, from warmer foothills, through temperate forests to places of permanent snow. At each climatic zone various species show preferences for one or more habitats such as soil slopes, rocks, boulders, stream banks and other wet places, tree trunks, forest floors, etc. Within them there are pockets of micro-habitats having specific light and humid conditions. These are inhabited by several endemic and rare species. Pant and Tewari (1983) have studied the bryophytic vegetation in and around Nainital and classified it on the basis of habitat.

In Dehra Dun and other Shiwaliks (500-1,000 m) *Trematodon capillifolius, Physcomitrium cyathicarpum* and *Funaria hygrometrica* are common on clay soil. They often grow in the vicinity of each other and can be seen profusely fruiting in winter, particularly from January onwards. *Hyophila involuta* comes up during rainy season and covers entirely the cemented walls of the town.

Dehra Dun and its neighbouring places such as Mussoorie and Tehri are also rich in endemics. Dixon (1942) included 5 new species from Mussoorie alone in a single publication. They have also been described in several other publications. Some of the new taxa discovered recently from these places include a new genus *Mitrobryum* (Robinson, 1968). The new species are: *Hydrogonium mussoorianum* (Vohra, 1967), *Campylium gollanii* (Vohra, 1970), *Plagiothecium dehradunense* (Vohra, 1974).

Dehra Dun is also surrounded by sal forests and several picnic spots, which are rich in mosses. Worth mentioning among them are Mohand, Rajaji Sanctuary, Lachhiwala forest, Sahastradhara, Mothranwala swamp. Species which are common on ground in sal forests are *Fissidens sylveticus* and *Isopterygium distichaceum,* while those on tree trunks include *Erythrodontium julaceum, Thuidium meyenianum, Oxystegus stenophyllus, Stereophyllum indicum* and *Ectropothecium cyperoides* (Vohra, 1970).

Sahastradhara, located about 15 km from Dehra Dun, is unique in the sense that several mosses such as *Barbula gracilenta, Bryum cellulare, Vesicularia montagnei* play active role in rock building called "tufa" (Parihar & Pant, 1982). Other species occurring in the area include *Hymenostylium recurvirostre, Hymenostyliella llanosii, Hyophila spathulata* and *Aulacopilum abreviatum* (Vohra, 1979.)

Other species which come down to below 1,000 m and have often been collected from Rishikesh and Tehri include *Taxiphyllum taxirameum, Haplocladium microphyllum* ssp. *capillatum, Bryum cellulare, Philonotis turneriana.* All of them grow on ground along roadsides. *Cladopodium pellucinerve* also occurs at Tehri but it is rare. It is more abundant sligtly higher up on the trunks of *Rhododendron arboreum.*

Around 1,500 to 2,000 m in Pauri, Mussoorie and Chakrata, the moss vegetation particularly in oak forests is both luxurient as well as rich in species as they get ideal conditions for their growth. At this elevation such species as *Brachythecium buchananii, Rhodobryum roseum, Atrichum pallidum* are common on forest floor, while *Thuidium sparsifilium, T. cymbifolium, Entodon prorepens* occur both on ground as well as on tree trunks. *Herpetineuron toccoae, Anomodon integerrimus, Trachypodopsis crispatula* are common on tree trunks. *Cryptoleptodon* *flexuosus, Meteorium buchananii, Meteoriopsis reclinata* hang from branches and twigs of trees. *Bryum argenteum* occurs on brick walls in open places, while *B. cellulare, Barbula constricta, Anoectangium stracheyanum, Gymnostomum aurantiacum, Hydrogonium amplexifolium* occür on roadside slopes.

Between 2,000-2,500 m, about a dozen species of *Grimmia* are reported. These black coloured species are firmly adpressed to the rocks and boulders. Between 3000-4000 m in districts of Chamoli and Uttar Kashi, the character of moss vegetation changes abruptly. At this altitude there is hardly any tree cover and snow line is also close by. Most areas remain buried under snow in winter. The mosses, therefore, are confined to exposed rocky mountain slopes or to glacial beds. The usual endemic or other asiatic species met with at lower altitudes disappear. The vegetation consists largely of European and other north temperate elements interspersed with high altitude endemics. Some of the species common on ground in this area are *Drepanocladus uncinatus, Mielichhoferia badhwarii, Desmatodon latifolius, Distichium capillaceum, Aloina rigida* and *Barbula unguiculata.* Species such as *Andreaea rupestris, Barbula vinealis* and *Schistidium apocarpum* which grow on exposed rocks and subjected to high insulation during the day, assume red colouration. *Rhacomitrium canescens* hangs from the branches and stems of birch trees.

Above 4,000 m in alpine meadows *Polytrichum juniperinum, Polytrichum piliferum, Dicaranum kashmirense* and *Bryum duvalii* occur in stream beds and other moist places.

Kashmir flora is somewhat isolated from the rest of the Himalayas. The Pir Panjal range acts as a barrier to migration of species to Kashmir. It also reduces the effect of summer monsoon in the valley, making the climate more cold and arid allowing the infiltration of European and Central Asian elements.

Kashmir Valley is about 136 Km long and 40 Km wide and is about 1600 m above sea level. It is completely enclosed by mountains on all sides on which are situated several tourist resorts, such as Pahalgam and Gulmarg. Between 3500 to 4500 m are situated such places as Kolhoi glacier, Apharwat, Thajwas glacier and holy cave of Amarnath. This entire area is very rich in mosses. At places the climb is very steep. Within distance of 15 Km it is possible to collect as many as 100 species.

Between Tangmarg and Gulmarg, at an attitude of 2000 3000 m several species of *Mnium*, such as *M. cuspidatum*, *M. lycopodioides*, *M. marginatum*, *M. rostratum*, etc. are found on ground within *Abies* forests. At Tangmarg, 2200 m as many as 6 species of *Orthotrichum* grow on tree trunks in the vicinity of each other. These are *Orthotrichum alpestre*, *O. anomalum*, *O. cupulatum*, *O. punillum*, *O. speciosum*. and *O. virens*. Also occurs in the same locality *Leptopterigynandrum brevirete*, an epiphytic moss which was so far known from its Type which is from Waziristan (Pakistan). Its occurrence in Kashmir valley is a recent discovery (Vohra, 1983). Other epiphytic species occurring in this area include *Anomodon viticulosus*, *Tortula inermis*, *T. subulata* var. *angustata*, *Pseudoleskea incurvata*, and *Leucodon sciuroides*.

Totula ruralis occurs on the bases of trees or on ground at higher alitudes. *Homomalium simlaense*, an endemic species occurs on rocks forming vast colonies between 2000-3000 m. It also occurs in Poonch at the same elevation as well as in Himachal Pradesh, while *H. incurvatum*, a boreal species, occurs at higher elvations in Kashmir. A third species *H. gollanii* is endemic to Mussoorie and Tehri Garhwal.

On slopes along foot paths as well as on ground in forest, several species of *Atrichum*, *Bryum*, *Dicranum*, *Pogonatum*, *Pohlia*, etc. are common. *Atrichum flavisetum* occurs between 2000 2500 m, while *A. undulatum* is more common between 2700 to 3350 m. Species of *Pohlia*, particularly, *P. cruda*, *P. elongata*, *P. minor*, *P. nutans* and *P. wahlenburgii* can tolerate a higher altitudinal range i.e. between 2000 to 3500 m. *Dicranum kashmirense* occurs around 3000 m. It can also be found on tree trunks as well as stumps, between Gulmarg and Khilanmarg. *Pogonatum himalayanum* is also common between 2500 - 3500 m. *Bryum* species such as *B. alpinum*, *B. argenteum* *B. teretiusculum*, *B. caespiticium*, *B. muehlenbeckii* and *B. capillare* are known to occur on ground as well as on rocks, stones, etc.

Though true aquatic mosses are not known from India, several species occur in stream beds or on stones, partially submerged in steams, or on wet ground on the margins of streams. These include *Bryum schleicheri*, *B. duvalii*, *B. weigelii*, *B. pallens*, *B. pseudotriquetrum*, *B. turbinatum*, *Cratoneuron commutatum* var. *falcatcum*, *Hygrohypnum dilatatum*, *H. luridum*, *H. nairii*, *Drepanocladus exannulatus*, *Cinclidotus* *acutifolius, Brachythecium rivulare, Amblystegium compactum, Philonotis turneriana, P. calcarea, P. falcata. Fissidens grandifrons,* and *Platyhypnidium riparioides* may be termed as semi-aquatic, as they require a constant supply of water for their growth.

Some pantropical species such as *Hyophila involuta* and *Semibarbula orientalis,* which also occur in Andaman Nicobar and at foot hills throughout Himalaya, have also been reported at a height of over 3000 m in Kashmir (Robinson, 1965). To find these species in Kashmir which is dominated by boreal element, is very interesting phenomenon.

Funaria hygrometrica is another cosmopoliton species, distributed throughout the plains of India, as well as at high altitudes in Himalaya. This is one species which is tolerant of all kind of climatic conditions from tropical to temperate, alpine and cold desert climates. The highest altitude recorded is 4000 m in Ladakh. The only difference is that in the plains of northern India this species is gregarious in habit and comes up during the onset of winter and with or during summer. But in Himalayas, they form close clumps and can be recognized throughout the year by their tall setae and reddish, glossy, convex lids of the capsules.

Bryum argenteum and *Philonotis turneriana* are also tolerant of altitudinal range from 500 m at foot-hills to 4000 m in Kashmir. Although they have not been reported from plains of India.

Pylaisiealla polyantha, a boreal species is represented in India only in Kashmir where it occurs at an altitude of 3000 - 4000 m. Other boreal species are *Orthothecium intricatum* which occur in Kashmir and Poonch at 3000 - 3500 m on ground in blue Pine forests. It has also been reported from Himachal Pradesh. *Plagiothecium denticulatum* and *P. nemorale* are common at Gulmarg between 2500-3000 m. Both occur on ground in forest.

Several European species of *Hypnum* such as *H. revolutum, H. pallescens* and some endemics, e.g. *H. plicaefolium* and *H. perrevolutum* occur at high altitudes, between 3500 - 4500 m on gound in Kashmir, while *H. reptile, H. cupressiforme* and *H. vaucheri* are found between Gulmarg and Khilanmarg at altitudes ranging from 3000 - 3500 m.

Kashmir is very rich in *Brachythecium* species. Out of 35 species occurring in India, about 30 are reported from Kashmir out of which 15 are endemic to Kashmir only. Most of them occur below 3000 m. But *B. collinum* has been reported between 3000-4500 m. Majority of them occur on ground, although *B. falcatulum*, *B. glabratum* and *B. kashmirense* are epiphytic on tree trunks.

Gulmarg is quite rich in both epiphytic and ground species because it is surrounded by *Picea*, *Abies* and *Pinus wallichiana* forest all around. Several species are reported from this place. These are *Isopterygeum seligeri*, *Platydictya subtilis*, *Polytrichum juniperinum*, *Bartramia ithyphylla*, *Dicranum scoparim*, *Weisia wimmeriana*, *Ceratodon purpureus*, *Orthotrichum duthei*, *O. striatum*, *O.venustum*, *Leskeella nervosa*, *Lescuraea sexicola*, *Drepanocladus uncinatus*, etc., while at Pahalgam, Lidderwat and Kolhoi *Timmia bavarica*, *Amblystegium serpens*, *Mnium trichomanes*, *Orthotrichum urnigerum*, *Brachythecium myurelliforme*, *B. kamounense*, *Hygrohypnum dilatatum*, *H. luridum*, *Drepanocladus exannulatus*, *Anomodon attenuatus*, *Philonotis turneriana*, *Funaria capillipes*, *Tortella tortuosa*, *Barbula veinealis*, *Bryoerythrophyllum atrorubens*, etc. are quite common.

Kashmir state is particularly poor in genus *Thuidium*. Only two out of 21 species occurring in India *i.e. T. philibertii* and *T. delicatulum* occur here.

From Himachal Pradesh *Thuidium assimile*, *T. cymbifolium* and *T. westitissimum* are reported. The remaining species are confined either to Eastern Himalaya or extend westward up to Garhwal only

Compared to Kashmir, Jammu is poorly explored. According to whatever data is available, including our observations, the moss flora has simlarity both with Kashmir as well as Himachal Pradesh and Garhwal. Species common with Kashmir are *Cratoneurorn filicinum*, *Hygrohypnum luridum*, *Fissidens grandifrons*, *Platyhypnidium riparioides*. All of them occur near streams and water falls. Those growing on soil are *Orthothecium intricatum*, which is found in blue Pine forest around 3000 m; *Entodon prorepens*, *Brachythecium procumbens* around 1500-2500 m. Epiphytic species include *Brachythecium microsericeum*, *Lindbergia duthiei* and species of *Campylium*, *Orthotrichum*, etc.

In alpine areas of Seoj, which is 10 km from Bhadrawa, *Drepanocladus uncinatus, Hypnum imponens, Dicranum scoparium* are of frequent occurence. Also found, in this place, is *Barbula asperifolia* which, apart from Sikkim, is recorded only from this locality (Vohra, 1966).

During a recent collection from Poonch several species were found, which are not knwon to occur in Kashmir but are reported from Garhwal and Himachal Pradesh. These include *Fabronia minuta, Pylaisiadelpha drepanoides, Lindbergia longinervis, Rhynchostegium duthiei,* all occurring on tree trunks. *Lindbeigia longinervis* is so far known from its type only which is from Binsar (Almora). An East Asiatic species *Anomodon minor* ssp. *integerrimus*, earlier known from Himachal Pradesh eastwards, has been collected from rocks in this area. *Rhodobryum roseum,* which was found occurring on soil in *Quercus* forest, *Dicranella* sp., and *Racomitrium* sp. are all generic additions to Jammu & Kashmir.

Due to extremely cold and arid conditions, not many species are reported from Ladakh, although there are more species in valley, with large number of endemics. Due to the absence of tree cover all of them are ground mosses occurring on rock or soil along rivers or in shady places, such as rock crevices, etc. or on high mountain passes, like Rohtang, Zoji La, Baralacha, Khardung' La, Zanskar, Sach pass, Drass, etc. Some of them are also common with Kashmir valley and other areas of Himachal Pradesh or with Western Tibet, with large number of them being boreal species. Three species of *Encalypta : E. alpina, E. rhabdocarpa* and *E. tibetana* occur in Ladakh as well as Kashmir and Western Tibet. Others are: *Tayloria froelichiana, Mielichhoferia himalayan, Aongstroemia orientalis, Aloina rigida, Desmatodon cernuus, D. suberectus, Tortula mucronifolia, T. norvegica, Anoectangium thomsonii, Leptobryum pyriforme, Orthothecium strictum, Myurella julacea, Leskeella incrassata, Platydictya subtiles, Campylium hallerii, Brachythecium glaciale, B. collinum, Oncophorus virens, Tortella fragilis, Hypnum revolutum,* etc.

Eastern Himalaya

Apart from Mitten (1859), the main contributors to the moss flora of Eastern Himalaya are Renauld and Cardot (1895, 1896, 1900, 1905), Dixon (1910, 1911, 1911a, 1914, 1931, 1937, 1938,) Noguchi (1964,1966, 1971), Noguchi *et al.* (1966), Robinson (1964, 1968), Wadhwa and Vohra

(1965), Gangulee (1969-1980), Chopra (1975), Vohra (1978, 1979, 1980, 1983), Iwatsuki (1979, 1979a) Noguchi and Iwatsuki (1975), Aziz and Vohra (1988).

This area is very rich in mosses. At foot hills and up to 1000 m, *Stereophyllum tavoyense, S. ligulatum, S. anceps, S. wightii, Thuidium cymbifolium, T. meynianum, Octoblepharum albidum* occur commonly on tree trunks. At the same height several species of *Fissidens* occur on rock and boulders. These are: *F. kurzii, F. curvato-involutus, F. sylvaticus, F. ceylonensis, F. intromarginatus, F. crenulatus, F. virens, F. ranchiensis, F. diversifolius, F. bryoides, F. schmidii, F. subpalmatus, Rhynchostegium hookri, R. vagens, Vesicularia montagnei, Brotherella falcata, Glossedelphus bilobatus Trematodon subulosus, T. longicollis, Wilisoniella decipiens, Pterobryopsis auriculata* and *Archidium birmannicum*, etc.

Pleuridiella colei, a monotypic genus, is endemic at Jorhat, upper Assam.

Garckea, phascoides with immersed capsules is a very common moss, occurring at lower elevation throughout Eastern Himalaya. *Semibarbula orientalis, Hyophila involuta, Hydrogonium arcuatum, H. javanicum, Philonotis falcata, Papillaria fuscescens, Floribundaria floribunda, Macromitrium moorcroftii* are other common mosses of the same altitude.

Between 1000-2000 m, *Leucobryum bowringii, L. juniperoideum, L. nilghiriense, L. mitteni, L. javanse,* and *L. scalare* form white cushions on tree trunks in open forests. Besides, *Sphagnum khasianum* occurs at Elephant falls, Shillong. Very common on ground are: *Ectropothecium* sikkimense *Taxiphyllum taxirameum* and *Entodon pulchellus.*Several species of *Campylopus : C. laetus, C. ericoides, C. goughii* form tufts on slopes. *Campylopus richardii* occurs frequently in Meghalaya as well as Arunachal Pradesh.

Dicranum loriforme, D. kashmirense, Fissidens areolatus often occur on slopes in open places. *Barbula constricta, Brachymenium exile, B. microstomum, B. sikkimense, Bryum billardieri, B. porphyroneuron* var. *erythrinum, Pohlia minor* var. *acuminata, Mnium integrum, M. rostratum, Philonotis turneriana, Brachythecium wichurae, Entodon rubicundus, Macrothamnium macrocarpum, Hypnum macrogynum, H. sikkimense* occur on ground. *Thuidium glaucinum, T. orientale* occur on forest floor, on rocks, soil or tree trunks, but *T. contortulum* occur on tree trunks only.

Rhynchostegium duthiei and *R. planiusculum* occur on variety of substrate in deep woods.

Between 2000-3000 m *Eurhynchium dumosum, Stereophyllum setschwanicum* occur on tree trunks, while *Claopodium pellucinerve, Haplocladium microphyllum* ssp. *capillatum,* occur in forests on soil, rocks or decaying woods. Those occurring on road-side slopes are *Campylopus involutus, C. latinervis, Dicranella heteromala, Dicranedontium caespitosum, D. casillifolium, Mnium cuspidatum, M. japonicum, Bartramia halleriana, Trachysodopsis crispatula, Aerobryidium filamentosum, Brotherella nictans, Wijkia tanytricha, Hypnum imponens,* and *Rhytidiadelplus triquetrus.*

Those occurring on tree trunks are : *Meteorium buchananii, M. helminthocladum* and *Homaliodendron scalpellifolium.*

Between 3000- 4000 m, in Tangloo - Sandakphu area of Darjeeling and in alpine regions of Sikkim, occur all the five species of *Andreaea; A. rupestris, A, indica, A. densifolia, A. commutata, A. rigida.* A number of species of *Sphagnum,* such as *S. ovatum, S. subsecundum, S. cuspidatulum, S. recurvum, S. squarrosum, S. girgensohnii, S. junghuhnianum, S. nemorum, S. impricatum, S. palastre* occur at the same height. Others occurring at this height are *Brachythecium buchananii* var. *cuspidiferum, Wijkia penicilata, Aongstroemia orientalis, Dicranodontium uncinatum, D. denudatum, Campylopus gracilis* and *Dicranum gymnostomum.*

Western Ghats

In Western Ghats the occurrence and distribution of mosses as in flowering plants has a direct relationship with the average annual rainfall. The number of species is more in high rainfall areas (Nayar & Subramanyam, 1974). Mahabaleshwar, Matheran in Maharashtra, Kanara and Shimoga Distt. in Karnataka, Nilgiri, Palnis, Cardamom and Anamalai Hills in Tamil Nadu and Kerala are some of the richest areas although mosses are found in abundance almost everywhere in Western Ghats. From Nandi Hill a small hillock in Bangalore, I collected 25 species in an area of less than one sq. km.

As one drives from Poona to Mahabaleshwer the tree trunks appear absolutely bare as this is a rain shadow area till one reaches Panchgani, where suddenly moss covered trees appear. In Mahabaleshwer the dense evergreen forests are moss collector's paradise. In these forests, 50% of the species are pleurocarpic. The vegetation is dominated by the tropical families of which about 40% of the species are ehiphytic (Vohra, 1982).

On the trees towards roadside *Stereophyllum tavoyense* and *Entodon plicatus* are quite common. Also abundant are species of *Fissidens*. From within the forests, a dozen species of *Fissidens* have been reported by Dabhade (1969). These are *F. walkeri, F. curvato-xiphioides, F. beryoides, F. zollingeri, F. schmidii, F. sedgwickii, F. splachnobryoides, F. karwarensis, F. sylvaticus* and *F. coorgensis*. They are mostly on boulders and soil but some species are also found on tree trunks. *Stereophyllum ligulatum, Symphyodon angustus, S. perrottetii, Macromitrium moorcroftii, M. leptocarpum, Meteoriopsis reclinata* -all occur on tree trunks. Other dominant species are: *Bryum ghatense, B. wightii, B. sahyadrense, Brachymenium walkeri* and *B. turgidum.*

In Mahabaleshwar, but more commonly in Matheran *Bryosedgwickia kirtikarii* is abundant on tree trunks. This glossy, golden green moss though remains firmly adpressed to bark, forms large carpets.

In open places on ground and slopes, *Splachnobryum indicum, Physcomitrium coorgenses, Campylopus gracilis* and *Hyophila involuta* are quite common. *Levierella fabroniacea* is present in herbarium from Purandhar.

From Agumbe, Shimoga distt. which is the highest rainfall area of Western Ghats with average annual rainfall up to 8000 mm in some areas, Wadhwa (1968, 1970), reported *Octoblepharum albidum, Racopilum schmidii, Brachymenium nepalense, Leucoloma walkeri, Hymenostomum edentulum, Macromitrium sulcatum, M. leptocarpum, Pinnatella limbata, Meteoriopsis squarrosa, Papillaria fuscescens and Vesicularia reticulata* among others. All of them occur on tree trunks.

Species reported from Kanara distt. are : *Archidium birmannicum, Calymperes nietneri, C. fordii, Hydrogonium consanguineum, Philonotis mollis, Leucoloma renauldii, L. walkeri, L. strictifolium,* and several others.

Vohra (1982) described the vegetation of tropical rain forests of Silent Valley in Kerala. These are one of the few such forests in the country. The luxuriance of mosses has no match anywhere in the country. These mosses are specially known for a large variety of life forms among them, such as cushion forming, carpet forming, hanging mosses and fan-shaped or dendroid habits.

Of all the species, *Leucoloma amaenevirens* was most abundant. The trunks of most of the trees were covered entirely and almost without any interruption with this soft, dark green moss, giving the appearance of a velvet. The growth of this species, which was observed everywhere, became thicker in interior parts of the woods.

Among cushion-forming mosses, *Leucobryum nilgiriense* and species of *Macromitrium* are noteworthy. The former, which is whitish, forms compact, large cushions sometimes looking like a miniature cauliflower in deeper woods, while on road-sides it is much smaller and scattered. The species of *Macromitrium* also form large cushions which become brownish on drying. This genus prefers horizontal branches of trees in open woods.

Among the hanging mosses *Pterobryopsis tumida, Barbella convolvens, Floribundaria walkeri, Meteoriopsis squarrosa, Himanto-cladium rugulosum* and *Papillaria feae* are worth mentioning. These have long and flexusoe stems and branches, which may be up to half a metre long in certain species and hang from horizontal branches of trees.

Another striking moss is *Homaliodendron flabellatum*, which is peculiar for its fan-shaped secondary stems. It prefers very dark and moist places and hence has been observed in greater numbers only at Veliaparathode, where visibility even at noon is very poor due to dense forest. In a few other places where it has been growing and where light could possibly penetrate even for a short duration its growth was restricted to the shaded side of the tree. It grows above the base of the trunk of those trees which have attained very large girth, and were already covered with several other species of mosses due to abundant moisture. Its stems which are pinnately branched, grow at right angles to the surface of the tree, giving the appearance of a miniature fan.

Among ground mosses, *Campyolpus erythrognaphalus*, *Bryum vellei* var. *robustum*. and *Hyophila involuta* occur on rocks and boulders, while *Dicranella divaricata*, species of *Philonotis* and *Pogonatum* are very common on soil on roadside slopes. *Fissidens sylvaticus* is equally common on wet rocks and boulders in and around streams as well as on soil.

As has been observed in Mahabaleshwar, in Silent Valley also there is abundance of *Fissidens*. As many as seven species have been collected. Some of these are: *F. firmus*, *F. sylvaticus* and *F. ceylonensis*. Others include *Calymperes tortilloides, C. lenchophyllum, Syrrhopodon gardneri, Hyophila comosa, H.mollifolia* and *Pohlia flexuosa.* Several species of *Bryum* are reported. These are *B. euryphyllum, B. rugosum, B. apalodictyoides* and *B. vellei.*

On Soil slopes Bartramiaceae with rounded capsules are quite prominant especially *Bartramidula dispersa, Philonotis anisoclada, P. heterophylla, P. thwaitesii* and *P. mollis*. The last species is also common in Nicobar Islands. *Racopilum schmidii* also occurs on ground, while *Trachypus bicolor* forms carpets on tree trunks. *Trachypodorpsis crispatula* occurs both on tree trunks as well as on rocks. *Pterobryopsis schmidii* and *Symphysodontella involuta* are all epiphytic.

The largest family in these forests is Meteoriaceae. This is represented by *Papillaria feae, P. fuscescens, P. chrysoclada, Aerobryopsis longissima, Aerobryidium filamentosum, Barbella flagellifera, B. convolvens, Floribundaria walkeri, F. floribunda* and *Meteoriopsis squarrosa.* Besides, Neckeraceae is well represented in these forests by several species of *Neckera* and *Neckeropsis*. These mosses have 10-15 cm. long fronds which in certain species are known to attain a length up to 30 cm. Another interesting species of this family is *Cryptoleptodon flexuosus.* This is the only species of the genus occuring out side Western Himalaya the remaining three are endemic to that region and have been discussed in that chapter. This species is characterised by its curled branches hanging from twigs and can be easily recognized in the field. The remaing taxa of the family are *Himantocladium rugulosum, Homaliodendron flabellatum* and *Handeliobryum setshwanicum* For *Handeliobryum setschwanicum*, a monotypic genus, Silent Valley is the only locality outside Eastern Himalaya and Setschwan province of China, where it is thriving and occurring in fruiting condition. It is not known to produce fruits in other localities.

Besides, *Regmatodon orthostegius, Claopodium assurgens, C. nervosum, Haplocladium vestitum, Thuidium cymbifolium, T. glaucinum,* *Entodon plicatus, Stereophyllum tavoyense, Clastobryum patentifolium, Trichosteleum stissophyllum, Ectropothecium cyseroides, E. drebanocladioides, Vesicularia reticulata,Atrichum aculeatum, Pogonatum hexagonum* and *P. microstomum* are other common mosses occuring there. *Trichosteleum stissophyllum* particularly has been collected from fallen logs in densely forested areas.

Andaman and Nicobar Islands

The Andaman & Nicobar Islands lie between 6° 10'N and 13° 30' N and are in a North, South direction in a line. These islands begin at 190 km South of Burma and end at 150 km North of Sumatra. Geologically, they are a continuation of the Burmese arc, which through Aracan. Andaman & Nicobars extends upto Sumatra Part of this arc lies submerged in the Bay of Bengal. The islands represent the unsubmerged peaks of the Southern portion of Burmese arc. The area has been totally neglected as far as mosses are concerned, although the humid climate and dense forest cover is highly suited for the rich growth of tropical vegetation. The Nicobar group need special attention, being closer to equator as well as to Sumatra. If properly investigated it may not only lead to the discovery of new taxa, but can also be a Phytogeographer's paradise

However, our present knowledge of the diversity of Islands is so meagre that it does not permit us to draw any conclusions on the relationship of the flora. So far 66 species belonging to 33 genera and 16 families are reported from these islands. 15 species are endemic to India. The remaining 51 species are widely distributed in South East Asia. Ten species are endemic to the Islands. These are: *Leucophanes nicobaricum, Mitthyridium andamense, M. nicobaricum Syrrhopodon nicobaricus, Calymperes kurzianum, C. lingulatum, C. nicobarense, C. andamense, Trichosteleum punctipapillosum, Isopterygium andamanicum.*

The most dominant families are: Calymperaceae, represented by 3 genera: *Calymperes* (7 species) *Mitthyridium* (3 species) and *Syrrhopodon* (2 species). Monogeneric family Fissidentaceae is represented by 9 species and Leucobryaceae by 4 genera: *Exodictyon* (1 species), *Leucobryum* (1 Species), *Leucophanes* (3 species), and *Octoblepharum* (1 species). In case of *Leucophanes* out of 4 species occurring in India, 3 are confined to Andaman & Nicobar only. Both Calymperaceae and Leucobryaceae are epiphytic families while Fissidentaceae occurs mostly on soil in these islands. Species endemic to Islands and Western Ghats are:*Calymperes manii, Ectropothecium manii, Vesicularia levieri,* while *Fissidens subbryoides* and *Ectropothecium cygnicolum* are endemic to the islands as well as Eastern Himalaya.

The flora is allied to Malaysian region. Malaysian species occurring only in Andaman and not on main land are: *Vesicularia kurzii, Syrrhopodon subconfertus Mitthyridium manii, Calymperes delesserti, C. punctulatum Leucophanes glaucescens, L. albescens, Fissidens robinsonii, Desmotheca apiculata* and *Neckeropsis submarginata. Pinnatella africana* is common with *Africa,while Isopterygium microplumosum* is common with Brazil. Species common with South India but not reaching Himalayas are: *Campylopus aureus, Fissidens zollingeri, F. asperisètus, Mitthyridium manii, Neckeropsis andamana, Meiothecium jagorii, Sematophyllum phoenicum, Wilsoniella decipiens and Taxithelium vernieri.*

Species common with the mainland are:*Octoblepharum albidum, Fissidens xiphioides, F. sylvaticus, Bryum coronatum, Philonotis mollis, Groutiella goniorrhyncha, Trachypodopsis serrulola* var. *guilbertii, Neckeropsis gracilenta, Chaetomitrium papillifolium, Thuidium cymbifolium, Entodon rubicundus, Trichosteleum luxurians, Exodictyon blumei, Leucobryum bowringii, Hyophilla involuta, Semibarbula orientalis, Bryum cellulare, Philonotis thwaitsii, Thuidium meyenianum, Acanthorrhynchium papillatum, Taxithelium kerianum, T. nepalense, Ctenidium lychnites, Ectropothecium beuitenzorgii, E. cygnicollum,* etc.

Plain Areas

Very few mosses are reported from plain areas of India, as they cannot withstand the summer heat. Some annuals do come up during rainy season usually on river banks or in shady slopes but they are visible only on the onset of winter when they produce sporophytes. Those occurring in Northern India and Rajasthan include *Physcomitrium cyathicarpum, P indicum, P. japonicum, Splachnobryum flaccidum, Semibarbula orientalis, Funaria hygrometrica, Trematodon capillifolius, Splachnobryum bengalensis, S. indicum, Arcnidium bermicum,* are reported from Bengal plains, while *Hydrogonium arcuatum,* has been collected from Gangetic Plain.

Some species of *Fissidens* are known for their occurrence in the plains of India. *F. splachnobryoides* occurs throughout India. *F.*

subpalmatus (East and South India). *F. bilaspurense*, *Trachyphyllum inflexum*, an epiphytic moss have been reported from M.P. Mosses of Plains is a fascinating subject and needs further study.

DIVERSITY

About 2000 species of mosses belonging to 342 genera under 54 families occur (including infraspecific categories) in India. Of these 1030 occur in Eastern Himalaya, 751 in Western Himalaya and 540 in Western ghats.

The largest family in India is Pottiaceae with 37 genera and 190 species, followed by Bryaceae with 12 genera and 150 species. A conspectus of dominant families is given in Table I. Comparison of dominant families in 3 different regions is shown in Table II. The dominant genera include *Fissidens* (67 species), *Bryum* (59 species) *Campylopus* (41 species) and *Brachythecium* (39 species). The list of dominant genera is given in Table III.

Table I
Dominant families

Family	No. of Genera	No. of Species
Pottiaceae	37	190
Bryaceae	12	150
Dicranaceae	29	146
Hypnaceae	18	92
Sematophyllaceae	25	84
Brachytheciaceae	9	78
Neckeraceae	11	73
Fissidentaceae	1	67
Orthotrichaceae	12	67
Thuidiaceae	10	53
Polytrichaceae	6	47
Meteoriaceae	11	46

Table II
Dominant families

Name of Families	E. Himalaya		W. Himalaya		W. Ghats	
	Genera	Species	Genera	Species	Genera	Species
Pottiaceae	24	80	30	126	21	52
Bryaceae	10	70	11	89	7	52
Dicranaceae	27	90	19	53	12	55
Hypnaceae	13	55	12	36	7	25
Sematophyllaceae	23	66	6	6	11	29
Brachytheciaceae	8	37	9	65	5	17
Neckeraceae	10	51	7	17	10	32
Fissidentaceae	1	51	1	33	1	38
Orthotrichaceae	10	25	5	26	6	30
Thuidiaceae	10	39	8	32	3	9
Polytrichaceae	6	42	5	20	2	10
Meteoriaceae	11	41	7	12	8	21
Calymperaceae	3	30	2	3	4	18
Hookeriaceae	10	31	1	1	7	9

Table III
Dominant genera

Name of genus	No. of Species	No. of endemics
Fissidens	67	40
Bryum	59	20
Campylopus	41	16
Brachythecium	39	23
Pogonatum	29	10
Brachymenium	27	16
Calymperes	26	13
Macromitrium	25	52
Pohlia	25	7
Thuidium	24	7
Barbula	24	13
Grimmia	21	9
Entodon	19	10
Mnium	19	
Hypnum	19	2
Orthotrichum	18	5

Sixteen genera are endemic to India. These, alongwith their distribution are listed in table IV.

Table IV
Endemic genera

Name	Distribution
Cyathothecium	Mussoorie (W. Himalaya)
Hyophilopsis	Panchgani (W. Ghat)
Macrothamniella	E. Himalaya
Mitrobryum	Tehri (W. Himalaya)
Nanothecium	Palni Hills (S. India)
Octogonella	Simla (W. Himalaya)

Name	Distribution
Orontobryum	E. Himalaya
Ortholimnobium	Arunachal Pradesh (E. Himalaya)
Orthotheciadelphus	N.W. Himalaya
Osterwaldiella	Darjeeling (E. Himalaya)
Pleuridiella	Assam
Pylaisiopsis	E. Himalaya
Retidens	Mussoorie (W. Himalaya)
Stenotheciopsis	Darjeeling, Kumaon (E & W. Himalaya)
Struckia	Himalayas
Trigonodiclyon	Kodaikanal, (South India)

129 spcies occur throughout the country. The remaining are confined to certain regions only.

Western Himalaya

Western Himalaya constitute the part of Himalaya located West of river Kali and includes the states of Jammu & Kashmir, Himachal Pradesh and Kumaon and Garhwal divisions of Uttar Pradesh. The annual precipitation decreases from East to North West. In Kashmir it is 62 cm in the valley and 80-87 cm in the surrounding hills, much of which is in the form of snow. 751 species, belonging to 215 genera and 47 families are reported from this region. Of these 443 taxa are acrocarpic, whereas 308 are pleurocarpic. List of dominant genera is given in Table V.

Table V
Dominant genera of W. Himalaya

Name	No. of Species	No. of endemics
Fissidens	33	2
Bryum	42	7
Brachythecium	35	21

Name	No. of Species	No. of endemics
Hypnum	12	1
Thuidium	13	
Orthotrichum	17	3
Philonotis	13	1
Grimmia	12	1
Barbula	18	4
Pohlia	13	2
Mnium	15	

Thirty two genera occur only in W. Himalaya, of which 7 are endemic in India (Table IV).

Besides, there are 10 genera common between Western Himalaya and South India. They are not reported from Eastern Himalaya. These are *Anacamptodon, Astomum, Braunia, Haplodontium, Homalia, Platydictya, Pottia, Rhamphidium, Timmiella* and *Weisia.*

It is interesting to note that family Sematophyllaceae represented by 84 species in India is known by only 6 species in Western Himalaya. These are *Aptychella tenuiramea, Brotherella perpinnata, Clastobryum capillaceum, Pylaisiadelpha drepanioides, P. tenuirostris* and *Struckia argentata.* Further, *P. tenuirostris* is a disjunct between Western Himalaya and Mexico, *P. drepanioides,* the type of which is from Simla, is widely distributed in Garhwal and has only once been reported from Eastern Himalaya, (Sikkim).

Other genera which have better representation in Western Himalaya are : *Didymodon, Hymenostomum, Tortula, Mielichhoferia, Anomobryum, Hypnum, Drepanocladus, Amblystegium, Campylium, Hygrohypnum, Forsstroemia, Lindbergia, Gollania, Timmia, Hymenostylium Desmatodon.* A comparison of the number of species in each region is given in Table VI.

Table VI
Comparison of some dominant West Himalayan genera in three regions

	S.I.	E.H.	W.H.
Didymodon	3	4	10
Hymenostomum	1	1	4
Tortella	2	2	5
Tortula	1	2	11
Hymenostylium	3	3	6
Desmatodon		2	8
Timmia		1	3
Gollania		2	4
Lindbergia		1	3
Orthothecium		1	3
Cryptoleptodon		1	4
Forsstroemia	1	1	4
Drepanocladus		2	4
Amblystegium		1	5
Campylium		2	6
Hygrohypnum		1	3
Hygroamblystegium		1	3
Hypnum	1	8	12
Mielichhoferia	1	3	7
Anomobryum	5	3	9
Hypoterygium	1	1	3

Family Neckeraceae, represented by 73 species in India, is known only by 17 species in Western Himalaya. However, all the 4 species of genus *Cryptoleptodon* are distributed in Western Himalaya. These are *C. acuminatus*, *C. flexuosus*, *C. pulvinii* and *C. rigidulus*. Except *C. flexuosus*, which is distributed in Garhwal and Eastern Himalaya, all others are confined to high altitude areas of Kashmir. *Cyathophorella*, a genus of

Sout East Asian distribution, is represented by 3 species viz. *C. adiantum, C. intermedia* and *C. tonkinensis* in Western Himalaya. While the former two are common to Eastern Himalaya. *C. tonkinenis* is a disjunct between Western Himalaya and Tonkin. *Dicranodotinum kashmirense* is also common betweem Westerm Himalaya and Arunachal Pradesh in the Eastern Himalaya.

144 species, including 5 genera, are endemic to the area which is 20% of the total number of species occurring in this region. The endemic genera include *Cyathothecium, Mitrobryum, Octogonella, Orthotheciadelphus* and *Retidens*, all of them monotypic. Except for *Mitrobryum koelzii*, which was collected from its type locality Tehri in recent years, none of the genera have been collected again. The largest number of endemics are in *Brachythecium*, where out of 35 species 21 are endemic. Other with large number of endemics are shown in Table VII

Most of the endemics of Western Himalaya are confined to the high altitude areas of Kashmir and Himachal Pradesh, although those occurring in Kumaon and Garhwal also are considerable in number. Some of those described in recent years include *Buxbaumia himalayensis, Andreaea kashyapii, Campylium gollani, Hygroamblystegium gangulianum. Hygrohypnum nairii, Brachythecium chakratense, B. garhwalense, Pseudoleskea laevifolia* var. *vasudharensis, Thuidium contortulum* var. *mussooriense, Plagiothecium dehradunense, Hydrogonium mussoorianum, Anoectangium kashmiriense, etc.*

It may be mentioned that *Hygrohypnum nairii*, type of which is from Pithoragarh, was collected again from the type locality. Others which have been subsequently collected for the first time since they were first described are: *Plagiothecium perminutum, Rhynchostegium subrectocarpum* and *Pylaisiadelpha drepanioides. Homomallium similaense* is quite frequent in Poonch. *Brachythecium myurelliforme, B. indicopopuleum, Pseudoleskea laeivifolia* and *Brachythecium microsericeum* were collected from the type localities while *Fabronia minuta* and *Lindbergia longinervis,* the types of which are from Kumaon, were collected from Poonch, in Jammu & Kashmir.

Table VII
Endemic genera in Western Himalaya

	No. of species	No. of endemics
Mielichhoferia	7	6
Amomobryum	9	7
Homomallium	3	2
Cryptoleptodon	4	3
Lindbergia	3	2
Plagiothecium	6	3
Entosthodon	7	3
Funaria	5	2
Tayloria	4	2
Hymenostylium	6	4
Trichostomum	3	2
Timmiella	4	2
Didymodon	10	6
Blindia	4	4

Encalypta, represented by *E. alpina, E. ciliata, E. rhabdocarpa, E. streptocarpa, E. tibetana* and *E. vulgaris,* occurs only in high altitude areas of Kashmir and Ladakh and is altogether lacking from other parts of Himalaya. Contrast between both the parts of the Himalayas is also evident from a study of genus *Sphagnum* and *Andreaea. Sphagnum,* with 20 species in Eastern Himalaya is represented only by 3 species : *S. fimbriatum, S. teres* and *S. squarrosum* in the Western Himalaya. These are distributed only in Kashmir and Himachal and are quite rare in the region. *Andreaea* represented by 5 species in Eastern Himalaya is known only by *A. rupestris* from Western Himalaya. This species, again is rare in the region and was collected only once from North Garhwal (Vohra, 1963)

Besides, Sematophyllaceae and Neckeraceae mentioned above, there is a general poverty of other tropical families such as Meteoriaceae, Pterobryaceae, Leucobryaceae and Calymperaceae. Hookeriaceae, represented by 11 genera and 35 species in India is known only by *Distichophyllum humifusum* in Western Himalaya. Lembophyllaceae, Leucomiaceae and Symphyodontaceae are altogether lacking.

Eastern Himalaya

Eastern Himalaya is botanically the richest part of the country. The outer ranges of the mountain receive full blast of the monsoon. The annual precipitation generally varies between 3000-5000 mm in these ranges. In Eastern Himalaya semi-evergreen and evergreen forests, which range from foot hills to 900 m, support luxurious moss vegetation. But the maximum number of taxa occur at higher elevations in temperate and alpine areas. 1030 species belonging to 276 genera and 53 families are reported from here, which is more than half of the total number of species in the country. Of these while 509 taxa are acrocarpic, the rest are pleurocarpic. This region is equally rich in endemics. As many as 8 genera are endemic. It is also floristically very interesting and is considered as a meeting place of the floras of several neighbouring countries. Besides, endemics boreal (Palearctic), Sino-Japanese, East Asiatic, Indo-Malayan, Oceanic elements and disjuncts occur here in large numbers. Meghalaya, Nagaland, Manipur and Arunachal Pradesh are considered as centre of origin of *Symphyodon* and several other taxa. Cherrapunji in Meghalaya is considered the wettest place on the earth, where the annual precipitation is very high. Although not much of forest cover is visible now, Cherrapunji is still bryologically very rich. A few years ago one could collect *Sphagnum khasianum* in plenty near Mawsmai falls from here, as well as from Elephant falls, Shillong that also in fruiting condition. Most other species of *Sphagnum* occur at an elevation of about 3000 m in Tongloo Sandakphu near Darjeeling and in Sikkim and Arunachal at similar height. The list of dominant genera is given in Table VIII.

Table VIII
Dominant genera of E. Himalaya

Name		No. of Species	No. of endemics
1.	*Fissidens*	51	17
2.	*Bryum*	27	6
3.	*Pogonatum*	27	5
4.	*Campylopus*	20	4
5.	*Sphagnum*	20	1
6.	*Thuidium*	20	2

Name		No. of Species	No. of endemics
7.	*Entodon*	17	9
8.	*Mnium*	17	-
9.	*Calymperes*	17	10
10.	*Brachymenium*	13	6
11.	*Barbula*	13	2

63 genera are distributed in E. Himalaya only. They are listed in Table IX. Six genera are endemic in E. Himalaya. These are *Macrothamniella, Oraontobryun, Ortholimnobium, Osterwaldiella, Pleuridiella* and *Pylaisiopsis.* Two genera, *Stenotheciopsis* and *Struckea* are endemic to both Eastern and Western Himalaya. Family Lembophyllaceae is also reported from this region only.

Table IX
Genera occurring exclusively in E. Himalaya

Diphyscium	*Plagiobryum*
Lyellia	*Orthomniopsis*
Polytrichastrum	*Meesia*
Pleuridiella	*Anacolia*
Ditrichopsis	*Groutiella*
Aongstroemiopsis	*Desmotheea*
Campylopodiella	*Sphaerotheciella*
Atractylocarpus	*Hydrocryphaea*
Cynodontium	*Pseudosspiridentopsis*
Leucophanes	*Trachyloma*
Exodictyon	*Osterwaldiella*
Bellibarbula	*Garovaglia*
Geheebia	*Endotrichella*
Prionidium	*Horikawaea*
Leptodontium	*Meteoriella*
Micromitrium	*Isotheciopsis*
Voitia	*Pseudobarbella*
Tetraplodon	*Aerobryum*

Isothecium	*Orontobryum*
Dixonia	*Swetschkeopsis*
Eriopus	*Pelekium*
Chaetomitrium	*Actinothuidium*
Chaetomitriopsis	

Other genera which have a better representation in E. Himalayas are given in Table X.

Table X
Comparison of some dominant genera in three regions

Name	S.I.	E.H.	WH
Dicranella	2	8	4
Dicranodontium	3	12	13
Dicranum	2	13	7
Isopterygium	6	15	6
Ectropothecium	9	12	2
Pylaisiella		5	1
Floribundaria	4	8	1
Barbella	7	9	2
Calyptothecium	4	9	1
Homaliodendron	7	12	4
Distichophyllum	3	7	1
Stereophyllum	5	8	3
Leucobryum	8	9	2
Racomitrium	2	9	3
Trematodon	3	8	4
Sphagnum	1	20	3
Andreaea		5	1

270 species are endemic to E. Himalaya, which is 27% of the total number of species. Largest number of endemics (17 species) are in genus *Fissidens*. Others with higher proportion of endemics are *Calymperes* (10), *Entodon* (9) and *Brachymenium* (6). Other genera with a significant number of endemics are given in Table XI.

Table XI

Name	No. of Species	No. of endemic
Dicranella	8	4
Dicranodontium	12	5
Trismegistia	9	4
Brothèrella	11	10
Pylaisiella	5	4
Floribundaria	8	4
Chrysocladium	5	4
Macromitrium	11	4
Symphysodontella	4	3
Daltonia	12	9
Distichophyllum	7	4
Symphyodon	8	6
Splachnobryum	5	3
Andreaea	5	4
Garimmia	13	7

Out of 276 genera occurring in Eastern Himalaya, 171 are common with the Western Himalaya. Similarly, out of 1030 species occurring in Eastern Himalaya, 360 are common with Western Himalaya.

Eastern Himalaya, as mentioned above has a high proportion of endemics and is also considered a region of active speciation. On the other hand many of the species have not been collected again and remain repressented by types only. Many of them are generally confined to smaller areas and have a preference for a particular habitat or a niche. These are often referred to either as ancient relicts or neoendemics. They are so rare that only experts can find them in the field.

Some of the species, still known by types only include all the four endemic species of *Andreaea: A. commutata, A. densifolia, A. indica* and *A. rigida, Polytrichastrum xanthopilum, Polytrichum densifolium, Pleuridium tenue, Ditrichum laxissimum, Trematodon megapophysatus, Dicranoweisia alpina,* to mention a few. All of them were described from higher altitude areas of Sikkim and were collected by Hooker. Others include *Oreoweisia brevidens, Hypnum sikkimense, Platygyrium subrussulum, Trolliella enendostoma, Pylaisiopsis speciosa, Hageniella sikkimensis,* also from Darjeeling and Sikkim. The list is unending.

Arunachal Pradesh, though very little explored (Dixon 1914, 1937; Vohra & Kar, in Press), has genus *Ortholimnobium* and 19 other species endemic, to the state. These include *Microdus assamicus, Dicranella leptoneura, Mitthyridium piluliferum, Ortholimnobium borii. Symphysodontella borii, S. subulata, S. pilifolia, S. tortifolia, Daltonia perlaxiretus, Symphyodon complanatus, S. scabrisetus* and *Leskea perstricta.*

It is interesting to note that *Symphysodontella* a genus of South East Asiatic distribution, achieves maximum diversification in Arunachal Pradesh. Out of 5 species occurring in India 3 are endemic to Arunachal and one to neighbouring Nagaland. Similarly, *Symphyodon* with 20 species in the world and distributed in South East Asia, is represented by 11 species in India, 8 of them distributed in Eastern Himalaya. Eastern Himalaya is considered as centre of origin and diversification for this genus (Dixon, 1937). *Hageniella* with 5 species in the world, 3 are endemic to Eastern Himalaya, one in Malaya and one in Hawaii. Other areas where endemics thrive in large numbers are Khasia Hills (Meghalaya) which is type locality for such species as *Clastobryum surculare, Entodon curvatus, Homalothecium neckeroids, Hookeriopsis secunda, Macromitrium incrustatifolium, Mielichhoferia assasmica, Merceya longirostris, Syrrhopodon asssamicus, Pylaisiella brevirostris, Rhaphidorrhynchium confertissimum* and *Fabronia assamica.* None of them have been collected again till date.

Hageniella assamica, H. isopterygioides, Aptychella borii, Forsstroemia inclusa, Macromitrium hamatum, Pseudosymbepharis pallidens, Dicranum assamicum, Leiodontitum complanatum, Chrysocladium horridum, Brotherella filiformis, Daltonia gemmipara are endemic to Nagaland and have never been reported for the second time.

Splachnobryum assamicum, S. synoicum, Aerobryopsis membranacea, Calyptothecium dixonii, Homalothecium incompletum, Trichostelum glaucovirens, Pleuridiella colei, Dicranella macrospora, Fissidens longisetus, Symphyodon orientalis are some of the rare species endemic to Assam.

In the recent years, a number of such species were collected for the first time, in a century,, which were feared to have become extinct. Notable among them are *Orontobryum hookeri, Plagiothecium entodontella, P. paleaceum, Barbula hastats,* (Type Darjeeling, Arunachal), *Dicranodontium capillifolium* (Type Arunachal), *Thamnobryum macrocarpum* (Type Nepal), *Entodon nepalense* (Type Nepal, collected from Darjeeling), *Macrothamnium leptohymenioides, Sematophyllum humile* (Type Nepal, collected from Shillong), *S. subhumile* (Type Nepal, collected from Shillong), *Hageniella assamica* (Type Nagaland, collected from Bhutan), *Entodon subplicatus* (Type Darjeeling, collected from Sikkim), *Stenotheciopsis serrula* (Type Darjeeling, collected from Bhutan), *Symphyodon scalerisetus* (Type Arunachal Pradesh). *Plagiothecium entodontella, P. paleaceum, Dicranodontium capillifolium, Entodon subplicatus* were collected from the vicinity of their type localities. They appear to have a limited range and need special efforts for conservation. Excepting *Orontobryum hookeri* and *Stenotheciopis serrula,* for which more than one specimen was collected, others are rare with only very small populations.

Western Ghats

Western Ghats constitute the mountain chain along the West coast of India from Gujrat to Trivendrum. It is also known as Malabar region. It encompasses the Sahyadri-range and Coorg region, the Nilgiri, Anamalai, Palni and Cardamom Hills. The vegetation of this region is influenced more by the variation in seasonal rainfall than the atmospheric temperature. On the western side the Sahyadri mountians rise abruptly to 1000 m within a distance of 2-3 km, the descent on the eastern side is gardual and through valleys and flat topped spurs. The south west monsoon strikes the region with full force from June to September. The average rainfall is 6250-7500 mm in Mahabaleshwar. The windward side is exposed to upto 6000 mm in Coorg, mostly on the western side. The eastern side is a rain shadow area. The evergreen forests which occur in the high rainfall areas are rich in mosses. On the other hand the deciduous forests are almost devoid of moss vegetation in Western ghats.

In the humid tropics of Southern Western Ghats, because of non seasonal warm climate, tropical rain forest, are developed on the windward side. These are more pronounced between 500-1500 m. These forests are very rich in moss vegetation (Vohra, 1982). But these are among the least explored areas of the country.

Our knowledges of the mossess of Western ghats is based on the work done during the last century or early part of 20th century. Since then this area has not seen much of activity. Mosses from Nilgiri were first reported by Montagne (1842), Carl Mueller (1853), Mitten (1859) and subsequently by Brotherus (1899), Dixon (1914). Mosses from western ghats were reported by Dixon (1909, 1911, 1912, 1921). Raghavan and Wadhwa (1968, 1970), Dixon and Potier dela Varde (1927, 1930) and Potier de la Varde (1922, 1923, 1924, 1925, 1928a, 1928b) described several new taxa from Palni Hills and other hill stations. Foreau (1961) listed 368 species from Palni Hills which included 95 new species and 15 varieties and 3 new genera described earlier by Dixon and Potier dela Varde (1982) reported 100 species from tropical rain forests of Silent Valley located in Palghat district of Kerala.

Aziz *et al.* (1995) had estimated 682 species from this region. These belong to 171 genera and 42 families. Of these, 347 taxa are acrocarpic, while 355 are pleurocarpic. However, for most part of the Western ghats and the rest of peninsula we do not have any data. Dominant genera of Western ghats are given in Table XII.

Table XII
Dominant genera of W. Ghat

Name	No. of Species	No. of endemics
Fissidens	38	8
Bryum	23	13
Brachymenium	15	8
Campylopus	27	12
Zygodon	9	4
Macromitrium	17	10
Pterobryopsis	14	8
Hyophila	10	5
Philonotis	9	1
Leucobryum	8	3
Entosthodon	8	2
Leucoloma	9	4
Ectropothecium	9	5

Three genera are endemic to W. ghats. These are *Hyophilopsis*, *Nanothecium* and *Trigonodictyon*. Besides, 11 genera occurring exclusively in W. ghats are *Calymperiopsis*, *Hedwigidium*, *Jaegerina*, *Juratzkea*, *Lepidopilidium*, *Lepidium*, *Rhaphidostichum*, *Solmsiella*, *Swetschkea*, *Trachycarpidium* and *Warburgiella*.

Genera with maximum number of species in this region are : *Brachymenium*, *Campylopus*, *Leucoloma*, *Sematophyllum*, *Glossadelphus*, *Vesicularia*, *Zygodon*, *Macromitrium*. Their comparison in 3 regions is given in Table XIII.

Table XIII
Comparison of some dominant genera in three region

	No. of species		
	S.I.	E.H.	W.H.
Brachymenium	15	13	8
Campylopus	27	20	7
Leucoloma	9	2	
Sematophyllum	6	5	
Glossadelphus	5	4	
Vesicularia	6	5	3
Zygodon	9	3	
Macromitrium	17	11	4
Racopilum	3	2	1
Pterobryopsis	14	9	1
Fabronia	5	3	3
Entosthodon	8	3	7
Archidium	3	1	1
Garckea	2	1	-
Trichostomum	6	1	3
Hyophila	10	7	5

Genera equally represented in all the 3 regions are : *Rhynchostegum*, *Papillaria*, *Meteorium*, *Trachypus*, *Fabronia*, *Regmatodon*, *Pseudoleskeopsis*, *Leskea*, *Levierieella*, *Philonotis*, *Pleuridium*, *Ceratodon*, *Anoectangium*, *Merceya* and *Bryosedgwickia*.

Fissidens and *Bryum* are two such genera, which are equally dominant in all the regions of the country. Another interesting genus is *Bryosedgwickia* represented by 3 species in India. *B. kirtikarii,* the type of the genus is endemic to Western ghats (Mahalealeshwar), *B. fragillifolia* is endemic to the Western Himalayas.Whereas, *B. aurea* is endemic to the Himalayas. The remaing 4 species of the genus are distributed in Central America. One of them also ocurs in Central Africa. This is an example of disjunction between Central Afria, India and Central America.

Out of 2 species *Astomum,* in India, *A. crispum* is distributed in Western Himalaya, wheras *A. minutum* occurs in Palni Hills.

Two species of *Entodon, E. longifolius* and *E. obtusatus,* earlier considered as endemic to Western ghats and South India respectively, are now reported from China (Hu, 1982).

228 species are common with Eastern Himalaya. But species occurring in Western ghats and Western Himalaya, and not reported from Eastern Himalaya are very few. They include *Fabronia goughii, Entosthodon physcomitrioides, Splachnobryum procerrimum, Haplodontium fabronioides, Weisia controversa, Timmiella anomala, Hyophila subflaccida, Atrichum sulcatum, Bryum sahayadrense* and *Breutelia sclerodictya.*

Species common between South India and Sri Lanka include: *Tortella ceylonensis. Papillaria flexicaulis, Meteorium miquelianum, Chrysocladium retrorsum, Meteoriopsis reclinata* var. *subreclinata, Lepideopilidium furcatum, Lepidium javanicum, Brachymenium lepstomoides, Fissidens aberrans, F. fuscoviridis, Macromitrium schmidii, Pterobryopsis schmidii, Symphyodon perrottetii, Entosthodon planifolius, Calymperes nietneri, Syrrhopodon strictus, Solmsiella ceylonica, Trichstomum orthodontium, Pterobryopsis frondosa, P. tumida, Rhynchostegiella fabroniadelphus, Rhaphidostichum cucullifolium, Ectropothecium laevigatum, Sphagnum ceylonicum, Glossadelphus vivicolor.* It is rather interesting that only 36 species are common between Western ghats and Sri Lanka while 163 species are common between Eastern Himalaya and Sri Lanka, most of them also occur in S. India.

190 species are endemic which is 300% of the species occurring there. 30 species endemic to W. Ghats of Maharashtra, and Karnataka, include *Oxystegus perannulatus, Bryum ghatense, Fissidens coorgiensis,*

F. Walkeri, F. subfirmus, F. karwarensis, F. macrosporus, F. sedgwickii, Macromitrium nigricans, M. leptocarpum, M. subleptocarpum, Bryosedgwickia kirtikarii, Hyophilopsis entosthodontacea, Daltonia brevipedunculata, Brachymenium turgidum, B. walkeri, Anomobryum brachymenioides, Trichostomum bombayense, Weisia ghatiense, Hyoplhila walkeri, Barbula dharwarensis, Merceya rothusta, Entoontopsis sedgwickii, Pohlia rostrata, Levierella fabroniacea var. *dilatinerve. Sematophyllum angusticuspis, Garckea abbreviata. Leucobryum imbricatum, Anoectangium walkeri, Merceya spathulifolia, Schwetschkea indica, Trichostomum hyalinoblastum,* The remaining species are endemic to Palni, Nilgiri or some other places of Peninsular India.

The occurence of such genera as *Hedwigidium, Calymperiopsis, Juratzkea, Lepidopilidium, Trachycarpidium* remind the links of the Indian peninsula with Africa and Southern hemisphere during ancient times. Further survey in these areas may bring out more of such genera.

PHYTOGEOGRAPHICAL AFFINITIES

Indian moss flora is a complex combination of several elements present in various proportion. They were first recognized by Brotherus (1898) and Dixon (1942), and were elaborated by Gangulee (1980). They include (1) Panboreal (Palaearctic). (2) Sino-Japanese, (3) Indo-Burmese, (4) Palaeotropical (Indo-Malayan) (5) Disjuncts, (6) Endemics, (7) Cosmopoliton

(1) **Panboreal**: These include European, North American, North and Central Asiatic with large number of arctic alpine species present in the Himalayan flora and can be split into (a) Those present in Eastern Himalaya (b) Western and Eastern Himalaya (c) Western Himalaya.

(a) **Eastern Himalaya:** 26 such species have been identified as: *Dicranodonticum asperulum, D. denudatum*, etc.

(b) **Himalayas:** 50 species are recognized in this category, such as: *Rhytidium rugosum, Rhytidiadelphus triquetrus*, etc.

(c) **Western Himalaya:** 115 species fall in this category and a few dominant ones are: *Encalypta alpina, E. ciliata, E. vulgaris, E. rhabdocarpa, Homomalium incurvatum, Saelania* *glaucescens, Orthothecium strictum, Pseudostereodon procerrimum, Pottia starkeana, Stegonia latifolia, Ambylodon dealbatus, Herzogiella seligeri, Hygrohypnum dilatatum, H. luridum, Brachythecium campestre, B. collinum, B. glaciale, B. reflexum, B. starkei, B. velutinum, Derpanocaladus aduncus, D. exannulatus D. fluitans, , Amblystegium juratzkanum, A. serpens* var. *saxicola, Campylium chrysophyllum, C. halleri, C. sommerfeltii, Anomodon attenuatus, Lescuraea mutabilis, L. saxicola, Myurella julacea, Tayloria froelichiana* and *Tortula norvegica.*

(2) **Snio Japanese** species : They are present in large numbers in Eastern Himalaya but are fewer in Western Himalaya as shown in Table XIV.

Table XIV
Sino - Japanese Species

Name of the species	Distribution
Pogoantum akitense	E.H. China, Korea, Japan
Desmatodon gemmascens	Himalaya, Yunnan
Bryoerythrophyllum atrorubens	Himalaya Yunnan
B. gymnostomum	Himalaya, Yunnan, Japan
Bryoerythrophyllum yunnanense	Kashmir, China
Hydrogonium subpellucidum	Himalaya, Yunnan, W. Tibet
Barbula gregaria	Himalaya, E. Tibet
Hyophila spathulata	India, Sri Lanka, China Japan
Schwetschkeopsis formosana	E. Himalaya, Taiwan.
Anoectangium clarum	Himalaya, Yunnan.
A. thomsonii	India, China, Japan
Fissidens elongatus	E. Himalaya, China, Japan
F. plagiochiloides	E. Himalaya, Yunnan, Japan
Physcomitrium repandum	E. Himalaya, China, N. vietnam.
P. japonicum	Darjeeling, U.P. Plain, Yunnan, Taiwan, Korea, Japan
Voitia Hookeri	Sikkim, S.E. Tibet
Brachymenium ochianum	E. Himalaya, Taiwan

Name of the species	Distribution
B. ptychothecicum	E. Himalaya, Yunnan.
Bryum paradoxum	India, China, Korea, Japan, Taiwan
Mnium laevinerve	Himalaya, China, Taiwan, Korea, Japan
M. confertidens	E.Himalaya, Korea, Japan, Manchria, Siberia
M. japonicum	Himalaya, China, Japan
M. punctatum var. *horikawae*,	E. Himalaya, Taiwan
M. striatulum	Himalaya, Taiwan, Korea, Manchuria, Japan
Eriopus spinosus	E. Himalaya, Taiwan
Orthotrichum hookeri	Himalaya, Yunnan, Setschwan
Macromitrium perrottetii	S. India, Sri Lanka, China
Sphaerotheciella sphaerocarpa	E. Himalaya, Yunnan, Setschwan
Leucodon secundus	India, W.Tibet, Japan, Vietnam
Trachypodopsis auriculata	India, Sri Lanka, Yunnan,
Floribundaria armata	Taiwan, Myanmar E. Himalaya, Yunnan
Calyptothecium pinnatum	E.Himalaya., Myanmar, Taiwan
Neckera setschwanica	Sikkim, Setschwan
Thamnobryum fruticoscum	E. Himalaya, Sri Lanka,
Thudium venustulum	E. Himalaya, Yunnan
T. haplohymenium	Himalaya, Yunnan
T. vestitissimum	Himalaya, Yunnan
T. assimile	W. Himalaya, Yunnan,
Brachythecium wichurae	E. Himalaya, Yunnan, Japan
B. procumbens	India, Sri Lanka, Korea, Japan
Entodon luridus	E.Himalaya, China, Korea, Japan
E. coninnus ssp. *caliginosus*	E. Himalaya, China, Japan
E. myurus	Himalaya, Yunnan, Korea

Name of the species	Distribution
Stereophylum setschwanicum	E.Himalaya, Setschwan
Aptychella delicata	E. Himalaya, Yunnan, Japan
Struckia argentata	Himalaya, Yunnan
Brotherella erythrocaulis	E. Himalaya, Yunnan
Taxiphyllum giraldii	Himalaya, China, Taiwan, Japan.
Isopterygium pallidulum	Himalaya, China, Japan
Horikawaea indica	Upper Assam, Taiwan
Hypnum flaccns	E. Himalaya, Yunnan
H. subimponens var. *ulbophyllum*	E.Himalaya, China, Taiwan, Korea, Japan
H. setschwanicum	E. Himalaya, China, Taiwan
H. macrogynum	E.Himalaya, China, Taiwan, Myanmar
H. submolluscum	E.Himalaya, China
Leiodontium gracile	E.Himalaya., Yunnan
Hylocomium himalayanum	Himalaya, Japan
Sphagnum pseudocymbifolium	China, Taiwon
S. acutifolioides	E.Himalaya, S.E. China
S. khasianum	E. Himalaya, China, Thailand.
S. ovatum	E. Himalaya, China.
Theriotia lorifolia	Kashmir, China, Japan
Anomodon thraustus	Simla, Mussoorie, China, Korea, Japan.
Gollania ruginosa	W.Himalaya, Japan
Weisia exserta	W. Himalaya, China, Japan
Timmiella diminuta	Garhwal, China
Barbula subcontorta	Nainital, China

(a) **Eastern Himalaya:** 60 species are present in Eastern Himalaya

(b) **Western Himalaya:** 9 species are present in Western Himalaya.

(c) **Western Ghat:** *Leskea consanguinea* is reported from Western Ghats.

(3) **Indo Burmese**

(a) **Those occurring in India and Burma** are : *Archidium birmanicum, Trematodon kurzii, Campylopus subgracilis, laetus, Fissidens crenulatus, F. intromarginatulus, F. kurzii, Calymperes burmense, Barbula marginatula, Splachnobryum flaccidum, Macromitrium calymperoideum, Pterobryopsis flexipes* and *P. acuminata.*

(b) **Species Common with Thailand**: *Syrrhopodon subconfertus, Philonotis angustata, Macromitrium turgidum, Homaliodendron sphaerocarpum, Thamnobryum siamense* and *Dixonia thamnioides*

(c) **Species common with Vietnam**: *Trematodon confermis, Dicranodontium didymodon* and *Fissidens virens.*

(d) **Common with Burma and Thailand**: *Pinnatella kurzii, Pterobryopsis divergens, Penzigiella cordata, Symphyodon erinaceus, Wijkia surcularis, Sematophyllum subhumile* and *Fissidens involutus.*

(4). **Paleotropical** : Included in this category, are the Asiatic species covering wholly or partly the area from New Guinea northward to Korea. This is the largest element in the Indian flora. Their number is more in Eastern Himalaya where about 230 species are represented.

(5) **Disjuncts**

Disjuncts are given in Table XV

Table XV
Disjunct distribution

Name of the species	Distribution
Anacolia menziesii	E.Himalaya, Vancouver, Mexico
Fleischerobryum machrophyllum	E. Himalaya, Philippines
Breutelia sclerodictya	Palni Hill, Madagascar
Philonotis speciosa	E. Himalaya, Jawa, Philippines
Leucobryum mittenii	Meghalaya, Japan
Fissidens robinsonii	Andaman & Nicobar, Philippines
Haplodontium fabronioides	Kashmir, Kodaikanal, Madagascar
Brachymenium acuminatum	Himalaya, Philippines
B. longicolle	E. Himalaya, Thailand, Africa, Mauritius.
Bryum bessonii	Palnis, E.Nepal, Madagascar
Dicranella setigera	E. Himalaya, Philippines
Orthomnium loheri	E. Himalaya, Philippines
Hyophila rosea	Garhwal, Kumaun, Gujrat, Orissa, Philippines
Pylaisiella falcata	Nagaland, Bhutan, Mexico
Cryptoleptodon flexuosus	Himalayas, C. Africa
Entodon longifolius	Bombay, recently reported from China,
E. obtusatus	W. Ghats, China
Aulacopilum luzonense	W. Himalaya, Philippins
Solmsiella ceylonica	Kanara, Sri Lanka, Indonesia, Africa
Macromitrium japonicum	Madras, Japan
Trachypus appendiculatus	W. Himalaya, Madagascar
Jaegerina stolonifera	Palni Hills, Cameron, Madagascar.
Symphysodontella subulata	Arunachal, Philippines
Cyathophorella adiantum	Himalaya, Philippines
Schwetschkeopsis fabroura	E. Himalaya, Japan, U.S.A.

Name of the species	Distribution
Entosthodon submarginata	Nilgiri, Palnis and Madagascar
Hymenostyliella elanosii	Dehradun (U.P.), Philippines
Didymodon platyneurus	Kashmir, Canada
Rhachithecium perpussilum	Shillong, Palnis, Yunnan, C. and S. Africa, Madagascar, Mexico, Andes, Brazil
Trachycarpidium tisserantii	Kanara Distt. (Karnataka), Central Africa
Pinnatella africana	Andaman & Nicobar Island, C. S.-W. Africa
Vesicularia Kurzii	Andaman Island, Java
Syrrhopodon subconfertus	Andaman Island, Thailand
Mitthyridium manii	Andaman Island, Malacca, Amboina
Calymperes delesserti	Andaman, Singapur, Molucca
C. punctulatum	Nicobar Islands, Sigapur
Fissidens robnsonii	Andaman & Nicobar Island, Philippines
Neckeropsis submarginata	Andaman Islands, Malaya
Symblepharis vaginata	Himalaya, China, North & Central America
Leucobryum mittenii	Khasia Hill, Japan
Reimersia inconspicua	Himalaya, China, Japan, Taiwan, Philippines.
Hyophila rosea	Orissa, W. Himalayas, Gujrat, Philppines.
Didymodon michiganense	Himalaya, Japan, Michigan (U.S.A.)
Arbula nigrescens	Himalaya, China, N. America
Bryoerythrophyllum wallichii	Himalaya, C. Asia
Splachnobryum indicum	India, Java, Philippines
Brachymenium longicolle	E.Himalaya, Thailand, C. Africa, Mauritius

Name of the species	Distribution
Zygodon obtusifolius	E. Himalaya, Sri Lanka, Central South America, Central Africa
Symphysodontella subulata	Arunachal Pradesh, Philippines
Anomodon acutifolius	Himalaya, Japan
Thruidium kiasense	E. Himalaya, Philippines
Homalothecium nilgheriense	India, Sri Lanka, China, Jawa, Philippines.
Clastouryopsis planula	E. Himalaya, Japan, Jawa, Philippines
Glossadelphus bilobatus	Naga Hills, Sri Lanka, Molucca
Taxiphyllum maniae	Himalaya, Jawa, New Guinea, Madagascar
Isopterygium microplumosum	Andaman, Brazil
I. distichaceum	India, Sri Lanka, Burma, E. N.America
I. micans	Assam, South Tibet, China, U.S.A., S. America, S. Africa.
Hypnum aduncoides	E.Himalaya, Burma, Yuman, Madagascar, S. Africa.
Ctenidium lychnites	E.Himalaya, Nilgiris, Sri Lanka, Philippines
Leptohymenium tenue	Himalaya, Yunnan, Myanmar, Thailand, Mexico
Oligotrichum semilamellatum	Himalaya, Sumatra
Calyptothecium himantocladioides	Darjeeling, Maynmar, Phillipines
Lyellia crispa	E. Himalaya, Yuman, N. America

(6) Endemics

About 678 taxa of mossess are endemic to India of which Eastern Himalaya accounts 270 followed by Western ghats (190) and Western Himalaya (144). Some of the endemic mosses are listed in Table XVI.

Table XVI
Some rare and threatened Endemics

Name	Distribution	Remarks
SPHAGNACEAE		
Sphagnum nepalense	E. Himalaya	
ANDREAEACEAE		
Andreaea indica	Sikkim	
A. densifolia	Sikkim	
A. commutata	Sikkim	
A. rigida	Sikkim	
POLYTRICHACEAE		
Pogonatum strictifolium	Darjeeling	
Polytrichum densifolium	Sikkim	
Polytrichastrum xanthopilum	Sikkim	
ARCHIDIACEAE		
Archidium microthecium	Kodaikanal	
A. octosporum	Kodaikanal	
BUXBAUMIACEAE		
Buxbaumia himalayensis	W. Himalaya	
DIPHYSCIACEAE		
Theriotia kashmirensis	Kashmir	
DITRICHACEAE		
Pleuridium tenue	Sikkim	Represented by type collection by J.D. Hooker from Kinchinhau, 5000 m.
P. denticulatum	Nilgiri, Palni	
Pleuridiella colei	Assam, Jorhat	Represented by Type collection by Cole.
Garckea abbreviata	Mangalore	
Ditrichum apophysatum	Darjeeling, Tongloo	
D. darjeelingense	Darjeeling	Represented by single collection by Miller.
D. laxissimum	Darjeeling	Represented by collection by J.D. Hooker.

Name	Distribution	Remarks
Ditrichopsis clausa	Sikkim	
SELIGERIACEAE		
Blindia campylopodioides	N.W. Himalaya, Dalhousie.	
B. himalayana	N.W. Himalaya, Dalhousie	
B. roerichii	N.W. Himalaya	
B. perminuta	W. Himalaya	
DICRANACEAE		
Trematadon assamensis	Garo Hills, Arunachal Pradesh	Known only by two collections.
T. megapophysatus	Darjeeling	Represented only by Hooker's collection.
T. schmidii	Nilgiris & Palnis	
Mitrobryum koelzii	Tehri	Represented by type.
Microdus assamicus	Arunachal Pradesh	Known from type by Bor
Dicranella leptoneura	Arunachal Pradesh	Known from type.
D. pseudosubulata	Darjeeling	Known by type by Kurz.
D. amplexans	E. Himalaya	Known from type.
D. macrospora	Assam	Known from type
D. cerviculata	W. Himalaya	
Campylopoliella tenella	Darjeeling	Known from type.
C. ditrichoides	E. Himalaya	
Campylopus milleri	Darjeeling	Known from Type by Miller.
C. durelli	E. Himalaya	
C. alpigena var. *lamellatus*	Darjeeling	
Dicranodontium capillifolium	Arunachal Pradesh	Known from type.
D. sordidum	E. Himalaya	Known from type.
D. perviride	S. India	
Atractylocarpus sinensis	Sikkim	
A. erectifolius	E. Himalaya	
Brothera himalayana	Sikkim	
Paraleucobryum himalayanum	N.W. Himalaya	
Oreoweisia brevidens	Sikkim	Known from type.
Dicranoweisia alpina	Sikkim	Known from type.
Oncophorus gracillimus	Kashmir	
Dicranum assamicum	Naga Hills	Known from type.

Name	Distribution	Remarks
D. orthophylloies	E. Himalaya	
D. dilatinerve	Kodaikanal.	
Leucobryum imbricatum	Coorg	
Leucophanes nicobaricum	Nicobar	
FISSIDENTACEAE		
Fissidens longisetus	Assam	Known from type by Griffith.
F. rambii	Darjeeling	
F. rigidiusculus	Darjeeling	
F. allanii	Darjeeling	
F. ranuii	Chhota Nagpur	
F. bilaspurense	Bilaspur, Midnapur	
F. subpulchellus	Arunachal	
F. polysetulus	Darjeeling Sikkim	
F. lèptoplema	Arunachal	
F. robinsonii	Andaman, Nicobar Is.	
F. jungermannioides	Meghalaya	
F. elongatus	Meghalaya	
CALYMPERACEAE		
Syrrhopodon assamicus	Khasia Hills,	
S. calymperoides	Palni Hills	
S. himalayanus	W. Himalaya	
S. leucophanoides	Palni Hills Madurai, Kerala	
Mitthyridium andamanense	Andamans	
M. nicobaricum	Nicobar Is.	
M. piluliferum	Arunachal	Known by type.
Calymperes delessertii	Andaman Is.	
C. griffithii	E. Himalaya	
C. manii	Andamans	
C. andamanense	Andaman	
C. mussuriense	W. Himalayas	
C. punctulatum	Nicobar Is.	
C. sikkimense	Darjeeling	
C. lingulatum	Andamans Mangroves.	Epiphytic on
C. nicobarense	Nicobars	
C. calcuttense	Calcutta	Known by type.
C. sundarbanense	Sundarbans	Known by type.
C. kurzianum	Andaman Is.	

Name	Distribution	Remarks
POTTIACEAE		
Anoectangium walkeri	W. Ghats, Coorg	
H. dicranelloides	Kumaon	
H. filiforme	Kashmir	
H. shepheardae	Kumaon	Known from type (Binsar)
H. validierve	S. India, (Palni, Kanan Deva Hill, Travancore).	
Oxystegus khasianus	Khasia Hills	
O. cylindrothecus	Darjeeling & Sikkim	
Pseudosymblepharis pallidens	Naga Hills	
Tortella alpicola	Kashmir	
T. goughii	S. India	
Weisia ghatiensis	W. ghats	
W. macrospora	Palni Hills	
W. norkettii	W. Himalaya	
W. rutilans	Kashmir	
Astomum minutum	W. Himalaya	
Trichostomum bombayense	Western India	
T. hyalinoblastum	Palni Hills	
T. miniusculum	Palni Hills., Kanan Deva Hills, Travancore	
T. orthodontum	Kodaikanal	
T. perannulatum	S. India	
T. subminiusculum	Palni Hills	
Hyophila walkeri	S. India, M.P.	
H. perannulata	Darjeeling, Khasia	
H. comosa	Travancore, Orissa	
H. kurziana	Darjeeling	
Hyophilopsis entosthodontacea	Panchgani (W. Ghats)	
Barbula hastate	Darjeeling, Sikkim	
B. tenuiretis	E. Himalaya	
B. dharvarensis	Dharwar, Palni Hills	
B. denticulata	S. India.	
Bellibarbula kurziana	Darjeeling	
Semibarbula ranuii	Chhotanagpur	
Hydrogonium decolyi	Darjeeling	
Bryoerythrophyllum ferrugineum	Darjeeling	

Name	Distribution	Remarks
B. dentatum	Sikkim	
Didymodon maschalogena	Darjeeling	
D. ovatus	Sikkim	Known from type by Hooker
D. fragilicuspis	W. Himalaya	
D. microstomus	Pahalgam (Kashmir)	
D. obscurus	Simla	
D. strictifolius	Palni Hills	
D. obtusifolius	S. India	
Merceya longirostris	Khasia Hills	
M. hymenostylioides	N.W. Himalaya	
M. spathulifolia	Panchgani, Mangalore.	
Pottia alpicola	N.W. Himalaya	
D. kabirkhanii	Kumaon	
Tortula pseudo-princeps	Kashmir	
T. rubripila	Kashmir	
T. schmidii	Nilgiri, Palni, Kanan Deva Hills	
GRIMMIACEAE		
Grimmia apophysata	Darjeeling	
G. subdoniana	E. Himalaya	
G. khasiana	Khasia	
G. inflectens	E. Himalaya	
Racomitrium strictifolium	Sikkim	
R. fuscescens	E. Himalaya	
FUNARIACEAE		
Entosthodon capillipes	Kashmir, Pangi	
E. diversinervis	Nilgiri	
Faunaria pulchra	S. India	
F. excurrentinervis	S. India	
F. Koelzii	Himachal, Kashmir, Mussoorie.	
SPLACNNACEAE		
Splachnobryum bengalense	Gangetic South Bengal	
S. assamicum	Assam	
S. synoicum	Upper Assam.	
S. procerrimum	S. India	

Name	Distribution	Remarks
BRYACEAE		
Epipterygium koelzii	W. Himalaya	
Mielchhoferia assamica	Meghalaya	
M. acutifolia	W. Himalaya	
M. badhwarii	Kashmir, Himachal	
M. himalayana	W. Himalaya	
M. pilifera	W. Himalaya	
M. schmidii	Nilgiri Hills	
M. lahulensis	Lahul	
Pohlia rigescens	Sikkim, Darjeeling	
P. himalayana	Sikkim	
P. ampulacea	Darjeeling, Sikkim	
P. trematodontoides	Nilgiris	
P. rostrata	Malabar	
P. chitralensis	W. Himalaya	
P. stewartii	W. Himalaya	
Brachymenium longidens	Darjeeling	
B. alpinum	Sikkim	
B. sikkimense	Darjeeling	
B. argenteoides	W. Himalaya	
B. himalayanum	W. Himalaya	
B. extenuatum	S. India	
B. fischeri	Attapadi Hills, Coimbatore	
B. bryorides	W. Himalaya	
B. cristatum	S. India	
B. walkeri	E. Himalaya, S India	
B. rugosum	Nilgiri	
B. leptostomoides	Plains, Sri Lanka	
B. turgidum	W. Ghats	
B. velutinum	S. India	
Anomobryum astorense	Kashmir	
A. brachymenioides	W. Ghats	
A. gemmigerum	W. Himalaya	
A. kashmirense	Kashmir	
A. marginatum	W. Himalaya	
A. parvifolium	Kashmir, Ladakh	
A. pellucidum	Kashmir	
A. schmidii	Nilgiris	
A. subnitidum	Palni Hills	
Bryum flaccum	Sikkim	

Name	Distribution	Remarks
B. sahyadrense	W. Ghats	
B. ghatense	W. Ghats	
B. vellei	S. India	
B. pachycladum	S. India	
B. euryphyllum	S. India	
B. apalodictyoides	Nilgiris	
B. amoenum	Kashmir	
lamprostegum	Nilgiris	
B. gamblei	Kashmir	
B. punjabense	W. Himalaya	
Rhodobryum madurense	Palni Hills, Madurai	
BARTRAMIACEAE		
Bartramidula dispersa	S. India	
Philonotis subrigida	Kodaikanal	
P. glomerata	Alpine Sikkim.	
P. trachyphylla	W. Himalaya (Zanskar)	
PTYCHOMITRIACEAE		
Ptychomitrium indicum	Darjeeling	
ORTHTRICHACEAE		
Zygodon brevisetus	Sikkim	
Z. acutifolius	Nilgiris	
S. erosus	Palnis, Madurai	
Orthotrichum sikkimense	Sikkim	
O. venustum	Kashmir	
O. virens	Kashmir	
Ulota robusta	E. Himalaya	
U. schmidii	Nilgiris	
Octogonella scabrifolia	Simla	
Trigonodictyon indicum	Kodaikanal	
M. incrustatifolium	Khasia Hills	
M. hamatum	Naga Hills	
M. rigbyanum	E. Himalaya	
M. polygonostomum	Sirumalur	
M. lingulatum	S. India	
M. leptocarpum	W. Ghats	
M. nigricans	Coorg	
M. squarrosulum	Nilgiris	

Name	Distribution	Remarks
HEDWIGIACEAE		
Braunia attenuata	Kashmir Kumaon	
CRYPHAEACEAE		
Forsstroemia secunda	Dalhousie	
PTEROBRYACEAE		
Pterobryopsis cancophylla	Darjeeling.	
P. auriculata	Assam	
Symphysodontella borii	Arunachal	
S. tortifolia	Naga Hills	
S. pilifera	Arunachal Pradesh	
Osterwaldiella monosticta	Sikkim	
METEORIACEAE		
Meteorium brevirameum	Nilgiris	
Aerobryopsis membranacea	Assam, Arunachal	
B. angustifolia	Darjeeling	
Chrysocladium flammeum	Sikkim, Darjeeling	
C. horridum	Naga Hills	
C. infuscatum	Sikkim, Darjeeling	
C. tumidoaureum	Darjeeling	
NECKERACEAE		
C. rigidulus	Kashmir	
Calyptothecium symphysodontoides	S. India	
C. oxyphyllum	S. India	
C. patulum	S. India	
C. nitidum	Darjeeling, Khasia	
C. dixonii	Assam	
C. prainii	Manipur	
Neckera aequalifolia	Palni Hills	
N. goughiana	Nilgiris	
N. semicrispa	Palni Hills	
Neckeropsis darjeelingensis	Darjeeling	
Homaliodendron stracheyanum	Kumaon	
Pinnatella foreauana	Palni Hill	
P. limbata	Kanara	
P. sikkimensis	Darjeeling	
Thamnobryum parvulum	Nilgiris	
T. macrocarpum		

Name	Distribution	Remarks
HOOKERIACEAE		
Daltonia brevipedunculata	Bombay	
D. perlaxiretis	Arunachal	
D. subangustifolia	Darjeeling	
D. marginata	E. Himalaya	
D. decolyi	Darjeeling	
D. subapiculata	Darjeeling	
D. himalayensis	Sikkim	
D. gemipara	Naga Hills	
Distichophyllum obovatum	Darjeeling, Meghalaya	
D. heterophyllum	Darjeeling	
D. decolyi	Darjeeling	
D. madurense	Palni Nills	
D. succulentum	Nilgiri & Palni	
D. humifusum	Kumaon	
Chaetomitrium sikkimense	Darjeeling	
Orontobryum hookeri	E. Himalaya	
SYMPHYODONTACEAE		
Symphyodon orientalis	Upper Assam	
S. echinatus	E. Himalaya	
S. complanatus	E. Himalaya	
S. scabrisetus	Arunachal Pradesh	
S. oblongifolius	Darjeeling	
S. asper	E. Himalaya	
LEUCOMIACEAE		
Leucomium decolyi	Darjeeling	
Cyathophorella anisodon	Sikkim, Darjeeling	
C. burkillii	Arunachal	
FABRONIACEAE		
Fabronia minuta	N.W. Himalaya	
F. schmidii	Nilgiri	
Anacamptodor splachnoides	W. Himalaya Pakistan	
A. validinervis	Palni Hills	
Juratzkea indica	Palni Hills	
Schwetschkea indica	Western Ghats, Palni Hills	
Schwetschkeopsis neckeroides	Meghalaya	

Name	Distribution	Remarks
LESKEACEAE		
Lindbergia longinervis	Kumaon	
Leskea hyaloapiculata	Kashmir	
L. perstricta	(Assam)	
Pseudoleskea ramuligera	Sikkim	
P. laevifolia	W. Himalaya	
THUIDIACEAE		
L. decolor	Sikkim	
Abietinella brandisii	W. Himalaya	
Thuidium subpellucens	Assam	
AMBLYSTEGIACEAE		
Sciaromium sikkimense	Darjeeling, Sikkim	
Hygroamblystegium gangulianum	Mussoorie	
H. obtusulum	Kumaon, Nepal	
Ortholimnobium borii	Arunachal	
Campylium gollanii	Tehri, Garhwal	
C. lacerulum	Darjeeling, Arunachal	
Hygrohypnum choprae	Darjeeling	
H. nairii	Kumaon	
BRACHYTHECIACEAE		
Homalothecium neckeroides	Meghalaya	
H. incompletum	Assam	
H. integerrimum	Kashmir	
brachythecium longicuspidatum	Sikkim, Darjeeling	
B. brachycladum	Kashmir, Chamba	
B. curvatulum	Kashmir	
B. garhwalense	Jaunsar	
B. indicopopuleum	Kashmir, Himachal Pradesh	
B. kashmirense	J. & K.	
B. laevi-velutinum	Kashmir, Chamba	
B. laxifolium	Mussoorie	
B. myurelliforme	Kashmir, Himachal Pradesh	
B. obsoletinerve	Kashmir, Rohtang Pass, Lahul, Kulu	
B. pachythecum	India	
B. spurio-populeum	Kashmir, Garhwal	

Name	Distribution	Remarks
B. stricticalyx	Himachal Pradesh Lahul	
B. waziriense	Kashmir, Himachal Pradesh	
R. leiopoda	Palni Hills.	
R. divaricatifolia	Darjeeling	
R. assamica	Arunachal	
R. sachensis	Himachal Pradesh	
Eurhynchium dumosum	E. Himalaya	
E. ovatum	Palni Hills	
Rhynchostegium brachythecioides	Tirumalai	
R. calderii	Darjeeling	
R. subrectocarpum	Dalhousie	
ENTODONTACEAE		
Rozea kenoyeri	W. Himalaya	
Trachyphyllum jeyporense	Orissa, Jeypore	
T. fragillifolium	Himachal Pradesh	
T. elongatum	Palni Hills	
Entodon longifolius	Bombay	
E. obtusatus	S. India	
E. ovicarpus	Arunachal Pradesh	
E. curvatus	Meghalaya	
E. pulchellus	Darjeeling, Meghalaya	
E. luteonitens	Darjeeling	
E. scariosus	Darjeeling, Sikkim	
Orthotheciadelphus ovicarpus	N.W. Himalaya	
Retidens stewartii	Mussoorie	
Nanothecium foreaui	Palni Hill	
PLAGIOTHECIACEAE		
Plagiothecium dehradunense	Dehra dun	
P. vesiculariopsis	Palni Hills	
P. perminutum	Kashmir	
P. cochleatum	W. Himalaya	
P. paleaceum	Darjeeling	
P. entodontella	Darjeeling	
Stereophyllum acuminatum	S. India	
S. subacuminatum	Kanara, Travancore, Palni Hills	
SEMATOPHYLLACEAE		
Hageniella sikkimensis	Darjeeling	

Name	Distribution	Remarks
H. assamica	Naga Hills	
H. isopterygioides	Nagal Hills	
Aptychella borii	Naga Hills.	
Clastobryum succulare	Meghalaya	
C. wichurae	Darjeeling	
Pylaisiopsis speciosa	Sikkim, Naga Hills	
H. renitens	Sikkim	
Wijkia penicillata	E. Himalayas	
W. baculifera	Naga Hills	
W. lexitexta	Darjeeling	
Sematophyllum angusticuspis	Palni Hills	
S. sebillei	Palni Hills	
Rhaphidorrhynchium confertissimum	Meghalaya	
Brotherella filiformis	Naga Hills	
B. curvirostris	E. Himalaya	
B. propinqua	E. Himalaya	
B. dixonii	Sikkim	
B. amblystegia	E. Himalaya	
B. pallida	Darjeeling	
Trichosteleum glauco-virens	Upper Assam	
*T. punct*ipapillosum	Andamart Is.	
T. stereodontoides	Darjjeling	
Taxithelium laeviusculum	Arunachal	
Glossadelphus anisopteris	Palni Hills	
G. vivicolor	Western Ghats, Palnis	
Trolliella euendostoma	Sikkim, Darjeeling	
Rhaphidostichum camptocladum	Kodaikanal	
R. subleptocarpum	Palni Hills	
HYPNACEAE		
Platygyrium subrussulum	Darjeeling	
Bryosedgwickia kirtikar i	Western Ghats	
Pylaisiella brevirostris	Meghalaya	Known by type.
P. extenta	E. Himalaya	Known by type.
P. kunisawae	Sikkim	
I. serrulatum	Darjeeling	
I. andamanicum	Andaman Is.	
I. longitheca	Darjeeling	
Hypnum caperatum	W. Himalaya	
H. sikkimense	E. Himalaya	
Ectropothecium densum	Palni Hill	

Name	Distribution	Remarks
E. drepanocladioides	S. India	
E. manii	S. India, Andamans	
E. andrei	S. India	
E. kerstanii	Darjeeling	
E. cygnicollum	Sikkim, Darjeeling	
E. ramuligerum	Arunachal Pradesh	
Vesicularia subcartuginosa	N.W. Himalaya	
V. kurzii	Andaman	
V. firma	Palnis	
V. nitidula	Palnis	
V. perreticulata	Palnis	
V. subbilicuspis	Palnis	
Leiodontium complanatum	Naga Hills	
HYLOCOMIACEAE		
Cyathothecium distichaceum	Mussoorie	
Stenotheciopsis serrula	Darjeeling	
Macrothamniella pilosula	E. Himalaya	
Macrothaminium stigmatophyllum	Sikkim	

(7) Cosmopoliton

Gangulee (1980) considers 99 species (10%) of the Eastern Himalayan flora as cosmopoliton. Figures for the whole of the country have not been computed. The North-eastern corner, particularly Assam, Nagaland and Arunachal Pradesh is considered floristic gateway of India. Some palaeotropical species confined to this corner, which is also their Western most outpost in India are: *Dicranodontium fleischerianum* (Assam), *Exodictyon blumei* (Arunachal Pradesh), *Syrrhopodon larminatii* (Upper Assam), *Calymperes vriesii* (Upper Assam), *C. hampei* (Arunachal Pradesh), *Pilotrichopsis dentata* (Arunachal Pradesh, Manipur), *Neckeropsis gracilenta* (Assam, Meghalaya, Nicobars) *Himantocladium loriforme* (Assam), *Eriopus remotifolius* (Manipur), *Chaetomitrium papillifolium* (Upper Assam), *Thuidium investe* (Assam), *Rhynchostegiella menadensis* (Arunachal Pradesh), *Wijkia baculifera* (Nagaland), *Acroporium baviense* (Meghalaya), *Brotherella falcata* (Arunachal Pradesh), *Trichostomum luxurians* (Upper Assam), *Taxithelium kerianum* (Arunachal Pradesh), *Isopterygium assamicum* (Assam, Nagaland), *Ectropothecium monumentorum, E. dealbatum* (Upper Assam)

,Endotrichella elegans, (Arunachal Pradesh), *Eriopus emotifolius, Glossadelphus bilobatus* (Nagaland, Arunachal Pradesh). Genus *Pelekium,* represented so far two species in India also occurs by in this area by *P. bifarium* in Assam and *P. velatum* in Arunachal Pradesh.

CONSERVATION

Mosses vary sometimes to micro climatic conditions and are easily affected by any change in environment. About 40% of moss species in India are ehiphytes. Among the ground mosses, majority of them prefer forest floor, being shade and moisture loving plants. Hence destruction of forests directly affect them. The felling of trees on which they depend for support not only distroys their habitats but also affects the physiological and reproductive phenomena, due to changes in light, temperature & moisture content of the soil. It also exposes the entire habitat to invasion by weeds, which being more hardy, squeeze the moss populations, threatening a large number of endemic species which already have a limited space for survival, and which cannot withstand further pressure.

The populations of a number of species and particularly of monotypic and other smaller genera have been gradually shrinking over the years. Many of them have not been collected for nearly a century now. Such species are highly vulnerable and are now restricted to a few localities in the country thus having a very narrow range of distribution. For example, *Plagiothecium entodontella* is restricted only to Kurseong in W. Bengal. In last 100 years only three specimens could be collected from this locality. *P. paleaceum* is restricted to Sikkim Darjeeling and only half a dozen specimens have been collected in a Century. About 20% of endemic are known only by their type material. Such species need special conservation effort. In Table XVI, are included some of the rare and threatened species, with their distribution.

The list has been compiled on the basis of the herbarium data and their availability in nature in the recent years. It also includes most of those which are represented by Types only.

Since the last few years mosses are facing a new threat from the most unexpected quarter i.e. the moss stems, the use of which is increasing day by day in gardens and house holds by the plant lovers. Truck loads of mosses are transporated from hills to plains to satisfy this new craze. Their use is also being propagated by horticulturists, floriculturist and by various plant based programmes over the media. In some programmes moss is referred to as moss-grass, which is scientifically incorrect. A moss is not a grass, but belongs to a group of moss flowering plants known as Bryophytes. Unlike grasses, they do not multiply through runners rather, a majority of them reproduce only sexually. Once removed from their habitat, in toto, there is hardly anything left behind which can multiply. Even otherwise the reproduction is very slow. So mosses which are being threatened even otherwise should be left to their selves in the forest.

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Pohlia štewartii - A rare and endangered species,
Jammu & Kashmir, W. Himalaya.

Campylopus gracilis in alpine meadows, Kaplasli, Jammu & Kashmir.

Grimmia ahmediana - A rare and endangered species in alpine areas, Jammu & Kashmir, W. Himalaya.

Philonotis falcata - An acrocarpic moss, Mussoori, W. Himalaya.

Philonotis turneriana - On slopes, Mussoorie, Pauri, Himalaya.

Hyophila involuta- On ground, near Darjeeling, E. Himalaya.

Bryum cellulare forming a colony on slopes near Darjeeling, E. Himalaya.

Erythrodontium julaceum - An epiphytic moss on tree trunk.

Thuidium cymbifolium, - A pleurocarpic moss, on forest flóors, Darjeeling, E. Himalaya.

Philonotis speciosa- A rare moss species, E. Himalaya.

Entodon pulchellus - An endemic moss of E. Himalaya.

Cryptoleptodon flexuosus - An epiphytic moss with
curled branches, hanging from tree twigs in W. Himalaya.

Hypnum imponens in association with *Rigidoporus microporus* (Fungi). (Courtesy: J.R. Sharma)

Barbula constricta- On rock. Mussoorie, W. Himalaya.

Entodon prorepens - A pleurocarpic moss, a closeup view Darjeeling, E. Himalaya.

A moss colony, on rock - Pauri, W. Himalaya.

A moss colony on rock - Pauri, W. Himalaya.

Entodon rubicundus - A pleurocarpic moss, spreading in forest floor, Darjeeling, E. Himalaya.

Hymenostylium recurvirostre spreading on rock, Darjeeling, E. Himalaya.

Bryum gamlilei - Daksum, Kashmir, N.W. Himalaya.

Amblystegium serpens in association with *Lycoperdon muscorum* (Fungi).
(Courtesy: J.R. Sharma)

PTERIDOPHYTES

S.R. Ghosh
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Pteridophytes are spore bearing vascular plants, growing luxuriantly as epiphytes and terrestrials in moist tropical and temperate forests. A few species also grow as floating hydrophytes. They constitute quite a conspicuous part of Indian Flora and grow abundantly in Himalayan region.

The initial studies on Indian pteridophytes were carried out by the pioneer workers like R.H. Beddome, C.B. Clarke and C.W.W. Hope, etc. during the end of 19th centuary. The most significant contribution, the "Hand Book of the ferns of British India, Ceylon and the Malay peninsula", then made by Beddome (1883), is still in wide use today as an authentic reference for Indian pteridophytes. Later, during the middle of 20th centuary R.C. Ching, E.B. Copeland and R.E.G. Pichi-Sermolli also made valuable contributions, that gave tremendous boost to pteridophytic studies not only in India but all over the World. As a result, Indian scientists viz. P.N. Mehra, S.S. Bir, K.K. Dhir, B.K. Nayar, S. Kumar, S.P. Khullar and many others published many research articles and floristic accounts on Himalayan Pteridophytes. Scientists from Botanical Survey of India also made huge collections of Pteridophytes from Indian region and neighbouring countries. Subsequent studies on these collections have resulted in the publications of more than 300 research papers and few books, dealing with systematic accounts, revisionary studies of families and genera, new species and new records for India. Some of the prominent Pteridologists of the survey are Dr. G. Panigrahi, Dr. N.C. Nair, Dr. R.D. Dixit, Mr. A.K. Baisya, Mr. S.R. Ghosh, Mr.B. Ghosh, Mr. R. Ghosh, Mr. Surender Singh, Mrs. Anjali Biswas, etc. However, for a detailed knowledge of Indian Pteridophytes one may consult Bir (1987).

VEGETATION

As compared to Phanerogams, the pteridophytes do not form dominant vegetation anywhere, but are always found where suitable conditions of plant growth are available. The pteridophytic vegetation may be grouped under following categories.

Terrestrial Pteridophytes

Terrestrial pteridophytes include mostly ferns which are found mostly in moist shady places along road sides, rivers, nalla's and by the side of streams. A vast majority also grow in forest and forest borders and belong to genera *Angiopteris, Athyrium, Plagiogyria, Pteris, Coniogramme, Allantodia, Dryopteris, Macrothelypteris,* etc.

At lower elevations (up to 500 m) the vegetation is not diverse due to poor contents of humus in the soil. The species like *Ampelopteris prolifera, Anisogonium esculentum, Christella dentata* and *Pteris vittata* are commonly seen in the plains in moist situations. Tree ferns like *Alsophila spinulosa* and *Gymnospermae gigantea* are also found at lower elevations on mountain slopes in open situations.

Well-lighted and exposed situations, on the fringes of forests, are colonized by *Pteris ensiformis, P. semipinnata, Anisogonium esculentum, Onychium* spp. Many other species like *Blechnum orientale, Onychium contiguum, Nephrolepis auriculata, Lygodium* spp., *Dryopteris* spp., etc., grow on road cuttings and in forests clearings. In humus rich soil on forest floors, species of *Equisetum* are met with on gravelly soil along the river courses and near streams.

At higher elevations, between 500 and 300 m on the forest floor, the vegetation is extremely rich and inhabited by some species like *Microlepia strigosa, M. platyphylla, Pteris longipes, Athyrium* sp. *Dryopteris hirtipes, Polystichum* spp., etc. Tree ferns such as *Alsophila spinulosa* and other species of the tree ferns are often seen in the forests between 900-2400 m altitude. Species of *Selaginella* cover the vast areas of forests and are abundant on road cuttings. *Athyrium* spp., *Pteris wallichiana, Christella papilio, Hypolepis* spp., *Pteridium aquilinum, Sphenomeris chinensis* etc. grow along the margin of the forests. Maximum species diversity occurs between 1300-2400 m. altitude. Here the species like *Pteris cretica, Plagiogyria communis, Pseudophegopteris aurita,* etc. grow in moist shady places.

Between 2400-4200 m, *Woodsia andersonii*, *Dryopteris wallichiana*, *Plagiogyria* spp. and species of *Parathelypteris* are met at higher altitudes. *Osmunda claytoniana* var. *pilosa* occurs between 2700-3300 m. *Matteuccia orientalis* and *Matteuccia intermedia* grow in Lachung and Lachen in North Sikkim. *Asplenium germanicum* and *Cheilanthes fragrans* are found in Kashmir.

Apart from this, some alpine pteridophytes like *Woodsia alpina*, *Cystopteris fragilis*, *Lycopodium dixittii*, *Polystichum prescottianum* grow on higher elevations.

Epiphytic pteridophytes

These pteridophytes grow on the trunks and branches of trees in moist evergreen forests. The composition of epiphytic vegetation changes with the change of altitude and nature of the forests. These are further divided into two types :

Low and middle hill epiphytes (500-1500 m)

These epiphytes do not grow on the bark of resinous coniferous trees but prefer branches covered with moss and humus. The common epiphytes of this zone are : *Lepisorus* sp., *Pyrrosia* sp., *Phymatosorus* sp., *Davallia* sp; *Nephrolepis auriculata*, etc. The nest forming epiphytes like *Neottopteris nidus* and *Pseudodrynaria coronans* are of common occurrence on branches of trees.

The fleshy rhizomes of these species are firmly adpressed to the host surface and fronds form compact nests or baskets around the tree trunks that serve as receptacles for accumulation of humus.

Similarly, *Drynaria quercifolia* commonly known as bracket-forming epiphyte has rhizome and sterile nest of leaves which accumulate humus for conserving water during dry weather. *Drynaria meeboldii*, a rare endemic fern also grows on trees. Interestingly *Platycerium wallichii* is also found growing on branches of big trees mostly in Mizoram and adjacent regions. *Ophioderma pendula* grows on branches of trees in Nicobar islands. The Western Himalaya has less number of epiphytes as compared to Eastern Himalayan region. Species like *Lepisorus nidus* and *L. excavatus* are fairly distributed in Kumaon hills.

Upper Hill Epiphytes (1500-2400 m)

The Pteridophytes of this zone complete their life cycle during short rainy season. They become dormant during winter and reoccur through their rhizomes during monsoon season. These ferns either grow on tree trunks towards base or on branches with middle of crown laden with mosses and leafy liverworts. The common epiphytes which grow at the bases of trees are : *Oleandra wallichii, Vittaria elongata, Loxogramme chinensis, Onychium contiguum,* etc. A few species found on the branches of top portion of trees are : *Lepisorus excavatus, L. kashyapii, Arthromeris lehmanii* and *Vittaria flexuosa.*

Beyond 3000 m altitude epiphytic fern vegetation decreases. Few species found growing on *Abies* and *Rhododendron* trees are : *Lepisorus nudus, Arthomeris wallichiana, Phymatopsis malacodon, Goniophlebium atkinsonii*, etc.

Lithophytic Pteridophytes

These usually grow on moist shaded moss covered rocks within the forests near water channels and also sometimes prefer to grow in crevices of stony walls and embakments. Many true epiphytes can also grow as lithophytes when dislodged from trees. *Lepisorus excavatus* and *L. nudus* are some such species.

Xerophytic Pteridophytes

These ferns also grow on rocks and in dry situations. They can withstand little moisture unlike other ferns. Some such species are *Aleuritopteris farinosa, Cheilanthes tenuifolia* and *Actiniopteris radiata.*

Sun-loving Pteridophytes

Though most of the species of ferns prefer to grow in shady situations, but certain species like *Pteridium aquilinum* ssp. *wightianum,* etc. strictly grow in open and sunny places, indicating the destruction of primary forests.

Dark shady forest Pteridophytes

A few species like are *Egenolfia appendiculata, Acrophorus paleolatus, Allantodia stoliczkae, Lindsaea tetragona, Christensenia assamica*, etc. strictly prefer to grow in dark shady forests.

Mangrove Pteridophytes

Species like *Acrostichum aureum* and *A. speciosum* usually grow near salty water.

Climbing Pteridophytes

These are found in tropical and sub-tropical forests and climb on trees and shrubs with the help of their rachi. Species belonging to this category are *Lygodium* spp., *Stenochlaena palustris, Microsorium superficiale, Nephrolepis radicans, Leptochilus* spp., *Lomariopsis lineata, Lomagramma mathewii, Lindsaea parasitica, Bolbilis heteroclita*, etc.

Aquatic and humid Pteridophytes

Humid ferns grow around water falls, along the water channels and ditches. Some such species are *Helminthostachys zeylanica, Isoetes* spp., *Equisetum* spp., *Egenolfia* spp., *Bolbitis* spp. *Acrostichum* spp., *Ceratopteris* spp, *Diplazium* spp., *Ophioglossum* spp., etc. Similarly, ferns of families Salviniaceae, Marsileaceae and Azollaceae belong to this category.

DIVERSITY

About 10,000 species of Pteridophytes occur in the world (Groombridge 1992). Of these, about 1135 species (11.35%) and 42 varieties under 204 genera and 64 families occur in India. In order to discuss the diversity of pteridophytes, the country is broadly divided into 4 pteridophytic zones as follows :

(a) **Eastern India** : Eastern Himalaya, North Eastern states and Eastern India..

(b) **Southern India** : Central India, Eastern and Western Ghats.

(c) **Western India** : Garhwal and Kumaon Himalaya, Jammu and Kashmir state, parts of U.P., states of North western India.

(d) **Andaman & Nicobar Islands** : All the islands in the Bay of Bengal under Indian jurisdiction.

An analysis of species diversity in different pteridophytic zones reveals that maximum number of species occurs in Eastern India (810 species), followed by Southern India (336 spp.), Western India (321 spp.) and Andaman & Nicobar Islands (125 spp.). A comparative analysis of taxa occurring in these zones is presented in Table-I.

Table I
Species diversity in different pteridophytic zones

Pterodophytic zone	Total no. of taxa				
	Families	Genera	Species	Subspecies or Varieties	% of species
India	64	204	1135	42	
Eastern India	60	179	810	37	71.4
Southern India	53	117	336	10	29.6
Western India	49	101	321	18	29.2
Andaman & Nicobar Islands	34	60	125	9	10.1

The species diversity of dominant families in India and a comparison with the different pteridophytic zones is presented in Table II. Polypodiaceae (137 species) is the largest family in India. It is followed by the Dryopteridaceae (124 spp.), Athyriaceae (97 spp.), Thelypteridaceae (83 spp.), Selaginellaceae (62 spp.) and Pteridaceae (61 spp.)

TABLE II
Dominant families in different pteridophytic zones

Family		Number of species								
		India	Eastern India	%	Southern India	%	Western India	%	Andaman & Nicobar Islands	%
1.	Polypodiaceae	137	114	83.21	25	18.24	32	23.35	13	9.4
2.	Dryopteridaceae	124	92	74.19	24	19.35	58	46.77	1	0.8
3.	Athyriaceae	97	76	78.35	18	18.55	38	39.17	3	3.09
4.	Thelypteridaceae	83	61	73.49	30	36.14	21	25.30	12	14.45
5.	Selaginellaceae	62	28	45.16	24	38.70	14	22.58	5	8.06
6.	Pteridaceae	61	43	70.49	24	39.34	16	26.22	7	11.47
7.	Aspleniaceae	57	39	68.42	29	57.87	20	35.08	8	14.03
8.	Sinopteridaceae	44	23	52.27	12	27.27	21	47.72	1	2.27
9.	Aspidiaceae	34	23	67.64	11	32.35	1	2.94	5	14.7
10.	Hymenophyllaceae	30	22	73.33	7	23.33	6	20	7	23.3
11.	Lindsaeaceae	21	9	42.8	6	28.57	1	4.76	15	71.4

Out of the 204 genera of pteridophytes known from India, *Selaginella* is the largest genus (62 spp.) followed by *Pteris* (53 spp.), *Dryopteris* (60 spp.) and *Asplenium* (45 spp.). These genera are widely distributed and found in dominance in all the pteridophytic zones. The genera *Pteris* (28 spp.) and *Asplenium* (126 spp.) dominate in South India, while the genera *Dryopteris* (28 spp.) and *Polystichum* (24 spp.) in the Western India. Similarly, the genera *Pteris* (43 spp.), *Polystichum* (37 spp.), *Dryopteris* (36 spp.) and *Asplenium* (28 spp.) dominate in Eastern India. A comparative statistics of species with percentage in different pteridophytic zones is presented in the Table III. A conspectus of genera with approximate number of species in different Pteridophytic zones is also presented in the Table IV.

Occurrence of monotypic genera in the flora makes diversity more interesting. Some such genera with their distribution are given below:

Ampelopteris prolifera : Throughout India and world.

Blechmidium melanopus : Arunachal Pradesh, Meghalaya

Brainea insignis : Meghalaya, Manipur, Myanmar, Malay Peninsula,.

Helminthostachys zeylanica : Plains of India, Andaman & Nicobar Islands and widely distributed in the world.

Holocosorus bisulcatus : Arunachal Pradesh, Borneo

Indiogramma microphylla : Eastern Himalaya

Lycopodiastrum casurinoides : Arunachal Pradesh, Meghalaya, Bhutan, Myanmar, China, Malay Peninsula.

Palhinhaea cernua : Mountaineous India, Tropics of both hemispheres

Psudodrynaria coronans : Throughout India, Nepal, China, Malay Peninsula, Hong Kong, Taiwan.

Ophioderma pendula : Nicobar Islands, Old World tropics

Luerssenia kehdingiana : Nicobar Islands, Sumatra.

Table III
Dominant genera in different pteridophytic zones.

	Genus	India	Eastern India	%	Southern India	%	Western India	%	Andaman & Nicobar Islands	%
1.	*Selaginella*	62	28	45.66	24	38.78	14	22.58	5	8.06
2.	*Pteris*	60	43	71.66	28	38.53	16	26.66	7	11.77
3.	*Dryopteris*	53	36	67.92	9	16.98	28	52.83		
4.	*Asplenium*	45	28	62.22	26	57.77	17	37.77	6	13.33
5.	*Polystichum*	45	37	82.22	8	17.77	24	53.33	1	2.22
6.	*Athyrium*	30	26	86.66	6	20	16	53.33	1	3.33
7.	*Pyrrosia*	25	19	76	7	28	5	20	2	8
8.	*Allantodia*	25	17	68	6	24	8	32	2	8
9.	*Lepisorus*	22	17	77.3	2	9.1	8	36.36		
10.	*Aleuritopteris*	21	15	71.43	4	13	8	33		
11.	*Lindsaea*	21	9	42.85	6	28.57			15	71.42

Table IV
Species occurring in different pteridophytic zones

Sl. No.	Name of the family	Name of the genus	No. of species, subspecies and varieties occurring in				
			India	Eastern India	South India	Western India	Andaman & Nicobar Islands
1.	2.	3.	4.	5.	6.	7.	8.
1.	PSILOTACEAE	*Psilotum*	2	1	1		2
2.	EQUISETACEAE	*Equisetum*	6	3	2	6	
3.	ISOETACEAE	*Isoetes*	15+1	2+1	8		
4.	HUPERZIACEAE	*Huperzia*	9+1	5+1	4	1	1
		Phlegmariurus	11+1	8+1	4	3	3
5.	LYCOPODIACEAE	*Diphasiastrum*	4	3	1		
		Lycopodiastrum	1	1			
		Lycopodium	6	6	1	2	1
		Palhinhaea	1+3	1+1	1+2	1	1
6.	SELAGINELLACEAE	*Selaginella*	62	28	24	14	5

1.	2.	3.	4.	5.	6.	7.	8.
7.	HELMINTHOSTA-CHYACEAE	*Helminthostachys*	1	1	1		1
8.	BOTRYCHIACEAE	*Botrypus*	2+2	2+2		2	
		Botrychium	1+1	1+1		1+1	
		Sceptridium	3	3	1	1	
9.	OPHIOGLOSSACEAE	*Ophioderma*	1				1
		Ophioglossum	9+2	7+2	5+1	5+2	1
10.	CHRISTENSENIACEAE	*Christensenia*	1	1			
11.	ANGIOPTERIDACEAE	*Angiopteris*	20	15	5	2	1
12.	MARATTIACEAE	*Marattia*	1		1		
13.	SALVINIACEAE	*Salvinia*	3	3	2	2	
14.	AZOLLACEAE	*Azolla*	1	1	1	1	
15.	MARSILEACEAE	*Marsilea*	14	11	7	3	1
16.	PARKERIACEAE	*Ceratopteris*	3	3	1	1	1
17.	CYATHIACEAE	*Alsophila*	5	2	3	1	1
		Gymnosphaera	4	4	1		
		Sphaeropteris	4	2	1		1
18.	DICKSONIACEAE	*Cibotium*	1	1			
19.	GLEICHENIACEAE	*Dicranopteris*	3+2	3+1	1+1	1	3+2
		Diplopterigium	3	3			

1.	2.	3.	4.	5.	6.	7.	8.
20.	STENOCHLAENACEAE	*Stenochlaena*	1	1	1		1
21.	LOMARIOPSIDACEAE	*Lomariopsis*	1	1			
		Lomagramma	1	1			
22.	ANEMIACEAE	*Anemia*	1		1		
23.	LYGODIACEAE	*Lygodium*	10	10	5	3	4
24.	HYMENOPHYLLACEAE	*Cephalomanes*	1	1			
		Crepidomanes	5	4	1		3
		Gonocormus	1	1	1	1	
		Hymenophyllum	2	2			
		Mecodium	7	5	2	3	1
		Meringium	3	2	1		
		Microgonium	3	1	1		1
		Microtrichomanes	1			1	
		Selenodesmium	1		1		
		Trichomanes	6	6	1	1	2
25.	OSMUNDACEAE	*Osmunda*	2+2	1+2	1	1+1	
26.	PLAGIOGYRIACEAE	*Plagiogyria*	16	16			
27.	MONACHOSORACEAE	*Monachosorum*	2	2			
28.	SCHIZAEACEAE	*Actinostachys*	1				1
29.	ONOCLEACEAE	*Matteuccia*	3	3		1	

1.	2.	3.	4.	5.	6.	7.	8.
30.	ADIANTACEAE	*Adiantum*	21+2	13+2	10	9+2	1
31.	ACTINIOPTERIDACEAE	*Actiniopteris*	2	2	1	1	
32.	TAINITIDACEAE	*Tainitis*	1				
33.	VITTARIACEAE	*Vittaria*	13+1	13+1	2	4	3+1
34.	PTERIDACEAE	*Idiopteris*	1		1		
		Pteris	58+2	42+1	23	16	7
35.	CRYPTOGRAMMACEAE	*Cryptogramma*	2	2		2	
		Onychium	7	5		5	1
36.	PTERIDIACEAE	*Pteridium*	+1	+1	+1	+1	1
37.	HYPOLEPIDACEAE	*Histiopteris*	1	1	1	1	
		Hypolepis	8	6	2	2	
38.	SINOPTERIDACEAE	*Aleuritopteris*	21	15	4	8	
		Cheilanthes	10	3	3	7	1
		Doryopteris	3	1	3	1	
		Leptolepidium	2	2		2	
		Mildella	2	2		1	
		Notholaena	2	1		1	
		Pellaea	3		2	1	
39.	HEMIONITIDACEAE	*Anogramma*	1		1		
		Coniogramme	13	13	1	6	

1.	2.	3.	4.	5.	6.	7.	8.
		Gymnopteris	2	1		2	
		Idiogramma	1	1			
		Parahemionitis	1	1	1		
		Pityrogramma	3	1	3	1	1
40.	DENNSTAEDTIACEAE	*Dennstaedtia*	1	1		1	
		Emodiopteris	2	2			
		Microlepia	14	9+2	2+1	3+1	1+1
41.	DIPTERIDACEAE	*Dipteris*	1	1			
42.	PLATYCERIACEAE	*Platycerium*	1	1			
43.	ANTROPHYACEAE	*Antrophyum*	6	6	2		3
44.	POLYPODIACEAE	*Arthromeris*	10+2	10+2		4+1	
		Belvisia	2	1	1		
		Christiopteris	1	1			
		Colysis	9	9			2
		Dendroglossa	1	1			
		Drymoglossum	1	1	1		1
		Holcosorus	1	1			
		Drymotaenium	1	1			
		Lemnaphyllum	2	2			
		Lepidogrammitis	2	2			

1.	2.	3.	4.	5.	6.	7.	8.
		Lepisorus	22	16+1	2	5+3	
		Leptochilus	1	1	1		1
		Metapolypodium	1	1			
		Microsorium	12+1	8+1	8	2	4
		Neolepisorus	2	2			
		Paraleptochilus	1	1	1		1
		Phymatopsis (=*Crypsinus*)	13+1	13+1		7	
		Phymatosorus (=*Phymatodes*)	5	3	2		2
		Phlepodium	1		1		
		Pleopeltis	1		1		
		Platygyria	1	1		1	
		Polypodiastrum	2	2		1	
		Polypodioides	6+1	6+1		3	
		Pyrrosia	25	19	7	5	2
		Thylacopteris	1	1			
		Tricholepidium	4	4			
		Schellolepis	1	1			
45.	ASPLENIACEAE	*Asplenidictyum*	1	1			

1.	2.	3.	4.	5.	6.	7.	8.
		Asplenium	40+5	23+5	22+4	14+3	5+1
		Ceterach	1			1	
		Ceterachopsis	3	3		1	
		Neottopteris	6	6	3	1	1+1
		Sinephropteris	1	1			
46.	DRYNARIACEAE	*Drynaria*	5	4	1	3	1
		Pseudodrynaria	1	1			
47.	ELAPHOGLOSSACEAE	*Elaphoglossum*	20	13	7		
48.	ACROSTICHACEAE	*Acrostichum*	2	1	1		2
49.	BOLBITIDACEAE	*Bolbitis*	11+1	6	4	1	1
		Egenolfia	7+1	5	3		2+2
50.	NEPHROLEPIDACEAE	*Arthropteris*	1		1		
		Nephrolepis	10	6	7	2	2
51.	GYMNOGRAMMI-TIDACEAE	*Gymnogrammitis*	1	1		1	
52.	DAVALLIACEAE	*Araiostegia*	9	8	2	5	
		Davallia	4	3	1		2
		Humata	6	4			3
		Leucostegia	1	1	1	1	

1.	2.	3.	4.	5.	6.	7.	8.
		Paradavallodes	2	2		1	
53.	OLEANDRACEAE	*Oleandra*	4	3	1	1	
54.	GRAMMITACEAE	*Ctenopteris*	1	1	1	1	
		Grammitis	2		2		
		Prosaptia	4	1	4		
		Scleroglossum	1	1			
		Xiphopteris	1	1			
55.	LOXOGRAMMACEAE	*Loxogramma*	17	17	1	1	
56.	WOODSIACEAE	*Cheilanthopsis*	1			1	
		Woodsia	7	5		6	
57.	BLECHNACEAE	*Blechnidium*	1	1			
		Blechnum	3	3	2	1	2
		Brainea	1	1			
		Doodia	1		1		
		Woodwardia	1	1		1	
58.	LINDSAEACEAE	*Lindsaea*	19+2	7+2	6	1	14+1
		Sphenomeris	1+1	1+1	1	1	1
		Tapeinidium	1		1		
59.	ATHYRIACEAE	*Acystopteris*	1	1		1	
		Allantodia	24+1	17	6	8	2

1.	2.	3.	4.	5.	6.	7.	8.
		Anisocampium	1		1		
		Anisogonium	1	1	1	1	
		Athyriopsis	3	2	1	2	
		Athyrium	30	26	6	16	1
		Cornopteris	4	4			
		Cystopteris	4+2	3		2+2	
		Dictyodroma	1	1			
		Diplaziopsis	1	1			
		Diplazium	6	6	1		
		Dryoathyrium	2	2	1	1	
		Gymnocarpium	2	1		1	
		Kuniwatsukia	1	1			
		Lunathyrium	7	4		4	
		Pseudocystopteris	5	5			
		Triblemma	1	1	1		
60.	PERANEMACEAE	*Acrophorus*	2	2			
		Diacalpe	2+1	2+1			
		Peranema	1	1	1	1	
61.	DRYOPTERIDACEAE	*Acrorumohra*	2	2			
		Arachniodes	12	8	4	2	

1.	2.	3.	4.	5.	6.	7.	8.
		Cyrtomium	8+1	5+1	2	2+1	
		Dryopteris	53	36	9	28	
		Lithostegia	1	1			
		Nothoperanema	2	2			
		Polystichum	45	37	8	24	1
62.	HYPODEMATIACEAE	*Hypodematium*	2	2		1	
63.	THELYPTERIDACEAE	*Ampelopteris*	1	1	1	1	
		Amphineuron	3	1	2		2
		Christella	23	19	5	6	3
		Coryphopteris	1	1			
		Cyclogramma	3	3		1	
		Cyclosorus	1		1		4
		Dictyoclene	2	2		1	
		Glaphyropteridopsis	1	1		1	
		Leptogramma	2	1	1	1	
		Macrothelypteris	2	2	2	2	
		Oreopteris	1	1			
		Parathelypteris	3	2	1		
		Phegopteris	2	1		2	
		Metathelypteris	2	2	1		

1.	2.	3.	4.	5.	6.	7.	8.
		Pneumatopteris	1+1	1+1	1		
		Pronephrium	8	6	3	2	1
		Pseudocyclosorus	7	4	5	2	1
		Pseudophegopteris	5	4		2	
		Sphaerostephanos	6	3	3		
		Stenogramma	2	2			
		Thelypteris	3		3		
		Trigonospora	3	3	2		1
64.	ASPIDIACEAE	*Ctenitis*	2	2			
		Ctenitopsis	3	2	2		
		Didymochlaena	2	1			
		Dryopsis	6	4	2		
		Lastreopsis	1		1		
		Luerssenia	1				1
		Pleocnemia	1	1			
		Pteridrys	3	2	1		
		Arcypteris	1				
		Quercifilix	1		1		
		Tectaria	13	11	4	1	4
64 FAILIES		**204 GENERA**	1135+42	810+37	336+10	321+18	125+9

Number after + sign indicate subspecies and variety

ENDEMISM

Endemism indicates the importance and uniqueness of flora of a region or area. Pteridophytes being a part of ecosystem also contribute much to endemism and several species hetherto are confined only to certain areas beyond which they do not occur. At present, about 193 (16.39%) species of Pteridophytes are endemic to different parts of India. Maximum endemic species (97 spp.) occur in Eastern India particularly in Himalayan region which is a centre of active speciation. Thus special attention is required to be given to conserve areas which are endemically rich and diverse. A list of endemic species alongwith their distribution is presented in Table V for future conservational strategies.

ENDANGERED, VULNERABLE AND RARE TAXA

From Conservation point of view, the endangered (E), Vulnerable (V) and Rare (R) taxa of Pteridophytes are very significant. Based on the herbarium and field observations about 254 species (21.58%) of Pteridophytes fall under different categories of threat. As the causual factors leading to depletion of species are immense and continued, further efforts are required to document more such taxa from the field. A list of taxa along with their status recorded so far is given in the Table VI.

ECONOMIC IMPORTANCE

As compared with flowering plants, the Pteridophytes have limited uses. There are numerous species which have great ornamental and medicinal values. Several species of *Selaginella, Pteris, Adiantum, Nephrolepis* and *Asplenium* are becoming popular in horticulture for beauty and variety of their frond forms and find place on terraces of houses, in coridors of hotels, parks and gardens. Young circinnately coiled fronds of *Anisogonium esculentum, Botrychium lanuginosum, Ampelopteris prolifera, Ceratopteris thalictroides,* etc. are popular with hill peoples as green vegetables. The spores of *Lycopodium* are used as skin powder vegetables and brime stone in firework on account of having high inflammable property. Similarly, many other species having minor or major uses are presented in the Table VII.

Table V
Endemic pteridophytes in India

No.	Name of the species	Family	Distribution
1.	*Isoetes coromandelina* ssp. *brachyglossa*	Isoetaceae	West Bengal : Serampur
2.	*Isoetes bilaspurensis*	Isoetaceae	Madhya Pradesh : Bilaspur
3.	*Isoetes debii*	Isoetaceae	Manipur : Nambol
4.	*Isoetes dixitii*	Isoetaceae	Maharashtra
5.	*Isoetes baahudangiri*	Isoetaceae	Karnataka
6.	*Isoetes panchaganiensis*	Isoetaceae	Maharashtra
7.	*Isoetes panchananii*	Isoetaceae	Madhya Pradesh, Maharashtra
8.	*Isoetes pantii*	Isoetaceae	Madhya Pradesh
9.	*Isoetes mahadevensis*	Isoetaceae	Maharashtra
10.	*Isoetes rajasthanensis*	Isoetaceae	Rajasthan : Mt. Abu
11.	*Isoetes reticulata*	Isoetaceae	Rajasthan : Mt. Abu
12.	*Isoetes sampathkumarinii*	Isoetaceae	Karnataka, Andhra Pradesh
13.	*Isoetes sahyadriensis*	Isoetaceae	Maharashtra, Tamil Nadu
14.	*Isoetes tuberculata*	Isoetaceae	Maharashtra
15.	*Isoetes unilocularis* (*Isoetes indica* & *I. Mirjapurensis*)	Isoetaceae Isoetaceae	Uttar Pradesh, Madhya Pradesh, Tamil Nadu

No.	Name of the species	Family	Distribution
16.	*Huperzia niligirica*	Huperziaceae	Tamil Nadu, Kerala
17.	*Huperzia dixitiana*	Hyperziaceae	N. Sikkim
18.	*Huperzia indica*	Hyperziaceae	W. Bengal (Darjeeling)
19.	*Phlegmariurus vernicosa*	Hyperziaceae	Tamil Nadu, Kerala
20.	*Selaginella bryopteris*	Selaginellaceae	Confined to hilly central, southern, eastern part of India at low elevations.
21.	*Selaginellapentagona*	Selaginellaceae	Confined to E. Himalaya
22.	*Selaginella radicata*	Selaginellaceae	Confined to mountains of southern India.
23.	*Selaginella ganguliana*	Selaginellaceae	Kerala
24.	*Selaginella adunca*	Selaginellaceae	Western Himalaya
25.	*Selaginella pallidissima*	Selaginellaceae	Western Himalaya
26.	*Selaginella nayarii*	Selaginellaceae	Kerala
27.	*Selaginella rajasthanensis*	Selaginellaceae	Rajasthan
28.	*Selaginella nairii*	Selaginellaceae	Orissa
29.	*Selaginella panchghaniana*	Selaginellaceae	Maharashtra
30.	*Selaginella panigrahii*	Selaginellaceae	Madhya Pradesh
31.	*Selaginella keralensis*	Selaginellaceae	Kerala
32.	*Selaginella tenera*	Selaginellaceae	Tamil Nadu, Karnataka, Kerala
33.	*Selaginella coonooriana*	Selaginellaceae	Tamil Nadu

No.	Name of the species	Family	Distribution
34.	*Selaginella cataractrum*	Selaginellaceae	Tamil Nadu, Kerala
35.	*Selaginella jainii*	Selaginellaceae	Madhya Pradesh
36.	*Selaginella miniatospora*	Selaginellaceae	Maharashtra, Goa, S. Kanara
37.	*Selaginella fulcrata*	Selaginellaceae	Central Himalaya
38.	*Selaginella proniflora*	Selaginellaceae	Western Ghat.
39.	*Angiopteris arnottiana*	Angiopteridaceae	S. India
40.	*Angiopteris assamica*	Angiopteridaceae	Assam
41.	*Angiopteris campsophlebia*	Angiopteridaceae	Eastern India
42.	*Angiopteris distans*	Angiopteridaceae	Eastern India
43.	*Angiopteris manniana*	Angiopteridaceae	Assam
44.	*Angiopteris latifolia*	Angiopteridaceae	Eastern India
45.	*Angiopteris laciniata*	Angiopteridaceae	Assam
46.	*Angiopteris hookeriana*	Angiopteridaceae	Eastern India
47.	*Angiopteris sylhetensis*	Angiopteridaceae	Assam
48.	*Angiopteris gaudichaudiana*	Angiopteridaceae	Assam
49.	*Angiopteris repandula*	Angiopteridaceae	Eastern India
50.	*Angiopteis hugeliana*	Angiopteridaceae	India
51.	*Angiopteris indica*	Angiopteridaceae	India
52.	*Angiopteris macrocephala*	Angiopteridaceae	Punjab

No.	Name of the species	Family	Distribution
53.	*Angiopteris wightiana*	Angiopteridaceae	S. India
54.	*Marsilea brachypus*	Marsileaceae	Nilgiri
55.	*Marsilea condensata*	Marsileaceae	Rajasthan
56.	*Marsilea gracilenta*	Marsileaceae	Western Ghats
57.	*Marsilea maheshwarii*	Marsileaceae	Pondichery
58.	*Marsilea major*	Marsileaceae	Bihar
59.	*Marsilea rajasthanensis*	Marsileaceae	Rajasthan
60.	*Marsilea rajasthanensis* var. *ballardii*	Marsileaceae	Rajasthan
61.	*Alsophila nilgirensis*	Cyatheaceae	Nilgiri
62.	*Alsophila balakrishnanii*	Cyatheaceae	M.P., Tamil Nadu, Kerala
63.	*Alsophila nicobarica*	Cyatheaceae	Nicobar Islands
64.	*Sphaeropteris albosetaceae*	Cyatheaceae	Nicobar Islands
65.	*Dicranopteris linearis* var. *sebastiana*	Dicranopteridaceae	Nilgiri
66.	*Dicranopteris linearis* var. *wattii*	Dicranopteridaceae	Manipur
67.	*Trichomanes indicum*	Hymenophyllaceae	Arunachal Pradesh
68.	*Plagiogyria elongata*	Plagiogyriaceae	Eastern India (Meghalaya)
69.	*Plagiogyria meghalayensis*	Plagiogyriaceae	Eastern India
70.	*Plagiogyria minguingensis*	Plagiogyriaceae	Arunachal Pradesh

No.	Name of the species	Family	Distribution
71.	*Adiantum indicum*	Adiantaceae	W.Bengal, Orissa
72.	*Vittaria himalayensis*	Vittariaceae	Himalayas
73.	*Vittaria wattii*	Vittariaceae	Manipur, Arunachal Pradesh
74.	*Pteris prainii*	Pteridaceae	Nagaland, Manipur
75.	*Pteris griffithii*	Pteridaceae	Assam, Arunachal Pradesh
76.	*Pteris pseudo-esquirolli*	Pteridaceae	Manipur
77.	*Pteris linearis* var. *manipurensis*	Pteridaceae	Manipur
78.	*Pteris nepalensis*	Pteridaceae	W.Bengal, Nepal
79.	*Pteris himalayensis*	Pteridaceae	Himalayas
80.	*Pteris khasiana*	Pteridaceae	Eastern India
81.	*Pteris furunculata*	Pteridaceae	Kerala
82.	*Pteris geminata*	Pteridaceae	S. India
83.	*Pteris perrotteti*	Pteridaceae	Nilgiri
84.	*Pteris perotteti* var. *brevilaciniata*	Pteridaceae	S. India
85.	*Pteris silent-valleyensis*	Pteridaceae	S. India
86.	*Onychium fragile*	Cryptogrammaceae	W. Himalaya
87.	*Hypolepis indica*	Hypolepidaceae	Sikkim
88.	*Hypolepis coerulescens*	Hypolepidaceae	Sikkim
89.	*Hypolepis sikkimensis*	Hypolepidaceae	Sikkim, W. Bengal

No.	Name of the species	Family	Distribution
90.	*Hypolepis viridula*	Hypolepidaceae	Sikkim
91.	*Hypolepis gamblei*	Hypolepidaceae	Sikkim
92.	*Aleuritopteris flavo-pygmaea*	Sinopteridaceae	Sikkim
93.	*Aleuritopteris sikkimensis*	Sinopteridaceae	Sikkim
94.	*Aleuritopteris doniana*	Sinopteridaceae	Himalayas
95.	*Aleuritopteris keralensis*	Sinopteridaceae	Kerala
96.	*Aleuritopteris dubia*	Sinopteridaceae	N.W. Himalaya
97.	*Coniogramme falcata*	Hemionitidaceae	Eastern Himalaya, Nepal
98.	*Coniogramme denticulato-serrata*	Hemionitidaceae	Himalayas
99.	*Coniogramme indica*	Hemionitidaceae	Eastern India
100.	*Coniogramme affinis*	Hemionitidaceae	Himalayas
101.	*Coniogramme purpurea*	Hemionitidaceae	W. Bengal
102.	*Microlepia khasiana*	Dennstaedtiaceae	Eastern India
103.	*Microlepia firma*	Dennstaedtiaceae	Eastern India
104.	*Mecrolepia firma* var. *hirta*	Dennstaedtiaceae	Eastern India
105.	*Microlepia haflangensis*	Dennstaedtiaceae	Assam
106.	*Microlepia speluncae* var. *pubescens*	Dennstaedtiaceae	E. India
107.	*Microlepia monohara*	Dennstaedtiaceae	S. India
108.	*Lepidogrammitis sikkimensis*	Polypodiaceae	Sikkim

No.	Name of the species	Family	Distribution
109.	*Phymatosorus beddomei*	Dennstaedtiaceae	Kerala, Tamil Nadu
110.	*Phymatosorus banergianus*	Dennstaedtiaceae	West Bengal, Calcutta
111.	*Microsorium indicum*	Dennstaedtiaceae	S. India
112.	*Arthromeris lungtauensis* var. *sikkimensis*	Dennstaedtiaceae	Sikkim
113.	*Arthromeris gamblei*	Dennstaedtiaceae	West Bengal
114.	*Arthromeris wallichiana* var. *biserialis*	Dennstaedtiaceae	Meghalaya
115.	*Arthromeris jarrettii*	Dennstaedtiaceae	Arunachal Pradesh, Manipur
116.	*Arthromeris repandula*	Dennstaedtiaceae	Himachal Pradesh
117.	*Arthromeris indica*	Dennstaedtiaceae	Sikkim
118.	*Neottopteris manipurensis*	Aspleniaceae	Manipur
119.	*Ceterachopsis biri*	Aspleniaceae	West Bengal (Darjeeling)
120.	*Aslenium unilaterale* var. *udum*	Aspleniaceae	Himalayas
121.	*Asplenium unilaterale* var. *rivale*	Aspleniaceae	S. India
122.	*Asplenium khasianum*	Aspleniaceae	Meghalaya, Manipur
123.	*Asplenium laciniatum* var. *subintegrifolium*	Aspleniaceae Aspleniaceae	Himalayas
124.	*Asplenium laciniatum* var. *obtusa*	Aspleniacesae	Darjeeling, Sikkim

No.	Name of the species	Family	Distribution
125.	*Asplenium affine*	Aspleniaceae	S. India
126.	*Drynaria meeboldii*	Drynariaceae	Manipur
127.	*Elaphoglossum jowaiense*	Elaphoglossaceae	Assam, Meghalaya, Nagaland, Sikkim
128.	*Elaphoglossum khasianaum*	Elaphoglossaceae	Meghalaya, Arunachal Pradesh
129.	*Elaphoglossum thomsonii*	Elaphoglossaceae	Sikkim
130.	*Elaphoglossum cherapunjii*	Elaphoglossaceae	Meghalaya
131.	*Elaphoglossum meeboldii*	Elaphoglossaceae	Nagaland
132.	*Elaphoglossum indicum*	Elaphoglossaceae	Meghalaya
133.	*Elaphoglossum marginatum*	Elaphoglossaceae	Eastern Himalaya
134.	*Elaphoglossum fasciculatum*	Elaphoglossaceae	Arunachal Pradesh, Meghalaya
135.	*Elaphoglossum simonsianum*	Elaphoglossaceae	Meghalaya
136.	*Elaphoglossum himalaycum*	Elaphoglossaceae	Sikkim, Arunachal Pradesh
137.	*Elaphoglossum prainii*	Elaphoglossaceae	Nagaland
138.	*Elaphoglossum sikkimense*	Elaphoglossaceae	Sikkim, Meghalaya
139.	*Elaphoglossum stigmatolepis*	Elaphoglossaceae	Tamil Nadu, Kerala
140.	*Elaphoglossum beddomei*	Elaphoglossaceae	Kerala, Tamil Nadu
141.	*Elaphoglossum nilgiricum*	Elaphoglossaceae	Tamil Nadu, Kerala
142.	*Elaphoglossum stelligerum*	Elaphoglossaceae	Kerala, Tamil Nadu

No.	Name of the species	Family	Distribution
143.	*Egenolfia keralensis*	Bolbitidaceae	S. India
144.	*Loxogramma manipuriana*	Loxogrammaceae	Manipur
145.	*Lindsaea rulandia*	Lindsaeaceae	Andaman
146.	*Lindsaea beddomeana*	Lindsaeaceae	S. India
147.	*Lindsaea tenera*	Lindsaeaceae	Andaman
148.	*Lindsaea himalaica*	Lindsaeaceae	Eastern Himalaya
149.	*Lindsaea andamanica*	Lindsaeaceae	Andaman
150.	*Lindsaea malaburica*	Lindsaeaceae	S. India
151.	*Cystopteris sikkimensis*	Athyriaceae	Sikkim
152.	*Cystopteris fragilis* f. *granulosa*	Athyriaceae	Himachal Pradesh, Kashmir
153.	*Cystopteris fragilis* f. *himalayansis*	Athyriaceae	Kashmir
154.	*Cornopteris birii*	Athyriaceae	Sikkim
155.	*Cornopteris quadripinnatifida*	Athyriaceae	E. Himalaya
156.	*Pseudocystopteris subtriangulare*	Athyriaceae	E. Himalaya
157.	*Pseudocystopteris sikkimensis*	Athyriaceae	Sikkim
158.	*Athyrium mehrae*	Athyriaceae	Sikkim
159.	*Athyrium himalicum*	Athyriaceae	Sikkim
160.	*Athyrium parasnathense*	Athyriaceae	Bihar, W. Bengal
161.	*Athyrium atratum*	Athyriaceae	Manipur

No.	Name of the species	Family	Distribution
162.	*Athyrium rubricaule*	Athyriaceae	W. Bengal, Sikkim
163.	*Athyrium paranigripes*	Athyriaceae	W. Bengal
164.	*Athyrium sledgii*	Athyriaceae	Eastern Himalaya
165.	*Athyrium khasianum*	Athyriaceae	Arunachal Pradesh, Manipur
166.	*Diplazium arunense*	Athyriaceae	Arunachal Pradesh
167.	*Allantodia bella*	Athyriaceae	Eastern Himalaya
168.	*Allantodia pseudospectabilis*	Athyriaceae	Sikkim, Manipur
169.	*Allantodia griffithii*	Athyriaceae	Assam
170.	*Allantodia pinnatifido-pinnata*	Athyriaceae	Assam, Arunachal Pradesh
171.	*Allantodia succulanta*	Athyriaceae	W. Bengal,
172.	*Allantodia himalayensis*	Athyriaceae	Eastern Himalaya
173.	*Allantodia torrentia*	Athyriaceae	W.Bengal, Sikkim
174.	*Allantodia frondosa*	Athyriaceae	Himalayas
175.	*Cyrtomium beddomei*	Dryopteridaceae	S. India
176.	*Dryopteris darjeelingensis*	Dryopteridaceae	Sikkim
177.	*Dryopteris khullarii*	Dryopteridaceae	W. Himalaya
178.	*Dryopteris austro-indica*	Dryopteridaceae	S. India
179.	*Dryopteris odontoloma*	Dryopteridaceae	S. India
180.	*Polystichum polypodon*	Dryopteridaceae	Assam, Meghalaya

No.	Name of the species	Family	Distribution
181.	*Polystichum subinerme*	Dryopteridaceae	S. India
182.	*Hypodematium levingei*	Hypodematiaceae	Sikkim
183.	*Christella kumaunica*	Thelypteridaceae	Himachal Pradesh
184.	*Cyclogramma squamistipes*	Thelypteridaceae	W. Bengal, Meghalaya
185.	*Cyclogramma khasiensis*	Thelypteridaceae	Meghalaya
186.	*Oreopteris elwesii*	Thelypteridaceae	Sikkim
187.	*Pneumatopteris truncata* var. *loyalii*	Thelypteridaceae	Darjeeling, Assam
188.	*Pronephrium stenopodum*	Thelypteridaceae	Meghalaya
189.	*Stegnogramma leptogrammoides*	Thelypteridaceae	Sikkim
190.	*Tectaria dubia*	Aspidiaceae	Assam
191.	*Tectaria subconfluens*	Aspidiaceae	E. India
192.	*Ctenitis manii*	Aspidiaceae	Assam, Meghalaya
193.	*Ctenitis scabrosa*	Aspidiaceae	S. India

Table VI
List of Endangered (E), Vulnerable (V), Rare (R) Pteridophytes in India

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
1.	*Psilotum nudum*	Psilotaceae	R	Population thin	Hilly region of S, C, E, India
2.	*Psilotum complanatum*	Psilotaceae	R	Population thin	Nicobar Islands
3.	*Isoetes coromandelina* ssp. *brachyglossa*	Isoetaceae	E	Habitats destruction	West Bengal: Serampur
4.	*Isoetes bagbabudangiri*	Isoetaceae	R	Population thin	Karnataka
5.	*Isoetes bilaspurensis*	Isoetaceae	R	Population thin	Madhya Pradesh
6.	*Isoetes debii*	Isoetaceae	V	Over exploitation	Manipur
7.	*Isoetes dixitii*	Isoetaceae	R	Population thin	Maharashtra
8.	*Isoetes mahadevensis*	Isoetaceae	R	Population thin	
9.	*Isoetes panchaganiensis*	Isoetaceae	R	Population thin	Maharashtra
10.	*Isoetes panchananii*	Isoetaceae	R	Population thin	Madhya Pradesh, Maharashtra
11.	*Isoetes pantii*	Isoetaceae	R	Population thin	Madhya Pradesh
12.	*Isoetes rajasthanensis*	Isoetaceae	R	Population thin	Rajasthan : Mt. Abu
13.	*Isoetes reticulata*	Isoetaceae	R	Population thin	Rajasthan : Mt. Abu
14.	*Isoetes tuberculata*	Isoetaceae	R	Population thin	Rajasthan : Mt. Abu
15.	*Isoetes sampathkumarinii*	Isoetaceae	R	Population thin	Karnataka, Andhra Pradesh
16.	*Isoetes sahyadriensis*	Isoetaceae	R	Population thin	Maharashtra, Tamil Nadu
17.	*Isoetes unilocularis*	Isoetaceae	R	Population thin	Uttar Pradesh
18.	*Huperzia nilagairica*	Huperziaceae	R	Population thin	Tamil Nadu, Kerala
19.	*Huperzia dixitiana*	Huperziaceae	R	Population thin	Sikkim

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
20.	*Huperzia carinata*	Huperziaceae	R	Population thin	Andaman & Nicobar Island
21.	*Phlegmariurus vernicosa*	Huperziaceae	R	Population thin	Tamil Nadu, Kerala
22.	*Phlegmariurus hamiltonii* var. *petiolatus*	Huperziaceae	R	Population thin	Sikkim, West Bengal, Meghalaya.
23.	*Lycopodiastrum casarinoides*	Lycopodiaceae	R	Population thin	Assam, Meghalaya
24.	*Diphasiastrum wightianaum*	Lycopodiaceae	R	Population thin	Tamil Nadu/Siastrum
25.	*Diphasiastrum complanatum*	Lycopodiaceae	V	Over exploitation Habitat destruction	Sikkim, Assam, Arunachal Pradesh/&W.B.
26.	*Diphasiastrum veitchii*	Lycopodiaceae	R	Population thin	Meghalaya/Siastrum/St.
27.	*Diphasiastrum alpinum*	Lycopodiaceae	R	Population thin	Sikkim
28.	*Palhinhaea cernua*	Lycopodiaceae	V	Over exploitation	Hilly parts of India
29.	*Lycopodium zonatum*	Lycopodiaceae	R	Population thin	Sikkim, Meghalaya Arunachal Pradesh
30.	*Lycopodium pesudoclavatum*	Lycopodiaceae	V	Over exploitation	Himalayas
31.	*Lycopodium japonicum*	Lycopodiaceae	V	Over exploitation	Himalaya, Hilly S. India
32.	*Selaginella frondosa*	Selaginellaceae	R	Population thin	Andaman
33.	*Seleginella bryopteris*	Selaginellaceae	V	Over exploitation	Confined to hilly part of S.C.E. India
34.	*Selaginella adunca*	Selaginellaceae	R	Population thin	Western Himalaya
35.	*Selaginella reticulata*	Selaginellaceae	R	Population thin	Arunachal Pradesh, Meghalaya
36.	*Selaginella rajasthanensis*	Selaginellaceae	R	Population thin	Rajasthan
37.	*Selaginella wattii*	Selaginellaceae	R	Population thin	Manipur

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
38.	*Helminthostachys zeylanica*	Helminthostachyaceae	R	Population thin	E.S.C.W. India
39.	*Botrypus lanuginosum*	Botrychiaceae	R	Population thin	Himalayas
40.	*Botrypus virginianum*	Botrychiaceae	R	Population thin	Himalayas
41.	*Botrypus lanuginosum* ssp. *nepalense*	Botrychiaceae	R	Population thin	Sikkim
42.	*Sceptridium multifidium*	Botrychiaceae	R	Population thin	Sikkim
43.	*Sceptridium ternatum*	Botrychiaceae	R	Population thin	Himalayas
44.	*Botrychium lunaria*	Botrychiaceae	R	Population thin	Himalayas
45.	*Botrychium lunaria* var *onondagense*	Botrychiaceae	R	Population thin	Himalayas
46.	*Ophioderma pendula*	Ophioglossaceae	R	Population thin	Nicobar Islands
47.	*Ophioglossum petiolatum*	Ophioglossaceae	R	Population thin	Himalayas
48.	*Ophioglossum reticulatum*	Ophioglossaceae	R	Population thin	Himalays, S. India
49.	*Ophioglossum vulgatum*	Ophioglossaceae	R	Population thin	Himalayas
50.	*Christensenia assamica*	Christenseniaceae	R	Population thin	Assam, Arunachal Pradesh
51.	*Marattia fraxinea*	Marattiaceae	R	Population thin	S. India
52.	*Alsophila nilgirensis*	Cyatheaceae	R	Population thin	Nilgiri
53.	*Alsophila balakrishnanii*	Cyatheaceae	R	Population thin	M.P. Tamil Nadu, Kerala
54.	*Alsophila nicobarica*	Cyatheaceae	R	Population thin	Nicobar Islands
55.	*Sphaeropteris albosetacea*	Cyatheaceae	R	Population thin	Nicobar Islands
56.	*Sphaeropteris crinita*	Cyatheaceae	R	Population thin	S. India
57.	*Sphaeropteris brunoniana*	Cyatheaceae	V	Habitat destruction	Eastern India
58.	*Gymnosphaera andersoni*	Cyatheaceae	V	Habitat destruction	Eastern India

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
59.	*Cibotium barometz*	Dicksoniaceae	V	Habitat destruction	N.E. India
60.	*Anemia tomentosa*	Anemiaceae	R	Population thin	S. India
61.	*Mecodium levingei*	Hymenophyllaceae	R	Population thin	Sikkim
62.	*Osmunda japonica*	Osmundaceae	V	Over exploitation	Himalayas
63.	*Osmunda regalis*	Osmundaceae	V	Over exploitation	S. India
64.	*Osmunda cinnamomea* var. *fokiensis*	Osmundaceae	V	Over exploitation	E. Himalaya
65.	*Osmunda clatoniana* var. *pilosa*	Osmundaceae	V	Over exploitation	Himalayas
66.	*Plagiogyria distanta*	Plagiogyriaceae	R	Population thin	Nagaland
67.	*Actinostachys digitata*	Schizaeaceae	R	Population thin	N.E. India
68.	*Matteuccia orientalis*	Onocleaceae	R	Population thin	N.E. India
69.	*Matteuccia struthiopteris*	Onocleaceae	R	Population thin	Himalayas
70.	*Matteuccia intermedia*	Onocleaceae	R	Population thin	Sikkim
71.	*Adiantum soboliferum*	Adiantaceae	R	Population thin	South & E. India
72.	*Adiantum proliferum*	Adiantaceae	R	Population thin	E. India
73.	*Adiantum myriosorum*	Adiantaceae	R	Population thin	Sikkim
74.	*Adiantum levingei*	Adiantaceae	R	Population thin	Sikkim. Arunachal Pradesh
75.	*Adiantum thalictroides*	Adiantaceae	R	Population thin	South & N.W. India
76.	*Adiantum wattii*	Adiantaceae	R	Population thin	N.W. India
77.	*Adiantum davidi*	Adiantaceae	R	Population thin	N.W. India
78.	*Actiniopteris radiata*	Actiniopteridaceae	R	Population thin	Dry hills of India
79.	*Actiniopteris semiflabellata*	Actiniopteridaceae	R	Population thin	Eastern India
80.	*Vittaria linearifolia*	Vittariaceae	R	Population thin	Arunachal Pradesh

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
81.	*Idiopteris hookeriana*	Pteridaceae	R	Population thin	S. India
82.	*Pteris pseudopellucida*	Pteridaceae	R	Population thin	E. India
83.	*Pteris prainii*	Pteridaceae	R	Population thin	E. India
84.	*Pteris pellucida*	Pteridaceae	R	Population thin	Arunachal Pradesh
85.	*Pteris venulosa*	Pteridaceae	R	Population thin	Eastern India
86.	*Pteris crassiuscula*	Pteridaceae	R	Population thin	Bhutan, Arunachal Pradesh
87.	*Pteris nervosa*	Pteridaceae	R	Population thin	Himalayas
88.	*Pteris scabripes*	Pteridaceae	R	Population thin	Meghalaya, Assam
89.	*Pteris cadieri*	Pteridaceae	R	Population thin	Manipur
90.	*Pteris grevilleana*	Pteridaceae	R	Population thin	Assam
91.	*Pteris amoena*	Pteridaceae	R	Population thin	Assam
92.	*Pteris pophrophlebia*	Pteridaceae	R	Population thin	Manipur
93.	*Pteris depauperata*	Pteridaceae	R	Population thin	Manipur, Andaman
94.	*Pteris sinensis*	Pteridaceae	R	Population thin	Manipur
95.	*Pteris tricolor*	Pteridaceae	R	Population thin	Manipur, Mizoram, West Bengal
96.	*Pteris barbigera*	Pteridaceae	R	Population thin	Sikkim
97.	*Pteris blumeana*	Pteridaceae	R	Population thin	Manipur
98.	*Pteris argyraea*	Pteridaceae	R	Population thin	S. India
99.	*Pteris heteromorpha*	Pteridaceae	R	Population thin	Orissa
100.	*Onychium tenuifrons*	Cryptogrammaceae	R	Population thin	Arunachal Pradesh
101.	*Onychium plumosum*	Cryptogrammaceae	R	Population thin	Sikkim
102.	*Onychium ipii*	Cryptogrammaceae	R	Population thin	Western Himalaya

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
103.	*Cheilanthes trichophylla*	Sinopteridaceae	R	Population thin	Sikkim
104.	*Leptolepidium dalhousiae*	Sinopteridaceae	R	Population thin	Himalayas
105.	*Leptolepidium subvillosum*	Sinopteridaceae	R	Population thin	Himalayas
106.	*Aleuritopteris keralensis*	Sinopteridaceae	R	Population thin	S. India
107.	*Aleuritopteris flava*	Sinopteridaceae	R	Population thin	Assam
108.	*Aleuritopteris tamburi*	Sinopteridaceae	R	Population thin	Sikkim
109.	*Mildella henryi*	Sinopteridaceae	R	Population thin	Arunachal Pradesh
110.	*Mildella nitidula*	Sinopteridaceae	R	Population thin	Western Himalaya
111.	*Notholaena marantae*	Sinopteridaceae	R	Population thin	Himalayas
112.	*Notholaena lanuginosa*	Sinopteridaceae	R	Population thin	Western Himalaya
113.	*Pellaea sericaulis*	Sinopteridaceae	R	Population thin	Tamil Nadu, Kerala
114.	*Pellaea bovinii*	Sinopteridaceae	R	Population thin	Tamil Nadu, Kerala
115.	*Pellaea calomelanos*	Sinopteridaceae	R	Population thin	U.P. Kumaon, Kashmir
116.	*Anogramma leptophylla*	Hemionitidaceae	R	Population thin	Nilgiri
117.	*Coniogramma pateolatti*	Hemionitidaceae	R	Population thin	Meghalaya, Manipur
118.	*Coniogramma serrulata*	Hemionitidaceae	R	Population thin	Manipur
119.	*Idiogramma microphylla*	Hemionitidaceae	R	Population thin	Eastern Himalaya
120.	*Gymnopteris vestita*	Hemionitidaceae	R	Population thin	Himalayas
121.	*Emodiopteris elwesii*	Dennstaedtiaceae	E	Population thin	Sikkim
122.	*Microlepia fadenii*	Dennstaedtiaceae	R	Population thin	S. India
123.	*Platycerium wallichii*	Platyceriaceae	R	Population thin	Manipur
124.	*Antrophyum henryi*	Antrophyaceae	R	Population thin	Sikkim, Arunachal Pradesh

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
125.	*Drymoglossum heterophyllum*	Polypodiaceae	R	Population thin	S. India
126.	*Pyrrosia lingua*	Polypodiaceae	R	Population thin	Arunachal Pradesh
127.	*Pyrrosia floccigera*	Polypodiaceae	R	Population thin	Arunachal Pradesh, Meghalaya
128.	*Pyrrosia laevis*	Polypodiaceae	R	Population thin	Meghalaya
129.	*Pyrrosia drakeana*	Polypodiaceae	R	Population thin	Arunachal Pradesh
130.	*Pyrrosia boothii*	Polypodiaceae	R	Population thin	Sikkim, Arunachal Pradesh
131.	*Christiopteris tricuspis*	Polypodiaceae	E	Population thin	Sikkim, West Bengal
132.	*Dendroglossa minutula*	Polypodiaceae	R	Population thin	Meghalaya
133.	*Holcosorus bisulcata*	Polypodiaceae	R	Population thin	Arunachal Pradesh
134.	*Drymotaenium miyoshianum*	Polypodiaceae	R	Population thin	Arunachal Pradesh
135.	*Neolepisorus tenuipes*	Polypodiaceae	R	Population thin	Meghalaya
136.	*Lepisorus heterolepis*	Polypodiaceae	R	Population thin	Eastern Himalaya
137.	*Lepisorus tenuicauda*	Polypodiaceae	R	Population thin	Meghalaya
138.	*Lepisorus pseudonuda*	Polypodiaceae	R	Population thin	Arunachal Pradesh, Sikkim
139.	*Lepisorus macrosphaerus*	Polypodiaceae	R	Population thin	Arunachal Pradesh
140.	*Lepisorus asterolepis*	Polypodiaceae	R	Population thin	Arunachal Pradesh, Manipur
141.	*Lepisorus clathratus*	Polypodiaceae	R	Population thin	Sikkim, Kashmir
142.	*Lepisorus bicolor*	Polypodiaceae	R	Population thin	West Bengal
143.	*Platygyria variabilis*	Polypodiaceae	R	Population thin	Himalaya
144.	*Phymatopsis chrysotricha*	Polypodiaceae	R	Population thin	E. Himalaya
145.	*Phymatopsis griffithiana*	Polypodiaceae	R	Population thin	Meghalaya
146.	*Phymatopsis decurrenti-adnata*	Polypodiaceae	R	Population thin	Manipur

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
147.	*Phymatopsis nigrovenia*	Polypodiaceae	R	Population thin	Sikkim
148.	*Phymatosorus longissima*	Polypodiaceae	R	Population thin	Assam
149.	*Phymatosorus banergianus*	Polypodiaceae	R	Population thin	West Bengal
150.	*Phymatosorus scolopendria*	Polypodiaceae	R	Population thin	S. India
151.	*Microsorium hymenodes*	Polypodiaceae	R	Population thin	Arunachal Pradesh
152.	*Microsorium fortunei*	Polypodiaceae	R	Population thin	Arunachal Pradesh
153.	*Microsorium linguaeforme*	Polypodiaceae	R	Population thin	S. India
154.	*Arthromeris tatsiensis*	Polypodiaceae	R	Population thin	Meghalaya
155.	*Arthromeris jarrettii*	Polypodiaceae	R	Population thin	Manipur, Arunachal Pradesh
156.	*Schellolepis subauriculata*	Polypodiaceae	R	Population thin	Meghalaya
157.	*Thylacopteris papillosa*	Polypodiaceae	R	Population thin	Arunachal Pradesh
158.	*Metapolypodium manmeiense*	Polypodiaceae	R	Population thin	Meghalaya
159.	*Neottopteris grevillei*	Aspleniaceae	R	Population thin	Arunachal Pradesh, Kerala
160.	*Neottopteris antiqua*	Aspleniaceae	R	Population thin	Manipur
161.	*Sinephropteris delavayi*	Aspleniaceae	R	Population thin	Manipur
162.	*Asplenium zenkerianum*	Aspleniaceae	R	Population thin	Arunachal Pradesh, S. India
163.	*Asplenium longissimum*	Aspleniaceae	R	Population thin	Assam
164.	*Asplenium pellucidum*	Aspleniaceae	R	Population thin	Sikkim
165.	*Asplenium decorum*	Aspleniaceae	R	Population thin	Manipur
166.	*Asplenium indicum* var. *recurvatum*	Aspleniaceae	R	Population thin	West Bengal, Sikkim
167.	*Asplenium capillipes*	Aspleniaceae	R	Population thin	Sikkim
168.	*Asplenium rockii*	Aspleniaceae	R	Population thin	Manipur, Nagaland

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
169.	*Asplenium neolaserpitiifolium*	Aspleniaceae	R	Population thin	Arunachal Pradesh
170.	*Asplenium germanicum*	Aspleniaceae	R	Population thin	Kashmir
171.	*Drynaria meeboldii*	Drynariaceae	E	Population thin	Manipur
172.	*Elaphoglossum blumeanum*	Elaphoglossaceae	R	Population thin	Meghalaya, Arunachal Pradesh
173.	*Arthropteris palisotii*	Nephrolepidaceae	R	Population thin	Kerala, Tamil Nadu
174.	*Humata platylepis*	Davalliaceae	R	Population thin	Meghalaya, Manipur
175.	*Oleandra undulata*	Oleandraceae	R	Population thin	Manipur
176.	*Scleroglossum sulcatum*	Grammitaceae	R	Population thin	Meghalaya
177.	*Prosaptia khasiana*	Grammitaceae	R	Population thin	Meghalaya
178.	*Xiphopteris sikkimensis*	Grammitaceae	R	Population thin	Sikkim
179.	*Loxogramma carinata*	Loxogrammaceae	R	Population thin	Sikkim, West Bengal
180.	*Loxogramma grammitoides*	Loxogrammaceae	R	Population thin	West Bengal, Arunachal Pradesh
181.	*Loxogramma lankokiensis*	Loxogrammaceae	R	Population thin	Arunachal Pradesh
182.	*Loxogramma linearis*	Loxogrammaceae	R	Population thin	Meghalaya,Arunachal Pradesh, S. India
183.	*Woodsia cycloloba*	Woodsiaceae	R	Population thin	Himalayas
184.	*Woodsia lanosa*	Woodsiaceae	R	Population thin	Himalayas
185.	*Woodsia andersoni*	Woodsiaceae	R	Population thin	Himalayas
186.	*Woodsia rosthorniana*	Woodsiaceae	R	Population thin	Eastern Himalaya
187.	*Woodsia alpina*	Woodsiaceae	R	Population thin	Kashmir
188.	*Brainea insignis*	Blechnaceae	V	Habitat destruction	Meghalaya, Manipur

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
189.	*Belchnum patersonii*	Blechnaceae	V	Habitat destruction	Sikki, S. India
190.	*Blechnum cartilagineum*	Blechnaceae	V	Habitat destruction	Arunachal Pradesh
191.	*Blechnidium melanopus*	Blechnaceae	R	Population thin	Meghalaya
192.	*Lindsaea bouillodi*	Lindsaeaceae	R	Population thin	Tamil Nadu
193.	*Lindsaea venusta*	Lindsaeaceae	R	Population thin	S. India
194.	*Kuniwatsukia cuspidata*	Athyriaceae	R	Population thin	Eastern India
195.	*Lunathyrium sikkimense*	Athyriaceae	R	Population thin	West Bengal
196.	*Lunathyrium tibeticum*	Athyriaceae	R	Population thin	Sikkim
197.	*Lunathyrium bagaense*	Athyriaceae	R	Population thin	Sikkim
198.	*Lunathyrium mackinnoni*	Athyriaceae	R	Population thin	N.W. Himalaya
199.	*Lunathyrium mcdonelli*	Athyriaceae	R	Population thin	N.W. Himalaya
200.	*Dryoathyrium subfluvialis*	Athyriaceae	R	Population thin	Arunachal Pradesh
201.	*Gymnocarpium oyamense*	Athyriaceae	R	Population thin	Sikkim
202.	*Gymnocarpium robertianum*	Athyriaceae	R	Population thin	N.W. Hiamalaya
203.	*Athyrium brevisorum*	Athyriaceae	R	Population thin	Arunachal Pradesh, Nagaland
204.	*Diplazium cordifolium*	Athyriaceae	R	Population thin	Manipur
205.	*Diplazium pinfaense*	Athyriaceae	R	Population thin	Manipur
206.	*Allantodia travancorica*	Athyriaceae	R	Population thin	Tamil nadu
207.	*Acrophorus dissectum*	Peranemaceae	R	Population thin	Meghalaya, Manipur
208.	*Diacalpe aspidioides*	Peranemaceae	R	Population thin	Meghalaya
209.	*Diacalpe laevigata*	Peranemaceae	R	Population thin	Meghalaya, Manipur
210.	*Acrorumohra diffracta*	Dryopteridaceae	R	Population thin	Assam, Arunachal Pradesh

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
211.	*Acrorumohra hasseltii*	Dryopteridaceae	R	Population thin	Assam
212.	*Arachniodes rhomboides*	Dryopteridaceae	R	Population thin	Meghalaya
213.	*Arachniodes nipponica*	Dryopteridaceae	R	Population thin	West Bengal
214.	*Cyrtomium micropterum*	Dryopteridaceae	R	Population thin	Nilgiri hills
215.	*Cyrtomium fortunei*	Dryopteridaceae	R	Population thin	Manipur
216.	*Dryopteris unanensis*	Dryopteridaceae	R	Population thin	E. Himalaya
217.	*Dryopteris conjugata*	Dryopteridaceae	R	Population thin	W. Himalaya
218.	*Dryopteris bonatiana*	Dryopteridaceae	R	Population thin	Sikkim
219.	*Dryopteris nobilis*	Dryopteridaceae	R	Population thin	Sikkim, Assam
220.	*Dryopteris alpestris*	Dryopteridaceae	R	Population thin	Sikkim, Arunachal Pradesh
221.	*Dryopteris lachoongensis*	Dryopteridaceae	R	Population thin	Sikkim
222.	*Dryopteris splendens*	Dryopteridaceae	R	Population thin	E. Himalaya
223.	*Dryopteris sikkimensis*	Dryopteridaceae	R	Population thin	Sikkim
224.	*Dryopteris petridiiformis*	Dryopteridaceae	R	Population thin	Nagaland
225.	*Dryopteris angustifrons*	Dryopteridaceae	R	Population thin	Sikkim
226.	*Dryopteris subimpressa*	Dryopteridaceae	R	Population thin	Himalayas
227.	*Dryopteris appoximata*	Dryopteridaceae	R	Population thin	S. India
228.	*Dryopteris varia*	Dryopteridaceae	R	Population thin	Assam
229.	*Dryopteris deparioides*	Dryopteridaceae	R	Population thin	S. India
230.	*Polystichum lonchitis*	Dryopteridaceae	R	Population thin	Kashmir
231.	*Polystichum glaciale*	Dryopteridaceae	R	Population thin	Sikkim
232.	*Polystichum capillipes*	Dryopteridaceae	R	Population thin	Himalayas

Sl.No.	Name of taxon	Family	Status	Causal factor	Distribution
233.	*Polystichum wattii*	Dryopteridaceae	R	Population thin	Manipur
234.	*Polystichum manii*	Dryopteridaceae	R	Population thin	Meghalaya, Assam
235.	*Polystichum grandiforns*	Dryopteridaceae	R	Population thin	Manipur
236.	*Polystichum cylobolum*	Dryopteridaceae	R	Population thin	E. Himalaya
237.	*Polystichum makinoi*	Dryopteridaceae	R	Population thin	Manipur
238.	*Christella clarkei*	Thelypteridaceae	R	Population thin	W. Bengal (Darjeeling)
239.	*Christella evoluta*	Thelypteridaceae	R	Population thin	Assam
240.	*Christella gustavii*	Thelypteridaceae	R	Population thin	Assam
241.	*Christella hispidula*	Thelypteridaceae	R	Population thin	South & E. India
242.	*Christella hokouensis*	Thelypteridaceae	R	Population thin	Assam
243.	*Christella loboefii*	Thelypteridaceae	R	Population thin	Assam
244.	*Christella namburensis*	Thelypteridaceae	R	Population thin	Assam
245.	*Christella papyracea*	Thelypteridaceae	R	Population thin	Assam
246.	*Christella siamensis*	Thelypteridaceae	R	Population thin	N.E. India
247.	*Christella subelata*	Thelypteridaceae	R	Population thin	E. India
248.	*Coryphopteris didymochlaenoides*	Thelypteridaceae	R	Population thin	Meghalaya, Assam, Manipur
249.	*Metathelypteris decipiens*	Thelypteridaceae	R	Population thin	E. Himalaya
250.	*Oreopteris elwesii*	Thelypteridaceae	R	Population thin	Sikkim
251.	*Phegopteris connectillis*	Thelypteridaceae	R	Population thin	Himalaya
252.	*Stegnogramma asplenioides*	Thelypteridaceae	R	Population thin	Meghalaya
253.	*Didymochlaena truncatula*	Aspidiaceae	R	Population thin	Manipur, Mizoram, Nagaland
254.	*Dryopsis manipurensis*	Aspidiaceae	R	Population thin	Manipur

Table VII
Useful ferns and fern allies

Sl. No.	Name of the species	Family	Uses
1.	*Psilotum nudum*	Psilotaceae	Cultivated as pot plant, used in preparation of tea given to children suffering from thrush, also used as purgative.
2.	*Equisetum arvense*	Equisetaceae	Strobilli eaten and base of the plants also cooked as food.
3.	*Equisetum diffusum*	Equisetaceae	Cultivated as pot plant.
4.	*Equisetum debile*	Equisetaceae	Diuretic and astringent, and given in treatment of gonorrhoea.
5.	*Equisetum ramosissimum*	Equisetaceae	Diuretic and astringent, and given in treatment of gonorrhoea.
6.	*Isoetes debii*	Isoetaceae	Fronds are eaten as fried 'Pakoda' in Manipur.
7.	*Huperzia selago*	Huperziaceae	Spores are collected for use as lycopodium powder.
8.	*Huperzia squarrosa*	Huperziaceae	Cultivated as pot plant.

Sl. No.	Name of the species	Family	Uses
9.	*Phlegmariurus phyllanthum*	Huperziaceae	Cultivated as popular pot plant.
10.	*Diphasiastrum complanatum*	Lycopodiaceae	Spore collected for use as lycopodium powder.
11.	*Diphasiastrum wightianum*	Lycopodiaceae	Spore collected for use as lycopodium powder.
12.	*Lycopodium annotinum*	Lycopodiaceae	Plant contains number of alkaloids, spores collected for use as lycopodium powder.
13.	*Lycopodium japonicum*	Lycopodiaceae	Indian species known as clavatum used as Lycopodium of commerce.
14.	*Lycopodium pseudoclavatum*	Lycopodiaceae	Indian species known as clavatum used as Lycopodium of commerce.
15.	*Palhinhaea cernua*	Lycopodiaceae	Decoction used as a lotion in beri-beri, cough and uneasiness of chest. Enbrocation of ashes in vinegar recommended in skin erruption. Dried plants are used for stuffing pillows.
16.	*Selaginella biformis*	Selaginellaceae	Cultivated as pot plant.
17.	*Selaginella braunii*	Selaginellaceae	Widely cultivated as pot plant.

Sl. No.	Name of the species	Family	Uses
18.	*Selaginella bryopteris*	Selaginellaceae	Considered equivalent to Sanjivani"; used as tonic having property of prolonging life.
19.	*Selaginella involvens*	Selaginellaceae	Said to have the property of prolonging life.
20.	*Selaginella monospora*	Selaginellaceae	Cultivated as pot plant.
21.	*Selaginella plana*	Selaginellaceae	Widely cultivated in the gardens of India.
22.	*Selaginella pulvinata*	Selaginellaceae	Said to have the property of prolonging life.
23.	*Selaginella uncinata*	Selaginellaceae	Widely cultivated in the gardens.
24.	*Selaginella wallichiana*	Selaginellaceae	Decoction is given as a protective medicine after parturition.
25.	*Selaginella willdenovii*	Selaginellaceae	Infusion given to bring down high fever, also cultivated as pot plant.
26.	*Helminthostachys zeylanica*	Helminthotachyaceae	Young fronds and fleshy rhizomes are cooked for starchy food. The fertile fronds are eaten in Nicobar Islands by "Shompens".

Sl. No.	Name of the species	Family	Uses
27.	*Botrychium lunaria*	Botrychiaceae	Juice of the root fronds are used in brest cancer.
28.	*Botrychium ternatum*	Botrychiaceae	Used in dysentery, also young fronds are eaten as vegetables.
29.	*Botrychium virginianum*	Botrychiaceae	Young fronds are eaten as vegetables.
30.	*Ophioderma pendula*	Ophioglossaceae	Long pendulus ribbon like fronds are shredded in coconut oil which is applied for growth of hair.
31.	*Ophioglossum reticulatum*	Ophioglossaceae	Tender leaves are eaten as salad, also cooked as vegetables.
32.	*Ophioglossum vulgatum*	Ophioglossaceae	Tender leaves are eaten as salad, also cooked as vegetables.
33.	*Angiopteris crassipes*	Angiopteridaceae	Rhizome are cooked and eaten during scarcity. Rhizomes are brewed to convert drink.
34.	*Angiopteris esculenta*	Angiopteridaceae	Young frond edible.
35.	*Angiopteris wallichiana*	Angiopteridaceae	Young frond edible.
36	*Salvinia molesta*	Salviniaceae	Cultivated as house plant in water.

Sl. No.	Name of the species	Family	Uses
37.	*Azolla imbricata*	Azollaceae	Used as green compost in rice fields to increase the yield of paddy. Rich in protien, also used in poultry feed.
38.	*Marsilea aegyptiaca*	Marsileaceae	Stalked leaves are cooked as vegetables and also for cooling nerve and good sleep.
39.	*Marsilea brachypus*	Marsileaceae	Leaves with stalk are eaten as vegetables. Juice is used for cooling nerve and good sleep.
40.	*Marsilea condenata*	Marsileaceae	Leaves with stalk ar eaten as vegerables. Juice is used for cooling nerve and good sleep.
41.	*Marsilea coromandelica*	Marsileaceae	Leaves with stalk are eaten as vegetables. Juice is used for cooling nerve and good sleep.
42.	*Marsilea crenata*	Marsileaceae	Leaves with stalk are eaten as vegetables. Juice is used for cooling nerve and good sleep.
43.	*Marsilea gracilenta*	Marsileaceae	Leaves with stalk are eaten as vegetables. Juice is used for cooling nerve and good sleep.
44.	*Marsilea maheshwarii*	Marsileaceae	Leaves with stalk are eaten as vegetables. Juice is used for cooling nerve and good sleep.

Sl. No.	Name of the species	Family	Uses
45.	*Marsilea major*	Marsileaceae	Leaves with stalk are eaten as vegetables. Juice is used for cooling nerve and good sleep.
46.	*Marsilla minuta*	Marsileaceae	Alkaloid Merielin is extracted from leaves and also used as vegetable.
47.	*Marsilea quadrifolia*	Marsileaceae	Stalked leaves are eaten as vegetables.
48.	*Marsilea rajasthanensis*	Marsileaceae	Stalked leaves are eaten as vegetables.
49.	*Ceratopteris thalictroides*	Parkeriaceae	Young fronds are eaten as vegetables and salad.
50.	*Ceratopteris cornuta*	Parkeriaceae	Young fronds are eaten as vegetables.
51.	*Ceratopteris pteridoides*	Parkeriaceae	
52.	*Gymnosphaera andersoni*	Cyatheaceae	Pith is eaten and also used for preparation of local drinks. Fronds are used as fodder.
53.	*Gymnosphaera gigantea*	Cyatheaceae	Pith is eaten and trunks are used to make pots for cultivation of ornamental plants.
54.	*Gymnosphaera khasiana*	Cyatheaceae	Pith is eaten.

Sl. No.	Name of the species	Family	Uses
55.	*Sphaeropteris brunoniana*	Cyatheaceae	Pith is eaten. Trunks are used to make pots for cultivation of ornamental plants.
56.	*Alsophila costularis*	Cyatheaceae	Pith is eaten and used for preparation of drinks.
57.	*Alsophila spinulosa*	Cyatheaceae	Pith is eaten and trunk is used to make pot for cultivation of ornamental plants.
58.	*Cibotium barometz*	Dicksoniaceae	Pith of the fronds is eaten.
59.	*Dicranopteris linearis*	Gleicheniaceae	Fronds and rhizomes used for asthma and as anthemintic.
60.	*Stenochlaena palustris*	Stenochlaenaceae	Cultivated as climber. Young fronds are eaten as salad or after cooking. Decoction of fronds used as febrifuge.
61.	*Lygodium circinatum*	Lygodiaceae	Stipes used for external application in wounds.
62.	*Lygodium flexuosum*	Lygodiaceae	Used as expectorant, fresh rhizomes are used for external application in rheumatism and sometimes cultivated as ornamental plant.

Sl. No.	Name of the species	Family	Uses
63.	*Lygodium japonicum*	Lygodiaceae	Dried fronds are powdered and mixed with rice powder and brewed as rice beer. Also cultivated as ornamental plant. Used as an expectorant. In China, decoction of vegetative parts and spores used as diuretic and cathartic.
64.	*Lygodium microphyllum*	Lygodiaceae	Young leaves are eaten, Decoction used in dysentery, leaves are also applied in the form of poultice in skin diseases and swellings. Old stem used for basket making.
65.	*Cephalomanes javanicum*	Hymenophyllaceae	Dried fronds mixed with garlic and onion smoked to cure headache.
66.	*Osmunda claytoniana* var. *pilosa*	Osmundaceae	Young leaves are used as vegetables. Rhizomes are used in America and Europe for the preparation of rooting media.
67.	*Osmunda regalis*	Osmundaceae	Root mucilaginous, tonic, stimulant, also used in dysentery and rheumatism, rickets, muscular debility.
68.	*Osmunda japonica*	Osmundaceae	Tender shoots used in balms and healing plasters.
69.	*Adiantum cuneatum*	Adiantaceae	Cultivated as an ornamental fern.

Sl. No.	Name of the species	Family	Uses
70.	*Adiantum capillus-veneris*	Adiantaceae	Decoction used as diuretic and antidysenteric.
71.	*Adiantum caudatum*	Adiantaceae	Used medicinally as antidysenteric.
72.	*Adiantum flabellulatum*	Adiantaceae	Cultivated as ornamental plant. Used as anthelmenthic, rhizome used for cough.
73.	*Adiantum incisum*	Adiantaceae	Used medicinally as antidysenteric.
74.	*Adiantum latifolium*	Adiantaceae	Fronds are used for making garlands and other decorative purpose.
75.	*Adiantum pedatum*	Adiantaceae	Rhizome used as stimulant, expectorant, demulcent, and emmenagouge.
76.	*Adiantum pectinatum*	Adiantaceae	Cultivated as ornamental plant
77.	*Adiantum peruvianum*	Adiantaceae	Giant maiden hair, grown ornamentally.
78.	*Adiantum lunulatum*	Adiantaceae	Used ornamentally as pot plant.
79.	*Adiantum polyphyllum*	Adiantaceae	Used ornamentally as pot plant.
80.	*Adiantum rubellum*	Adiantaceae	Cultivated as pot plant.

Sl. No.	Name of the species	Family	Uses
81.	*Adiantum thalictroides*	Adiantaceae	Infusion of leaves used as emolient in cough and chest disease.
82.	*Adiantum tenerum*	Adiantaceae	Farlayense Barbodose maiden hair fern and wightii maiden hair grown as pot plant
83.	*Adiantum trapeziforme*	Adiantaceae	Giant maiden hair fern, grown ornamentally.
84.	*Adiantum venustum*	Adiantaceae	Used as major Constituent of drug Hingharaj. Used in tumour, disease of chest opthalmia.
85.	*Actiniopteris radiata*	Actiniopteridaceae	Antibiotic, antiseptic, decoction of the frond is used in Manorrhoegia in female.
86.	*Pteris argyraea*	Pteridaceae	Grown ornamentally.
87.	*Pteris ensiforme*	Pteridaceae	'Victorae' Victoria fern grown ornamentally.
88.	*Pteris cretica*	Pteridaceae	Sometimes cultivated as ornamental plant.

Sl. No.	Name of the species	Family	Uses
89.	*Pteris multifida*	Pteridaceae	Decoction of the rhizome and fronds used in dysentery. Toasted fronds and paste of rhizomes are applied in skin disorder. Grown also as ornamental ferns.
90.	*Pteris semipinnata*	Pteridaceae	Cultivated as pot plant.
91.	*Pteris tricolor*	Pteridaceae	Cultivated as pot plant.
92.	*Pteris wallichiana*	Pteridaceae	Young fronds are eaten as vegetables.
93.	*Pteridium aquilinum ssp. wightianum*	Pteridiaceae	Starch present in rhizome is bitter but can be removed; there after boiled and roasted for eating. Tender fronds used as vegetables.
94.	*Hypolepis punctata*	Hypolepidaceae	Fronds are used as poultice on for poulticing boils.
95.	*Pellaea calomelanos*	Sinopetridaceae	Fronds are smoked in Asthma and cold in head and chest. Rhizome is anthelmintic.
96.	*Parahemionitis arifolia*	Hemionitidaceae	Juice of the fronds are applied in burns and also used as oranmental plant.

Sl. No.	Name of the species	Family	Uses
97.	*Pityrogramma calomelanos*	Hemionitidaceae	Silver fern, cultivated as pot plant, decoction used in kidney troubles.
98.	*Pityrogramma chrysophylla*	Hemionitidaceae	Golden fern, cultivated widely as pot plant.
99.	*Platycerium wallichii*	Platyceriaceae	Cultivated as popular pot plant.
100.	*Lemnaphyllum carnosum*	Polypodiaceae	Fronds diuretic, pectoral, astringent, used in urinary calculas and rheumatism. Decoction prescribed to stop haemmorrhages.
101.	*Microsorium punctatum*	Polypodiaceae	Cultivated as pot plant.
102.	*Microrosium membanaceum*	Polypodiaceae	Cultivated as pot plant.
103.	*Phymatopsis nigrescens*	Polypodiaceae	Cultivated as pot plant, fronds edible.
104.	*Phymatosorus banerjiana*	Polypodiaceae	Cultivated as pot plant, fronds edible.
105.	*Phymatosorus scolopendria*	Polypodiaceae	Young fronds are used in chronic diarrhoea. Yields coumarin containing essential oil, cultivated as ornamental plant.
106.	*Asplenium adiantoides*	Polypodiaceae	Used for enlarge spleen, Jaundice and malaria.

Sl. No.	Name of the species	Family	Uses
107.	*Asplenium adiantum*	Polypodiaceae	Bitter, diuretic, laxative, used in disease of spleen and jaundice also produce sterility in woman, Rhizome ahthelmintic.
108.	*Asplenium macrophyllum*	Polypodiaceae	Decoction of fronds a powerful diuretic.
109.	*Asplenium .nidus*	Polypodiaceae	"Bird nest fern" grown as pot plant.
110.	*Asplenium ruta muraria*	Polypodiaceae	Used as an expectorant, also for rickets.
111.	*Asplenium trichomanes*	Polypodiaceae	Expectorant and refrigerant, used for abscesses of uterus.
112.	*Neottopteris nidus*	Polypodiaceae	'Bird nest fern' grown as pot plant.
113.	*Drynaria quercifolia*	Drynariaceae	Decoction of the rhizomes is antipyretic. Cultivated as pot plant.
114.	*Acrostichium aurium*	Acrostichaceae	Young fronds are eaten as vegetables. Rhizome paste applied in boils.
115.	*Nephrolepis auriculata*	Nephrolepidaceae	Fresh tubers are eaten as vegetables and decoction is given in cough.

Sl. No.	Name of the species	Family	Uses
116.	*Nephrolepis biserrata*	Nephrolepidaceae	Cultivated as ornamental fern. Furcans (fish tail fern) is a horticultural variety.
117.	*Nephrolepis duffi*	Nephrolepidaceae	Cultivated as pot plant.
118.	*Nephrolepis exaltata*	Nephrolepidaceae	'Whitmanni' sturdy lace fern, 'Norwoodii' compact lace fern, 'Verona' dwarf lace fern. Cultivated as ornamental ferns.
119.	*Davallia bullata*	Davalliaceae	'Squirrel foot fern', cultivated as pot plant.
120.	*Davallia fejeensis*	Davalliaceae	Cultivated as pot plant.
121.	*Davallia griffithiana*	Davalliaceae	Rabbit foot fern, cultivated as pot plant.
122.	*Davallia trichomanoides*	Davalliaceae	Grown ornamentally.
123.	*Oleandra neriiformis*	Oleandraceae	Decoction of the stipes emmenogogue.
124.	*Oleandra wallichii*	Oleandraceae	Rhizome used by the aged for rejuvenation.
125.	*Loxogramma involuta*	Loxogrammaceae	Decoction of rhizome is used in dismenorrhoea and other female diseases.

Sl. No.	Name of the species	Family	Uses
126.	*Blechnum brasilense*	Blechnaceae	Cultivated ornamentally.
127.	*Blechnum occidentalis*	Blechnaceae	Cultivated ornamentally.
128.	*Blechnum orientale*	Blechnaceae	Used as anthelmintic.
129.	*Lindsaea odorata*	Lindsaeaceae	Yield coumarin containing essential oil.
130.	*Sphenomeris chinensis*	Lindsaeaceae	Yield red dye from fronds. Prescribed in chronic enteritis.
131.	*Athyrium asperum*	Athyriaceae	Young fronds are eaten as vegetable.
132.	*Athyrium biserrulatum*	Athyriaceae	Young fronds are eaten as vegetable.
133.	*Cystopteris fragilis*	Athyriaceae	Decoction of chizome used as anthelmintic enema.
134.	*Anisogonium esculentum*	Athyriaceae	Young coiled fronds are very palatable.
135.	*Allantodia frondosa*	Athyriaceae	Young coiled fronds are eaten as vegetable.
136.	*Cyrtomium falcatum*	Dryopteridaceae	Holy fern, cultivated as pot plant. Used as anthelmintic for tapeworms.
137.	*Cyrtomium fortunii*	Dryopteridaceae	Widely cultivated in garden as pot plant.

Sl. No.	Name of the species	Family	Uses
138.	*Dryopteris blanfordii*	Dryopteridaceae	Widely cultivated in gardens as pot plant.
139.	*Dryopteris barbigera*	Dryopteridaceae	Rhizome is anthelmintic.
140.	*Dryopteris cochleata*	Dryopteridaceae	Young fronds used as vegetables after hot washings.
141.	*Dryopteris marginata*	Dryopteridaceae	Rhizome is anthelmintic.
142.	*Dryopteris sparsa*	Dryopteridaceae	Young leaves are used as vegetables.
143.	*Hypodematium crenatum*	Hypodemataceae	Young leaves are eaten as vegetables.
144.	*Ampelopteris prolifera*	Thelypteridaceae	Young fronds are eaten as vegetables. Fronds are aperient.
145.	*Christella arida*	Thelypteridaceae	Young fronds are eaten as vegetables.
146.	*Christella dentata*	Thelypteridaceae	Young fronds are eaten as vegetables and also used medicinally.
147.	*Pseudopegopteris aurita*	Thelypteridaceae	Sometime cultivated.
148.	*Tectaria coadunata*	Aspidaceae	Vegetable curry prepared from tender fronds.
149.	*Tectaria polymorpha*	Aspidaceae	Cultivated as garden plants.

CONSERVATION

Although, lower plants constitute major portion of Indian Flora, but they have not received due attention from policy makers as far as their conservation strategies are concerned. Hence, proper studies on lower group of plants need to be intensified as there are few specialists working on them. As mentioned earlier that the Pteridophytes are inhabitants of tropical and temperate forests, thus the protection of the forests will ensure the conservation of the plants in general in effective manner to formulate long term strategies. Apart from this, for effective conservation, fern conservatories need to be established in different climatic zones. Similarly, many rich Pteridophytic sites having high species diversity can be identified and protected in different botanical zones under *in situ* programmes. Interesting and rare epiphytic species can be protected by establishing gene sanctuaries in their natural habitats. Under *ex situ* conservation, threatened and endemic species can be rehabilitated by growing them in botanical gardens under suitable environmental conditions or by multiplying them through tissue culture technique. The species of *Selaginella, Lycopodium* and many others are becoming vulnerable in nature on account of heavy collection by students for studies. College and University teachers can play very important role in this direction in order to protect them.

An Indian chapter-Pteridophytes specialist group should be opened under Species Survival Commission. The specialists group should Survey, monitor and evolve techniques for conservation of endangered, threatened, rare and vulnerable pteridophytes.

Above all, the most important aspects to conserve this plants is to create awareness among the people for lower groups of plants in general and Pteridophytes in particular as many species are on the verge of depletion due to heavy deforestation.

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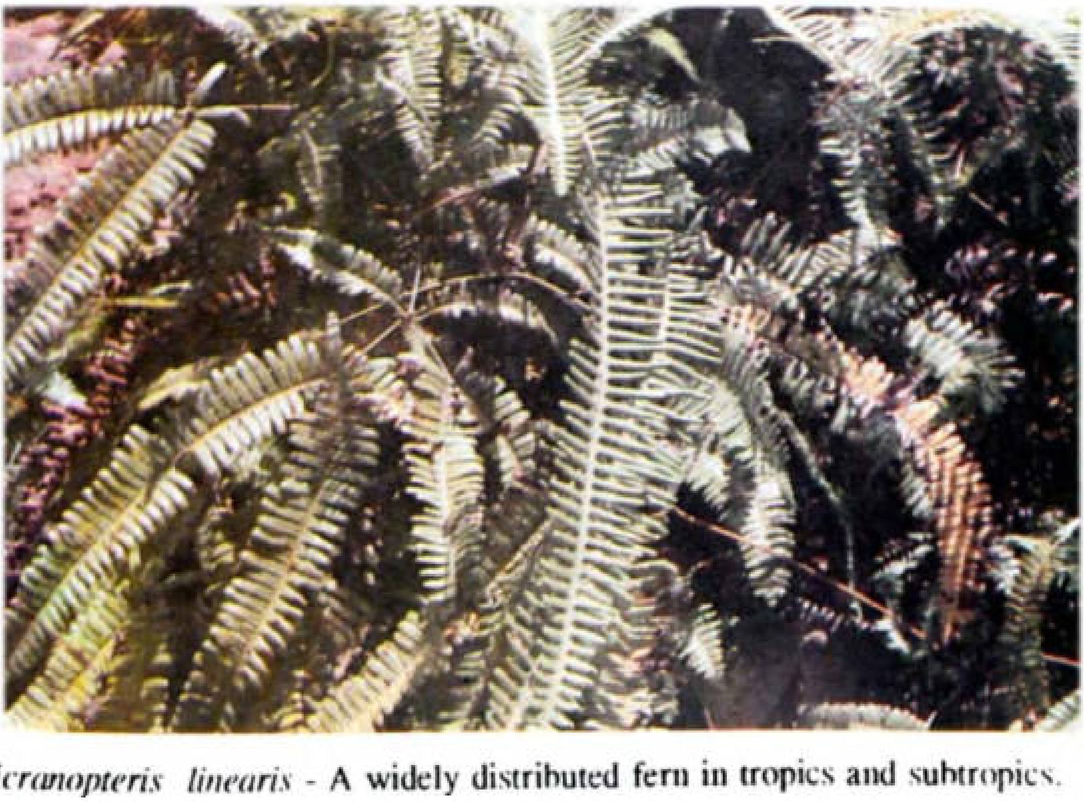
Acrostichum aureum - A fern of mangrove forests



Dicranopteris linearis - A widely distributed fern in tropics and subtropics.

Dryopteris sino- fibrillosa
(Courtesy: Subhash Ghosh)

Polystichum stimulans - A common Himalyan fern
(Courtesy: Subhash Ghosh)

Pronephrium nudatum
(Courtesy: K.K. Khanna)

Adiantum incisum - A fern of medicinal value
(Courtesy: K.K. Khanna)

Platycerium wallichii - The Stag-horn fern
(Courtesy: R.K. Chakraverty)

Psilotum nudum - A rare, nonvascular fern
(Courtesy: R.K. Chakraverty)

Drynaria quercifolia - A rare fern, growing on tree trunks in Car-Nicobar

Lygodium flexuosum - A trailing fern

GYMNOSPERMS

K.P. Singh
V. Mudgal

The Gymnosperms represent the most primitive type of seed plants. Together with angiosperms they are classified under the division Spermatophyta or Phanerogams. This group of plants has its own significance in the plant kingdom because of attractive foliage and stately appearance, providing beauty to the hills, particularly at higher elevations.

The term 'gymnosperm' was used in 300 B.C. by Theophrastus in his book 'Enquiry into Plants' to include all those plants whose seeds were naked before and after fertilization, whereas in the angiosperms the ovules are enclosed in a pericarp. As the protection of the ovules plays very imporant role and provides certain biological advantages, the angiosperms are considered to be more advanced than the gymnosperms which are, therefore, regarded as intermediate between the vascular cryptogams and angiosperms, representing a particular level of evolution rather than a taxonomic group.

Gymnosperms originated about 265 million years ago during the late Palaeozoic era from Psilopsidan stock, perhaps independently of the fern and fern-allies, but flourished well during Mesozoic era. Their long evolutionary history is diverse and interesting, during which many members flourished and then became extinct, but some like Giant Redwoods of California are still making their last stand along the Pacific coast of North America.

The gymnosperms are all woody perennials either shrubs or trees. Herbaceous members are not known so far. Except two larches *(Larix griffithiana, L. himalaica)*, the majority are evergreen as they do not shed their leaves all at once but replace them continually with a few at a time. Some other important characters are the presence of unisexual inflorescence, lack of true vessels, heterosporous habit (production of micro and megaspores) and formation of endosperm before the fertilization.

They occur both in fossil and living state. The most significant studies on fossil gymnosperms were carried out by late Professor Birbal Sahni (1920, 1931). Since 1950, the Birbal Sahni Institute of Palaeobotany (BSIP) at Lucknow, has been the main active centre of research on Indian fossil gymnosperms with Dr. K.R. Surange, Dr. R.K. Kar, Dr. M.N. Bose, Dr. Vishnu Mitre, etc. as most important workers. Fossils studies were also carried out at the Universities of Lucknow (by Prof. B.S. Trivedi and his associates). Allahabad (by Prof. D.D. Pant and his associates), Calcutta (by Prof. I. Sen) and Jodhpur (by Prof. B.D. Sharma and his associates). Other centres engaged in fossil studies are Maharashtra Association for the Cultivation of Science, Pune, and the different units of Geological Survey of India. Similarly, the important studies on living gymnosperms have been carried out by Maheshwari and Biswas (1970), Maheshwari and Vasil (1961), Maheshwari and Konar (1971), Mehra and Jain (1976), Pant (1973), Raizada and Sahni (1960), Sahni (1990), etc.

The extant gymnosperms are commonly divided into five orders : the Cycadales, Ginkgoales, Taxales, Coniferales and Gnetales. The Cycadales and Ginkgoales include living members that have a long fossil history and are known as 'living fossils' The Cycadales have palm like habit and are confined to limited areas in the tropical and subtropical regions of the world. The order Ginkgoales with a monotypic family Ginkgoaceae is represented by a single species *Ginkgo biloba* which occurs in wild state in south eastern China, and as ornamental in many areas of the temperate zone presently.

Among living gymnosperms, the Coniferales form the most conspicuous order that now comprise a major forest type primarily in temperate regions of the Northern and Southern Hemisphere, including the most familiar and economically important genera like *Pinus*, *Cedrus*, *Abies*, *Juniperus*, *Cupressus*, *Thuja*, etc. They do not bear flowers but produce pollen and seeds in cones and hence the name 'Conifer' The seeds and pollen grains are usually winged. Another important feature of these plants is that their leaves are needle shaped except *Podocarpus* and *Agathis*, which are broad leaved. Some Conifers are the world's largest and longest lived trees. There are some very huge trees of Deodar in Manali, Himachal Pradesh and Mundali and Belcha in Garhwal himalaya. A cross section of Deodar tree trunk having width of 2.5 m and said to be more than 750 years old is kept as an exhibit in the Museum of Forest Research Institute, Dehradun. Similarly the Redwoods of California occurring in the Pacific coast of North America are considered to be the tallest trees in the world, having height up to 120 m and width up to 10 m. They are estimated to be 3000 years old. Sahni (1986) reported that in North America, some trees of *Pinus aristata* (Bristle-cone pine or Foxtail pine), estimated to be 6000 years old and germinated even before the Indus civilization, are considered oldest living things on the earth today. The weight of *Sequoidendron giganteum* (Giant sequoia) is estimated to be 2000 tonnes and is the most massive tree in the world. In short, we can say that the Conifers have so many specialities which are not found in other trees.

The Gnetales are represented by living genera like *Gnetum, Ephedra, Welwitschia,* and *Sarcopus.* The genera *Welwitschia* and *Sarcopus* are monotypic and represented by *Welwitschia mirabilis* (from Coastal belt of South-West Africa) and *Sarcopus aberrans* (from Indo-China) respectively. The species of first two genera *(Ephedra* and *Gnetum)* which occur in India are distributed in tropical and temperate regions of the world.

FLORISTIC ELEMENTS AND THEIR GEOGRAPHICAL DISTRIBUTION

In India, living gymnosperms grow luxuriantly and form extensive forests in Western and Eastern Himalayas. An account on distribution of these plants has been presented earlier by Biswas (1993), Raizada and Sahni (1960) and Sahni (1990). The present brief account is based mainly on the data presented in those publications with little modifications. However, a distribution of living gymnosperms excluding those of exotic taxa is also given in the Table-I for quick reference.

All the five orders *Cycadales, Coniferales, Taxales, Ginkgoales* (introduced), *Gnetales* known so far, are represented in the Indian flora. Cycadales, represented by a single family Cycadaceae and single genus *Cycas* with 4 species, are widely distributed in tropical and subtropical regions of the world. They are found in east from Madagascar to Japan including Australia, touching the Indian main land. Thus, the distribution pattern of the living Cycadales is unique and difficult to interpret in terms of phytogeography (Foster & Gifford, 1974).

The Taxales comprise single family Taxaceae with two genera - *Taxus* and *Amentotaxus* having one species each. *Taxus wallichiana,* a small evergreen tree is distributed in moist shady areas all along the Himalayas, Meghalaya, Naga hills and Manipur above 1800 m, but mostly between 2300 3400 m. *Amentotaxus assamica* is extremely rare and confined to certain places only in Delai valley (Methumna ridge) of Arunachal Pradesh.

The Coniferales, comprising 10 genera and 25 species in India, are well represented in tropics but are abundant in temperate areas of both Northern and Southern Hemispheres. Conifer trees are tall, elegant and graceful with foliage and branches presenting a magnificent cone-like appearance. The genera of Northern Hemisphere that occur in India are - *Pinus, Abies, Picea, Tsuga, Cedrus, Larix, Cephalotaxus, Podocarpus, Juniperus* and *Cupressus*. The Southern Hemisphere genera include *Araucaria, Agathis* and *Podocarpus*, which are introduced mostly in our country. The last genus *Podocarpus* occurs also in Northern Hemisphere. All of them except *Podocarpus* are restricted to the Himalayas. Some of them occur in both Eastern and Western Himalayas, whereas others are restricted in distribution. Their distribution is governed mainly by the altitude.

The present coniferous flora of India is a mixture of two elements. One element originating from the North and West is represented by *Abies, Cedrus, Picea* and *Pinus*, all of which dominate the Western Himalaya mostly between 1066 to 3048 m. The other element is derived from the East and South-east and is typified by *Cephalotaxus* and *Podocarpus*. These genera are mainly inhabitants of the Eastern Himalaya. Central Himalaya or the intermediate zone, with Nepal in the centre has both the elements. The only known Conifer from Peninsular India is *Podocarpus wallichianus* which is distributed from Assam to Malay peninsula through Myanmar and considered as residual element.

The species of *Abies* form extensive forests in Himalayas, at high altitudes, above 2300 m. Western Himalaya has 2 species, viz. *Abies pindrow* and *A. spectabilis*, whereas Eastern Himalaya has 3 species, viz. *A. spectabilis, A. delavayi* and *A. densa*. *A. spectabilis* grows along the higher ranges from Pakistan to Arunachal Pradesh including Tibet and Myanmar mostly between 2800 to 4000 m altitude in association with *Betula utilis* and *Rhododendron campanulatum*. Similarly, *A. pindrow* is found from Afghanistan to Nepal throughout the Western Himalaya between 2300 to 3350 m, sometimes descending below 2,150 m. *A. delavayi*, a Chinese species common in Szechwen occurs in remarkable pure strands in Bhutan, Arunachal Pradesh, and extending into upper Myanmar. The last remaining species *A. densa* grows abundantly in E. Nepal, Darjeeling to Arunanchal Pradesh and Myanmar between 2750 to 3950 m. *Cedrus deodara* attains gigantic dimensions from Afghanistan to Garhwal

Himalaya, absent in Kumaon and present in Kurnauli valley in W. Nepal, mostly between 1200 to 3300 m, but most common between 1700 to 2400 m. Recently it has also been introduced in West Kameng district of Arunachal Pradesh, where its performance of growth is well. *Cupressus torulosa,* a common associate of *Cedrus deodara,* grows throughout the outer and middle ranges of Himalayas from Chamba (Himachal Pradesh) to Nepal including W. Szechwen, but not in abundance. *Cupressus cashmeriana* is largely cultivated in India, whereas *C. corneyana* occurs in Sikkim, Arunachal Pradesh and Tibet.

Genus *Juniperus* grows in inner valleys at higher ranges above the tree limit in Eastern and Western Himalayas. *Juniperus communis,* a shrub is mostly distributed in Kumaun Himalayas. *J. indica,* with low spreading branches, forms dense patches between 2800 to 4600 m in association with *Betula* and *Rhododendron* species. *J. polycarpos* occurs in Western Himalaya, whereas *J. squamata* is found in Eastern Himalaya.

Commercially important genus *Pinus* with 7 species is distributed in Eastern and Western Himalayas. *P. wallichiana* forms an evergreen forest belt and is widely distributed all along the Himalayan ranges from Pakistan to Arunachal Pradesh between 1800 to 3700 m. But it is rare in Sikkim and some parts of Kumaon. *P. armandii* grows luxuriously in Eastern Himalaya, Central and West China and Taiwan. *P. bhutanica* - a five needled pine occurs in Bhutan and Arunachal Pradesh. *P. gerardiana* (Chilgoza) forms profuse forests in the inner semi-arid valleys of N.W. Himalaya from Bashahr (Himachal Pradesh) westwards to Kashmir, North Baluchistan and Afghanistan between 1800 - 3000 m. *P. kesiya* is found in Khasi, Jaintia, Naga, Lushai (Champhai area along the Myanmar border) Manipur, Upper Myanmar and Philippines between 800 to 2000 m, but more abundantly between 1200 to 1400 m altitude. The two needled pine, *P. merkusii* of Myanmar has also been found over extensive areas in Lohit district and to some extent in Changlang district of Arunachal Pradesh. It is the most tropical of all pines and is the only pine in the world that crosses the equator. It also occurs in many South-East Asian countries. *P. roxburghii* (Chir pine) is widely found in the Himalayas from Pakistan to Arunachal Pradesh at an altitude ranging from 450 to 2300 m. *Larix griffithiana,* a graceful tree up to 18 m tall and the only deciduous conifer of India, grows in Eastern Himalaya from East Nepal through Chumbi valley of Tibet to Bhutan, Darjeeling, Sikkim, Mishmi Hills of Arunachal Pradesh and Upper Myanmar, between 2400 to 3650 m, usually on glacial moraines, often mixed with *Pinus wallichiana* or *Abies* or *Tsuga* species. *Tsuga dumosa,* distributed in Western, Central and Eastern Himalayas, is a tall tree up to 36 m tall with massive trunk and beautiful drooping branches.

Picea smithiana, a tree of pendulous habit up to 60 m tall with whorled branches, grows in Western Himalaya, whereas the remaining 2 species, viz. *P. spinulosa* and *P. brachytyla* grow in Eastern Himalaya. *Podocarpus wallichianus,* the only conifer from the Nilgiri southwards has a wider range of distribution, occurring in the far off Assam, Myanmar and interior of great Nicobar islands. *P. neriifolius,* occurring up to 990 m in evergreen forests of Eastern Himalaya, Eastern Myanmar and Andamans, is a graceful tree.

Ginkgoales are represented by a monotypic family Ginkgoaceae containing both extinct and only one living species by the name of maiden hair tree *(Ginkgo biloba). Ginkgo bibola* still exists in the wild state in restricted and almost inaccessible region in South-eastern China. This living fossil is sacred to the Buddhist and has been cultivated for centuries in China and Japan around the monasteries and temples. In India it is introduced and growing well in the gardens and parks at Mussoorie, Dehradun, Darjeeling, Simla, Odhagamandalam and elsewhere having moist cool climate.

The genus *Ephedra* consists of swithchy green shrubs with one climber *Ephedra foliata,* which is found in plains of Southern Punjab and drier parts of Rajasthan. Most of the Indian taxa are distributed in dry or rocky regions at higher elevations in the Western Himalaya having alkaline soils.

The genus *Gnetum* consists of 5 species in India, inhabiting the evergreen tropical rain forests below an altitude of 1500 m. Majority of the species are climbers or lianas, only few species are either trees or shrubs.

Besides, there are numerous exotic taxa which are flourishing in different climatic areas and thus enriching the species diversity. These are dealt separately in Table-IV.

Table I
Distribution of Indian Gymnosperms

Name of species	Distribution	
	India	Other Regions
Cycas beddomei (Beddome's Cycas)	In dry places of Cuddapah hills in Andhra Pradesh and Tamil Nadu.	
C. circinnalis (Crorier Cycas)	Widely distributed in western peninsular India, in deciduous forests of western Ghats from sea level to 1070 m from Malabar southwards to hills on the east side as far north as Orissa.	Sri Lanka, Maldives (near Male) East-tropical Africa, Madagascar, Comora Island, Sumatra and Java
C. circinnalis var. *orixensis*	In the hill forests of Puri and Angul in Orissa.	
C. pectinata (Nepal Cycas)	In Sal forests (Darjeeling to Sikkim), Sameshwar hills and plains (Bihar), Goalpara, Kamrup (Assam), Khasi hills (Meghalaya) and Manipur.	Bangladesh, Myanmar and Martaban
C. rumphii (Rumphius Cycas)	In Littoral forests of Andamans and Nicobars.	South Myanmar, Cocos islands, Sri Lanka, Malaya, New Guinae and North Australia
Taxus wallichiana (Common Yew)	Eastern and Western Himalayas from Jammu & Kashmir to Arunachal Pradesh	Myanmar, Afghanistan, Pakistan and South-West China.

Name of species	Distribution	
	India	Other Regions
	Meghalaya, Nagaland, Manipur, mostly between 1800-3400.	
Amentotaxus assamica	Delai valley (Mithumna ridge between 1600 to 1800 m) in Lohit district, Arunachal Pradesh; in dense temperate broad-leaved forests on the slopes in association with *Rhododendron, Castanopsis, Exbucklandia populnea.*	
Cephalotaxus mannii (Khasi plum yew)	A small tree in Khasi, Jaintia and Naga hills between 1370-2590 m altitude.	Upper Myanmar.
C. griffithii (Plum yew)	Jameri in West Kameng district of Arunachal Pradesh; Mishmi hills, Lohit district between 1520-1820 m, Naga hills, Manipur.	Myanmar.
Podocarpus neriifolius (Coleander Podocarpus)	In evergreen forests of Arunachal Pradesh, Andamans and Sikkim.	Bhutan, Myanmar, Malaya peninsula, S.W.China, Sunda islands.
P. neriifolius var. *brevifolius*	Eastern Himalaya and Khasi hills (Meghalaya).	
P. wallichianus (Wallich's Podocarpus)	Western Ghats from the Nilgiris southwards, interior of Great Nicobar island and Assam.	Martaban and Tenasserim.

Name of species	Distribution	
	India	Other Regions
Pinus wallichiana (Bhutan Pine or Blue Pine)	All along the Western Himalayas from Jammu & Kashmir to Arunachal Pradesh between 1800-3700 m, rare in Sikkim and Kumaon regions.	Pakistan, Nepal, Bhutan.
P. wallichiana var. *parva*	A temperate rain forest tree in Tawang district of Arunachal Pradesh at an altitude of *ca.* 3300 m.	
P. armandii (Armand's Pine)	In Lohit district of Arunachal Pradesh at an altitude of 2100 m.	Tseng PoGorge, South East Tibet, Central & Western China and Taiwan.
P. bhutanica (Arunachal Pine)	Tenga valley in West Kameng district of Arunachal Pradesh	East Bhutan.
P. gerardiana (Chilgoza Pine)	Bashar Westward to Kashmir.	Chitral, North Baluchistan and Afghanistan between 1800-3000 m.
P. kesiya (Khasi Pine)	Meghalaya, Nagaland, Manipur, Mizoram between 800-2000 m altitude.	Upper Myanmar, Philippines.
P. roxburghii (Chir Pine or Himalayan long needle Pine)	All along the Himalaya from Kashmir to Arunachal Pradesh between 450-2300 m, except Kashmir valley proper.	Pakistan.

Name of species	Distribution	
	India	Other Regions
P. merkusii (Two needle Pine or Merkus Pine)	Arunachal Pradesh : Lohit and Changlang districts	Myanmar, Thailand, Sumatra,Cochin-Java, Borneo China, and Phillippines.
Tsuga dumosa	Uttar Pradesh:Almora district; Sikkim; Arunachal Pradesh; West Kameng district, Lachung and Perila between 2400-3000 m.	Upper Myanmar, Nepal, Bhutan, Tibet.
Picea smithiana (West Himalayan Spruce)	In Western Himalaya between 2150-3300 m in association with fir, *Pinus wallichiana, Cedrus deodara* and at higher elevations with *Quercus semi-carpifolia.*	Afghanistan.
P. spinulosa (East Himalayan Spruce)	Eastern Himalaya between 2600-3350 m altitude.	Tibet, Bhutan.
P. brachytyla	Arunachal Pradesh; West Kameng district at an altitude of 3500 m in pure patches or sometimes mixed with *Pinus wallichiana, Abies densa, Tsuga dumosa* and *Taxus wallichiana.*	Bhutan, W. Hupah, W. Szechwen, W.Yunan, Upper Myanmar.
Abies pindrow (West Himalayan Fir, Pindrow Fir, Low level Fir)	Western Himalaya between 2300-3350 m, sometimes descending below 2150 m, mostly in association with	Afghanistan, Pakistan, Nepal.

Name of species	Distribution	
	India	Other Regions
	Cedrus *deodara*, Spruce, *Quercus dilatata* and *Q. semicarpifolia*, but last two species are not found in Kashmir valley proper.	
A. spectabilis (High level Fir)	All along the Western and Eastern Himalayas between 2800-4000 m.	Afghanistan, Myanmar and Tibet.
A. densa (East Himalayan Fir, Red Fir)	Eastern Himalaya (Sikkim, Arunachal Pradesh) between 2750-3950 m, at higher elevation it is stunted and often associated with *Juniperus* Spp. and *Rhododendron campanulatum*.	East Nepal, Bhutan, South-East Tibet.
A. delavayi (Delavay's Fir)	Arunachal Pradesh: West Kameng (Se la, Peri la); Tawang (Woming la) between 2750-3300 m.	Bhutan, S.W. Szechuen, China, N.E. Upper Myanmar.
Cedrus deodara (Deodar, Himalayan Deodar)	Kashmir, Himachal Pradesh, Garhwal between 1200-3300 m, but common between 1700-2400 m.	Pakistan, Afghanistan and West Nepal.
Larix griffithiana (Himalayan Larch)	Eastern Himalaya, Darjeeling, Sikkim, Arunachal Pradesh between 2400-3650 m, mostly on glacial morraine.	Nepal, Bhutan, N.E. Upper Myanmar and Tibet.

Name of species	Distribution	
	India	Other Regions
Juniperus polycarpos (Himalayan pencil juniper)	Western Himalaya (Kashmir, Lahul to Kumaon) between 2500-4300 m.	Afghanistan, Baluchistan, Kagan valley and West Tibet.
J. recurva (Drooping Juniper)	Kumaon, Arunachal Pradesh; Kameng (Se la) and Tawang between 2700-4600 m, usually mixed with *Juniperus communis,* widely spread.	Afghanistan, Upper Myanmar and China.
J. communis (Common Juniper, Ground Juniper)	Kumaon, westward in Western Himalaya between 1800-3600 m. A widely distributed species.	In Temperate and subarctic Europe, Asia, North America and North Africa.
J. squamata (Single seed/Scaly leaved Juniper)	Western and Eastern Himalayas between 2400-4300 m, usually in association with *J. communis.*	Upper Myanmar, China, Taiwan and Japan.
J. indica (Black Juniper)	Western and Eastern Himalayaa (Sikkim) between 2800-4600 m, usually in association with *Betula utilis,* and *Rhododendron campanulatum.*	Indus, Bhutan, and West Tibet.
Cupressus torulosa (Himalayan Cypress)	Western Himalaya (Chamba in Himachal Pradesh); Eastern Himalaya (Tenga	Nepal, China and Tibet.

Name of species	Distribution	
	India	Other Regions
	valley in Arunachal Pradesh) between 1800-2800 m; Chakrata in Uttar Pradesh.	
C. corneyana	Sikkim, Arunachal Pradesh near religious places.	Bhutan, Tibet.
C. cashmeriana	Kashmir (Ladakh); not known in the wild state since long, cultivated as ornamental in Kameng, Subansiri (Arunachal-Pradesh); Dehradun and Kalimpong, etc.	
Gnetum gnemon	Small trees or shrubs in Arunachal Pradesh, Meghalaya, Tripura and Great Nicobar island.	Indonesia.
G. gnemon var. *brunonianum*	Assam (Golaghat), South Mizoram, Nagaland.	Myanmar.
G. gnemon var. *griffithii*	Assam (Sibsagar), Nagaland and Mizoram up to 1500 m, in the rain forests.	Myanmar.
G. ula	Large lianae in the hill forests usually above 600 m in Western Ghats, Andhra Pradesh, Goa, Orissa and Andaman island.	Lower Myanmar.

Name of species	Distribution	
	India	Other Regions
G. montanum	Eastern Himalaya usually at 1500 m, Bihar, Orissa, and Andaman island.	Myanmar, Thailand, Bangladesh, Indo-China and Nepal.
G. montanum f. *megalocarpum*	Dafla hills in Arunachal Pradesh.	Endemic.
G. contractum	Scandent shrub in Tamil Nadu (Nilgiri hills, Coonoor); Kerala (Qnilon) up to 1500 m.	Endemic.
G. latifolium var. *macropodum*	Andaman & Nicobar . islands	Endemic.
G. latifolium var. *funiculare*	South Andamans.	Malaya, Thailand, Sumatra, Java and Myanmar.
Ephedra przewalskii	Western Himalaya (Nanga Parbat in Kashmir, along the bed of Shyok river in Ladakh).	
E. foliata	Punjab plains ascending to 800 m in Salt Range and Rajasthan (Jodhpur).	Pakistan, Arabia and Aden.
E. pachyclada	Ladakh at an altitude of 3800 m.	Baluchistan, Nepal, South Iran, Afghanistan and Chitral.
E. intermedia	Western Himalaya (Ladakh at an altitude 3300 m on rocky soil) and Himachal Pradesh.	Tibet.

Name of species	Distribution	
	India	Other Regions
E. intermedia var. *tibetica*	Ladakh, Himachal Pradesh between 2100-3000 m.	Nepal, Afghanistan, Gilgit and North Tibet.
E. regeliana	Dwarf shrub, Western Himalaya (Ladakh) in dry habitats at an altitude of 4000 m.	Baltistan, Pamir.
E. gerardiana (Gerad's Ephedra)	Western Himalaya (Kashmir, Ladakh, Chamba, Lahul, Garhwal, Kumaun, Badrinath) between 1450-5450 m.	Pakistan, Tibet.
E. saxatilis	N.W. Himalaya (Garhwal, Simla, Deoban) in relatively humid but rocky habitats between 2640-3000 m.	
E. saxatilis var. *sikkimensis*	In semi-arid areas between 3650-5000 m in Sikkim.	S. Tibet, Nepal, Bhutan.
E. nebrodensis var. *procera*	Western Himalaya (Lahul).	Western Tibet, Baluchistan, Afghanistan and eastwards to Greece.

DIVERSITY

Although gymnosperms have lesser number of species as compared to angiosperms but they are equally important like other plants. The total number of living gymnosperms in the world comprise about 53 genera and

750 species. Out of these, about 17 genera and 60 species occur in Indian subcontinent. In present Indian boundaries only 48 species, and 10 varieties under 15 genera are known to be growing in wild state in different environmental habitats.

Besides, there are numerous exotic species in cultivation in the gardens, parks and along the roadside at many places. These species enrich the species diversity and are dealt separately. Out of the 11 families of living gymnosperms found in India, 3 families - Ginkgoaceae, Araucariaceae and Taxodiaceae are of exotic species. If we see the species diversity in remaining 8 families at generic and family level, we find that the family Pinaceae is the largest and represented by 6 genera and 17 species, followed by Cupressaceae (2 genera, 8 spp.), Ephedraceae (8 spp. under genus *Ephedra*), Gnetaceae (1 genus, 2 spp.), Cycadaceae (1 genus, 4 spp.), Taxaceae (1 genera, 2 spp.), Cephalotaxaceae (1 genus, 2 spp.) and Podocarpaceae(1 genus, 2 spp.). At generic level the species diversity is different. *Ephedra* is the largest genus with 8 species, followed by *Pinus* (7 spp.), *Juniperus* and *Gnetum* (5 spp. each), *Cycas* (4 spp.), etc. A comparative statistics of number of species occurring in different families and genera at global and India level is presented in the Tables II and III respectively.

Table II
Number of genera and species in different families

Name of family	World		India	
	Genera	Species	Genera	Species
Pinaceaae	10	250	6	17
Cupressaceae	19	130	2	8
Ephedraceae	1	44	1	8
Gnetaceae	1	30	1	5
Cycadaceae	9	70-100	1	4
Taxaceae	5	16-20	2	2
Cephalotaxaceae	1	4-7	1	2
Podocarpaceae	7	130-135	1	2

Table III
Number of species in different genera

Name of the genus	World	India
Ephedra	44	8
Pinus	91	7
Juniperus	60	5
Gnetum	30	5
Cycas	20	4
Abies	40	4
Cupressus	20	3
Picea	60	3
Cephalotaxus	4-7	2
Podocarpus	100	2
Taxus	10	1
Amentotaxus	1-4	1
Tsuga	10	1
Cedrus	4	1
Larix	10-12	1

An analysis of species diversity of living gymnosperms leads to the following categorisation.

Number of genera with 1 species	5
Number of genera with 2, 3, 4, and 5 species.	2 each.
Number of genera with 7 and 8 species.	1 each.

Thus, it is interesting to note that maximum number of genera belong to single species category. Gymnosperms are mostly found in Western and Eastern Himalayan regions while few occur in other parts of the country. The species diversity in these regions is also discussed below.

Western Himalayan region

The species diversity is not much prevalent here but the coniferous forests are most extensive and dense than the forests of Eastern Himalayan region. Out of the 48 species found in India, 23 species (48%) occur in Western Himalayan region. The maximum species diversity occurs in the genera *Juniperus* and *Ephedra*. Out of the 8 species of *Ephedra* known from India, 7 species and 1 variety occur in this region at various places (Ladakh, Lahul and Spiti) having high altitude. All the 5 species of *Juniperus* known from India, are also wide spread here. Out of the 4 species of *Abies*, 2 species grow here. The only one species of *Tsuga*, represented by *Tsuga dumosa*, is also found. Similarly the only known species of *Cedrus*, the *Cedrus deodara* exhibiting dense and extensive forests is also confined to North-West Himalaya.

Eastern Himalayan region

In this region, all the seven sister states of North-East India, Sikkim state and Darjeeling district of West Bengal are taken into account for the consideration of species diversity. The climate of this region is most suitable for the rich growth of gymnosperms. Out of the 48 species known from India, 28 species (58.3%) of wild nature grow in this region. The maximum species diversity occurs in the genus *Pinus*. Out of the 7 species of *Pinus* found in India, 6 species occur in Eastern Himalayan region, and out of these 6 species, 5 species occur in Arunachal Pradesh alone. Similarly other genera like *Amentotaxus* (1 sp.), *Cephalotaxus* (1 sp.), *Podocarpus* (2 spp.) and *Larix* (1 sp.) are also found in Arunachal Pradesh. Out of the 28 species known from Eastern Himalayan region, 17 species (60%) grow in wild state in Arunachal Pradesh. Hence, the state of Arunachal Pradesh can be considered as centre of species diversity. Two species (out of 4 known from India) of *Abies*, 2 species (out of 3) of *Picea*; 3 species (out of 5) of *Gnetum* and single species of *Taxus* grow in Eastern Himalayan region. Hence, in the number of species, this region is more rich than any other region in the country.

Other regions

Gymnosperms occur in limited number in other parts of the country due to unsuitable conditions. Andaman and Nicobar islands have 5 species (*Cycas rumphii*, *Podocarpus neriifolius*, *P. wallichianus*, *Gnetum gnemon*, and *G. ula*). Similarly 4 species (*Cycas circinnalis*, *Podocarpus wallichianus*, *Gnetum ula*, *G. latifolia*) are known from Western ghats. The gymnosperms from Eastern ghats are not known but species like *Cycas circinnalis* and *C. beddomei* grow in its neighbouring places like Orissa, Andhra Pradesh and Tamil Nadu. The other species like *C. pectinata* is known from Bihar and *Ephedra foliata* from Punjab and Rajasthan (Jodhpur).

EXOTIC SPECIES

Apart from 48 indigenous species, about 26 species are exotic, which are introduced in Indian gardens, parks and as avenue trees along the roadside for attraction and some other reasons. These are acclimatized and flourishing profusely in Indian climate, and thus, enriching the species diversity of gymnospermous flora as a whole. *Cycas revoluta* a native of Japan and China is cultivated in Indian gardens for its beauty. *Ginkgo biloba,* a living fossil and native of Chekiang and Anhewi provinces in Eastern China, is in cultivation at Dehradun, Mussoorie, Simla, Udhagamandalum (Ooty), Srinagar, Shillong and other places having moist and cool climate. Three species of *Araucaria* (*A. bidwillii*, *A. columnaris*, *A. cunninghamii*) which are found in Southern Hemisphere (S. America, Australia, New Guinea, etc.), are successfully introduced in Indian gardens and parks between 1000 to 1500 m altitude. The species brought from different places and introduced at various places in the country are shown in the Table-IV. Like these species, other exotic taxa can be also introduced in suitable habitats in order to promote the exotic species diversity.

Table IV
Exotic species

Name of species	Native place	Places where introduced in India
Cycas revoluta	Japan and China	In many Botanical Gardens.
Ginkgo biloba	Eastern China	In the gardens at Mussoorie, Simla, Dehradun, Udhagamandalam, Srinagar, etc.
Podocarpus gracilior	Ethiopia	Dehradun.
Araucaria bidwillii (Bunya Bunya Araucaria, Bidwills Araucaria)	Queensland, Australia.	Udhagamandalam, Nilgiri hills.

Name of species	Native place	Places where introduced in India
A. columnaris (Cook's Araucaria, Columnar Araucaria)	New Caledonia and Polynesia.	Arunachal Pradesh; Udhagamandalam, Nilgiri hills.
A. cunninghamii	Australia.	Udhagamandalam, Nilgiri hills, Dehradun.
Agathis robusta	Queensland.	Dehradun and Forest Research Institute, Dehradun; Deomali and Kharsingsa in Arunachal Pradesh.
Pinus canariensis	Canary island.	Srinagar.
P. caribaea	Bahama, America.	Assam, Dehradun.
P. edulis	South-West, U.S.A.	Nilgiris.
P. halepensis	Aleppo (Syria).	Srinagar.
P. massoniana	Central & South China.	Kulu, Manali; Raman.
P. nigra var. *calabrica*	Corsica island, Southern Italy.	Kulu, Manali, Raman.
P. patula	Eastern Mexico. Palamau Bihar);	Kulu, Manali, Raman , Yachuli
P. pinastser	Southern Europe (Mediterranean)	Kulu, Manali, Rahini.
P. radiata	Mexican islands.	Nilgiris.
P. sabiniana	California, U.S.A.	Nilgiris.
P. taeda	South-east U.S.A.	Kulu, Manali, Rahini.

Name of species	Native place	Places where introduced in India
P. thunbergii	Japan.	Samundar, Takedah, Darjeeling.
Taxodium distichum (Bald Cypress, Marsh Cypress)	North America.	Dehradun: Forest Research Institute along the canal.
Cryptomeria japonica (Japanese Cedar)	Japan.	Shillong, Darjeeling.
Cunninghamia lanceolata (Chinese Fir)	South and West China.	Forest Research Institute, Dehradun and Chakrata.
Cupressus macrocarpa	Monterey, California.	Nilgiris.
C. sempervirens (Mediterranean Cypress)	East Mediterranean.	Tajmahal garden Agra, Srinagar,
Callitris rhomboidea (Cypress pine)	Coastal eastern Australia.	Nilgiris.
Thuja orientalis (Peacock feathers)	Western China.	Indoor gardens, residential campus, botanical gardens, parks, etc.

ECONOMIC IMPORTANCE

Economically gymnosperms are most important, providing timber, wood pulp, resins, tars, turpentines and also planted for checking soil erosion etc. Most of the timber used in modern buildings is derived from Conifers. Pines, firs and spruces are the main source of wood pulp for industries. Several coniferous tree e.g. *Abies, Juniperus, Pinus, Podocarpus* are leading source of soft woods. *Cedrus deodara* (Deodar) yield the strongest Indian coniferous wood and is in great demand for construction work and furniture. Owing to the presence of oil is durable and resistant to termites. The timber of *Abies pindrow* is used in making fruit cases, plank for ceilings, floor boards and shingles for houses in the Himalayas. The *Podocarpus* wood is used for making oars, spars and masts. The twigs of Juniperus are usually burnt as incense in monasteries. The oil extracted from pines and spruces is used as scents in soap and perfumes. The oil extracted from *Cedrus deodara* is used as medicine in pulmonary and urinary disorders, piles and rheumatism. *Pinus roxburghii* produces resin and turpentine oil for commercial importance. In Assam and Meghalaya, the tender fleshy shoots of *Cycas pectinata* are eaten as vegetable by the hilly tribal communities and seeds are also edible. The leaves of *Cycas circinnalis* are used for making mats in South India and sago is also obtained from the trunk. The juice of tender leaves of *C. revoluta* is said to be a tonic and an expectorant. The sago is also extracted from the trunk of *C. rumphii*. The cooked fruits of *C. rumphii* are eaten by the Andamanese tribes while the uncooked fruits are poisonous. The seeds of *Pinus gerardiana* commonly known as "Chilgoza" are eaten as dry fruits during winter season and are very nutritious. The oil extracted from them is applied as a dressing to wounds and ulcers.

The taxol, a chemical extracted from *Taxus wallichiana* is used in curing the ovarian and breast cancer. The species of *Ephedra* are exploited comercially. 'Ephedrine' a drug obtained from some species of *Ephedra* (*Ephedra gerardiana, E. intermedia, E. nebrodensis*) is of great importance in the treatment of asthma, hey fever and other bronchial troubles. The young leaves and strobili of *Gnetum gnemon* are edible. *G. contractum* and *G. latifolium* are used as fish poison. The seed oil of *G. ula* is employed for cooking, illumination and massage for rheumatism. Coniferous forests provide a cool and soothing environment suitable for health and recreation. They create suitable habitats for animals and birds. Many species are used for land scaping of parks and gardens. Thus in short, the gymnosperms are closely associated with the life of human beings.

ENDEMIC AND RARE TAXA

Out of 48 species of Indian gymnosperms known to occur in wild state in Indian flora, 7 species are endemic. These taxa are distributed in a restricted area or region and thus enrich the diversity of species in a particular area. Apart from this, there are rare and scarce taxa found in the flora and need to be paid special attention for their effective conservation. The taxa along with their distribution and status are presented in the Table-V.

Table V
Endemic and rare taxa

Name of species	Status	Distribution in India
1. *Cycas beddomei*	Endemic and rare	Cuddapah district, Andhra Pradesh, Tamil Nadu.
2. *C. circinalis* var. *orixensis*	Endemic	Puri and Angul (Orissa).
3. *Amentotaxus assamica*	Endemic and rare	Delai valley Arunachal Pradesh)
4. *Cephalotaxus mannii*	Scarce	Eastern Himalaya.
5. *C. griffithii*	Scarce	Eastern Himalaya.
6. *Pinus wallichiana* var. *parva*	Endemic	Tawang (Arunachal Pradesh)
7. *P. gerardiana*	Scarce	North-West Himalaya
8. *P. bhutanica*	Scarce	Kameng, Arunachal Pradesh and Bhutan.
9. *P. merkusii*	Scarce	Lohit district (Arunachal Pradesh)
10. *Abies delavayi*	Scarce	Kameng and Tawang (Arunachal Pradesh)
11. *Gnetum montanum* var. *megalocarpum*	Endemic	Dafla hills (Arunachal Pradesh)

Name of species	Status	Distribution in India
12. *G. contractum*	Endemic	Nilgiri, Tamil Nadu and Kerala
13. *G. latifolium* var. *macrocarpum*	Endemic	Andaman & Nicobar islands.

CONSERVATION

Like other plants, the gymnosperms are also under threat. Their extensive population in nature is gradually depleting due to great demand of timber for various purposes. The activities of human population particularly in Western Himalayan region have posed numerous problems due to deforestation, resulting change in the environment. The degradation of natural forests in Eastern Himalaya is also commencing at alarming rate. Coniferous forests in and around Ukhrul in Manipur, Bomdila, Dirang, Tawang, Mechuka, Manigao in Arunachal Pradesh; Kohima and Kephire, etc. in Nagaland; Shillong and Nongstoin, etc. in Meghalaya, which were once extensive and densely populated, have now been eliminated for various reasons. The extraction of resin from the very young trees of *Pinus* species at various places in Arunachal Pradesh has effected the growth and finally reduced the life span of trees. Being economically very important, afforestation programmes need to be launched on extensive scale in the Himalayas particularly in Western sector. Gymnosperms can easily be grown through their seeds and cuttings. They can be cultivated at higher elevations in waste lands and at places where deforestation had occurred earlier.

There are rare, endangered and endemic species which need also to be conserved, *Cycas beddomei*, an endangered and endemic species in Cuddapah district of Andhra Pradesh needs immediate conservation. *Amentotaxus assamica* a most rare and endangered taxon rediscovered after 60 years from Delai valley in Arunachal Pradesh needs to be protected. This species is vulnerable to extinction on account of developmental activities (construction of roads, buildings) and the practice of shifting cultivation in Arunachal Pradesh. Certain areas in Arunachal Pradesh, which are rich in this rare taxon are needed to be identified and demarcated as gene sanctuaries. This taxon can also be rehabilitated and multiplied at Lloyed Botanic Garden, Darjeeling, and at experimental garden of Botanical

Survey of India, Shillong. *Cephalotaxus mannii* and *C. griffithii* occur scarcely in the areas of shifting cultivation and also need conservation. Similarly *Pinus bhutanica* and *P. merkusii* which are found in specific localities in Arunachal Pradesh also need to be multiplied. The conservation of all the above species can be effected by two well established means, the *in situ* and *ex situ* methods. *In situ* conservation can be brought about by establishing gene sanctuaries. National Parks and Biosphere reserves. *Ex situ* conservation can be effected by cultivating these species in the gardens and parks under suitable climatic conditions or by tissue culture techniques. As far as tissue culture studies on Indian gymnosperms are concerned, very little work has been carried out. However, some studies have been made on *Pinus gerardiana* by Dr. R.N. Konar at the University of Delhi and on *P. kesiya* by Prof. Pramod Tandon at the North-Eastern Hill University, Shillong. Successful tissue culture studies on this group of plants will be an invaluable contribution for rapid propagation and for *in vitro* conservation.

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Juniperus polycarpos - The Himalayan Pencil Juniper
(Courtesy: Dev Raj Agarwal)

Pinus gerardiana - The chilgosa Pine
(Courtesy: Dev Raj Agarwal)

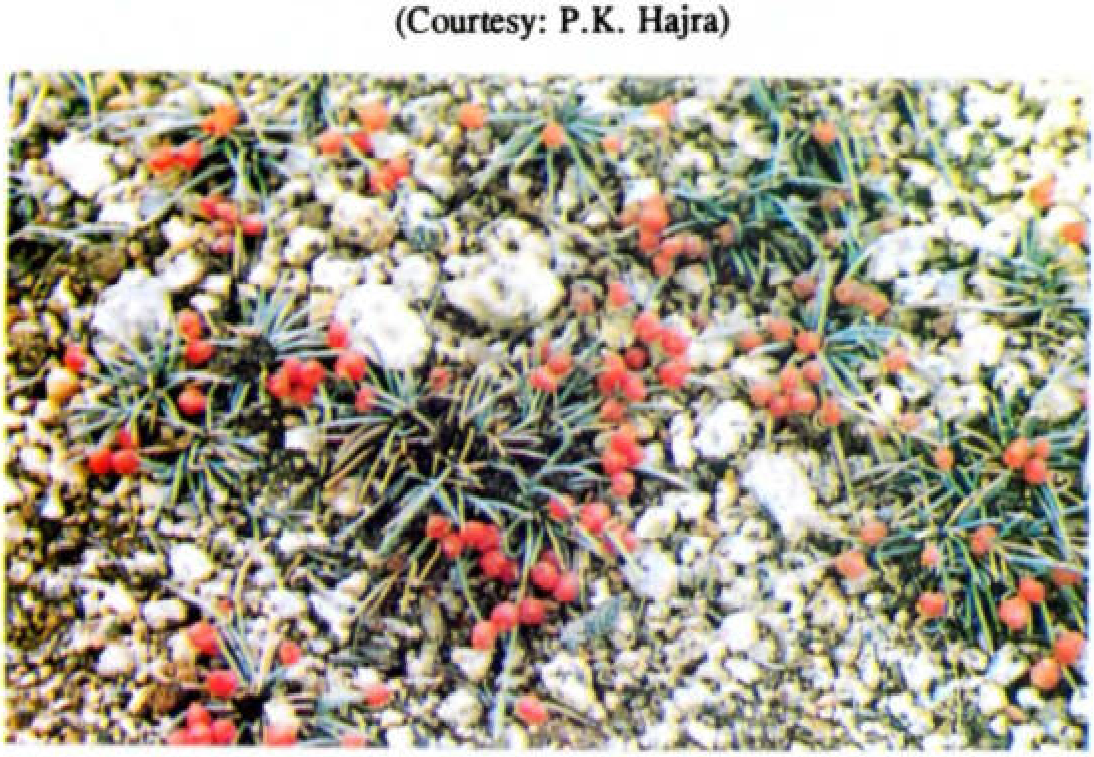
Ephedra gerardiana - An important medicinal plant
(Courtesy: Dev Raj Agarwal)

Pinus wallichiana - The Blue Pine
(Courtesy: Dev Raj Agarwal)

A coniferous forest of Western Himalaya
(Courtesy: Dev Raj Agarwal)

Cycas pectinata - A cycad with restricted distribution
(Courtesy: D.K. Singh)

Cycas rumphii - The Rumphius Cycas
(Courtesy: P.K. Hajra)



Ephedra intermedia **- A species of North Western Himalaya**
(Courtesy: Dev Raj Agarwal)