FLORISTIC DIVERSITY AND CONSERVATION STRATEGIES IN INDIA

Vol. IV: ANGIOSPERMS (SELECTED GROUPS) AND ETHNOBOTANY

BOTANICAL SURVEY OF INDIA

Ministry of Environment and Forest

FLORISTIC DIVERSITY AND CONSERVATION STRATEGIES IN INDIA

VOLUME - IV

Angiosperms (Selected Groups), Economic and Ethnobotany

Editors

N.P. Singh

D.K. Singh

भारतीय वनस्पति सर्वेक्षण

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Front Cover : *Sapria himalayana* – a root parasite

Back Cover : (Top) *Amomum subulatum* – wild, large cardamom
(Bottom) *Musa sikkimensis* – wild banana

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PREFACE

Based on the enormous data, accumulated by the scientists of the Botanical Survey of India over a period of more than hundred years, on various facets of the floristic wealth of our country, the department initiated a series on *Floristic Diversity and Conservation Strategies in India* to take stock of the status of diversity and conservation in various taxonomic groups of *Flora of India* and related applied aspects. The first volume in the series, covering a general review of floristic diversity and conservation strategies in the country, and specific chapters on different groups of Cryptogams, viz. Algae, Fungi, Lichens, Bryophytes (Liverworts and Mosses), Pteridophytes, and the Gymnosperms was published in 1997. Whereas, the next two volumes dealing with floristic diversity in context of States and Union Territories of India were brought out in 1999. The volume IV in the series is devoted to selected taxa of Angiosperms, viz. dominant families, genera and groups, including agrobiodiversity, medicinal plants and ethnobotany, besides a general overview of taxonomic, economic, aesthetic, cultural and conservational aspects of species diversity in Indian Angiosperms. These volumes will provide an important input for the *Biological Wealth of India,* a publication proposed to be brought out by the Ministry of Environment and Forests on the lines of *Megadiversity : Earth's Biologically Wealthiest Countries.*

The editors express their deep sense of appreciation for Dr. P.K. Hajra, ex-Director and late Dr. V. Mudgal, ex-Additional Director of Botanical Survey of India, who conceptualised the theme and scope of this series of publication and edited the first three volumes.

We are also thankful to various scientists, both within and outside the department, who have contributed chapters for this volume, and to Dr. P.S.N. Rao, Scientist-in-Charge, Publication Section and his team for their help in various ways during the course of this publication.

Finally we thank Shri Gajendra Singh Gahlot of M/s Shiva Offset Press, Dehradun for quick printing of this volume in final form.

N.P. SINGH
D.K. SINGH

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CONTRIBUTORS

N.P. Balakrishnan	Botanical Survey of India Southern Circle Coimbatore-641 003
A.K. Banerjee	Botanical Survey of India Indian Botanic Garden Howrah-711 103
Debjani Basu	Botanical Survey of India Central National Herbarium Howrah-711 103
P. Bujarbarua	Botanical Survey of India Eastern Circle Shillong-793 003
D.B. Deb	Botanical Survey of India Central National Herbarium Howrah-711 103
J.L. Ellis	Karnataka Association for the Advancement of Science Central College Bangalore-560 001
S. Gantait	Botanical Survey of India Indian Botanic Garden Howrah-711 103
P.K. Hajra	"Orchids", 19/6 Inder Road Dehradun-248 001
D.K. Hore	National Bureau of Plant Genetic Resources Shillong (Umiam)-793 103
K.K. Khanna	Botanical Survey of India Central Circle Allahabad-211 002

A.A. Mao	Botanical Survey of India Eastern Circle Shillong-793 003
Reshma Mathur	Botanical Survey of India Northern Circle Dehradun-248 195
M.S. Mondal	Botanical Survey of India Indian Botanic Garden Howrah-711 103
V. Mudgal	Botanical Survey of India Central National Herbarium Howrah-711 103
P.K. Mukherjee	Department of Botany University of Calcutta Kolkata- 700 019
Moonmoon Munshi	Botanical Survey of India Indian Botanic Garden Howrah-711 103
S.K. Murti	Botanical Survey of India Northern Circle Dehradun-248 195
V.J. Nair	Botanical Survey of India Southern Circle Coimbatore-641 003
D.C. Pal	Botanical Survey of India Central National Herbarium Howrah-711 103
M.K. Pathak	Botanical Survey of India Central National Herbarium Howrah-711 103

Sandhyajyoti Phukan	Botanical Survey of India Eastern Circle Shillong-793 003
V.P. Prasad	Botanical Survey of India Western Circle Pune-411 001
A.K. Sahoo	Botanical Survey of India Central National Herbarium Howrah-711 103
M. Sanjappa	Botanical Survey of India Central National Herbarium Howrah-711 103
J.R. Sharma	Botanical Survey of India Northern Circle Dehradun-248 195
D.K. Singh	Botanical Survey of India Northern Circle Dehradun-248 195
K.P. Singh	Botanical Survey of India Eastern Circle Shillong-793 003
N.P. Singh	Botanical Survey of India P-8, Brabourne Road Kolkata-700 001
S.C. Srivastava	Botanical Survey of India Central National Herbarium Howrah-711 103
M.S. Swaminathan	Botanical Survey of India Southern Circle Coimbatore-641 003

Sharmila Thomas	Botanical Survey of India Southern Circle Coimbatore-641 003
B.P. Uniyal	Botanical Survey of India Northern Circle Dehradun-248 195
K. Vivekanathan	Botanical Survey of India Southern Circle Coimbatore-641 003

SPECIES DIVERSITY IN ANGIOSPERMS

N.P. Singh
J.R. Sharma
K.P. Singh
V. Mudgal

The distribution and density of flowering plants vary in different habitats and different countries. Mc Neely *et al.* (1990) estimated that world's 12 countries : Australia, Brazil, China, Columbia, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Peru and Zaire together hold 70 per cent of its total flowering plant diversity and these have been termed "Megadiversity" countries (Table 1). It is interesting to note that seven of the above megadiversity countries figure among the 10 most species rich countries of the world (Groombridge, 1992; Bisby *et al.*, 1992).

Table 1
Megadiversity countries of the world

Country	Number of species
Brazil	55,000
Columbia	35,000
China	30,000
Mexico	25,000
South Africa	23,000
Former USSR	22,000
Indonesia	20,000
Venezuela	20,000
USA	18,000
Equador	18,000
India	17,000
Australia	15,000

*Only flowering plants.

India is a vast country with a rich diversity of biotic resources. The rich biodiversity is largely due to a varied physical environment, latitude, longitude, altitude, geology and climate. The geographical area of India is about 329 million ha and its coastline stretches to over 7,000 km. Almost all shades of climate from hot arid in Thar desert to arctic in the Himalaya with all intermediate gradations occur here. The rainfall varies from about 100 mm in Thar desert to over 5,000 mm at Mawsmai in Meghalaya. Though, the area of the country is only 2.4 per cent of the world landmass, yet it supports over 11 per cent of all known species of plants.

Angiosperms comprise *ca* 17,000 species (excluding infraspecific categories) under 2984 genera and 247 families and represent roughly 7 per cent of the world's angiospermic flora (Hooker, 1872-1897; Karthikeyan *et al.*, 1989; Sharma & Balakrishnan, 1993; Sharma & Sanjappa, 1993; Sharma *et al.*, 1993; Hajra *et al.*, 1995a, 1995b, 1995c, 1996; Mudgal & Hajra, 1995-1999; Singh *et al.*, 2000; Karthikeyan, 2000). Out of these, the Dicotyledones dominate with *ca* 12,750 species under 2282 genera and 203 families while the Monocotyledones follow with *ca* 4250 species under 702 genera and 44 families. The ratio between the genera of Dicot and Monocot is about 3.25:1, while it is about 3:1 for the species. Dicots account for *ca* 75 per cent of flowering plants in terms of both genera and species. Similarly, the Monocots account for approximately 25 per cent, i.e. one fourth of the flowering plants in terms of both genera and species.

Among the Dicotyledones, the family Asteraceae has the largest number of genera i.e. *ca* 166 followed by Fabaceae (133), Rubiaceae (113), Acanthaceae (92), Euphorbiaceae (84), Lamiaceae and Apiaceae (72 each), Brassicaceae (64), Scrophulariaceae (62) and Asclepiadaceae (57). These ten families represent *ca* 40 per cent of the dicot genera, whereas the remaining 193 families account for the rest. Similarly, it is interesting to note that family Fabaceae has the maximum number of species i.e. *ca* 975 followed by Asteraceae (892), Rubiaceae (616), Euphorbiaceae (527), Acanthaceae (510), Lamiaceae (435), Rosaceae (432), Scrophulariaceae (368), Apiaceae (288) and Asclepiadaceae (260). About 42 per cent of the species of dicots belong to these 10 families only, while the remaining 58 per cent species are represented by 193 families. Among dicots *ca* 61 families have only one genus while the maximum number of families i.e., 87 lie in the category of (2-10) genera. About 27 families have only one species while 36 families have more than 100 species each in India.

The figures for Monocotyledones are also quite interesting. Eighty seven per cent of the monocot genera are represented by seven families only, viz. Poaceae with 263 genera, Orchidaceae (184), Liliaceae (45), Cyperaceae (38), Araceae (29), Arecaceae (24) and Zingiberaceae (24). The remaining 37 families account for only 95 genera i.e. only *ca* 13 per cent of the total monocot genera. The distribution of species is again interesting as the larger families, viz. Poaceae with *ca* 1291 species, Orchidaceae (1229), Cyperaceae (545), Liliaceae (214), Zingiberaceae (191), Araceae (126) and Arecaceae (24) together account for 87 per cent of the total monocot species in India, whereas the remaining 37 families account for just 13 per cent of Indian monocots. Further, unlike dicots, the families dominating both in genera and species are the same. Among the monocots 18 families have one genus each, while maximum number of families, i.e. 19 families have between 2-10 genera. Six families have more than 100 species and about six families are represented by only one species each in India.

The genus *Impatiens*, with *ca* 205 species, followed by genera, like *Primula* (135), *Ficus* (132), *Crotalaria* (104), *Pedicularis* (98), *Rhododendron* (97), *Syzygium* (91), etc. dominate among the dicots while *Carex* with 117 species, *Habenaria* (100), *Dendrobium* (100) dominate among the monocots. About 189 genera of flowering plants are monotypic with 56 belonging to monocots and the remaining to dicots (Uniyal & Mathur, 1994). Family Poaceae has the maximum number of 32 monotypic genera.

DIVERSITY IN PLANT RESOURCES AND THEIR UTILIZATION

Flowering plants provide wide range of useful products relied on by people not only in different parts of the country but all over the world. The immense diversity met in floweirng plants of India not only provides ecological security to the nation but also contributes towards the economic benefits as important source of timber, medicine, food, vegetable oils, gums, resins, spices, fibres and flosses, dyes and tannins, beverages, narcotics, fodder, insecticides and pesticides, etc. (Anonymous, 1948-76; Krishnamurthy, 1993; Shiva, 1998).

Timber yielding plants

Indian flowering plants include *ca* 2560 tree species (15%) occurring predominantly in families Euphorbiaceae, Lauraceae, Annonaceae, Rubiaceae, Moraceae and Fabaceae. The wood of such tree species is used as timber for construction, furniture, agricultural implements, industry and other household articles. Some popular species valued for their long durability and strength are listed in Table-II.

Table II
Some timber yielding tree species of India.

Name	Trade name	Family
Albizia lebbeck	Kokko	Mimosaceae
Albizia odoratissima	Black siris	Mimosaceae
Albizia procera	White siris	Mimosaceae
Altingia excelsa	Silaras	Altingiaceae
Amoora wallichii	Amari	Meliaceae
Anogeissus acuminata	Bultom tree	Combretaceae
Aphanamixis polystachya	Amoora	Meliaceae
Artocarpus heterophyllus	Jack fruit	Moraceae
Artocarpus lakoocha	Monkey jack	Moraceae
Bridelia squamosa	Kasi	Euphorbiaceae
Calophyllum elatum	Poonspar tree	Clusiaceae
Careya arborea	Wild Guava	Myrtaceae
Cassia fistula	Amaltas	Caesalpiniaceae
Castanopsis tribuloides		Fagaceae
Cinnamomum inunctum		Lauraceae
Dalbergia latifolia	East Indian Rose wood	Fabaceae
Dalbergia oliveri	East Indian Rose wood	Fabaceae
Dalbergia sissoo	Shisham	Fabaceae
Dipterocarpus indicus	Gurjan	Dipterocarpaceae
Dipterocarpus zeylanicus	Gurjan	Dipterocarpaceae
Dysoxylum binectariferum		Meliaceae
Dysoxylum malabaricum	White cedar	Meliaceae
Eriolaena candollei	Salmon wood	Sterculiaceae
Fagara budrunga		Rutaceae

Name	Trade name	Family
Gluta tavoyana		Anacardiaceae
Gluta travancorica		Anacardiaceae
Gmelina arborea	Gambar	Verbenaceae
Grewia tiliaefolia	Dhammi	Tiliaceae
Hardwickia binata	Anjan	Caesalpiniaceae
Hopea cordifolia		Dipterocarpaceae
Hopea glabra		Dipterocarpaceae
Hopea odorata	Thingan	Dipterocarpaceac
Hopea parviflora	Hopea	Dipterocarpaceac
Kayea assamica		Clusiaceae
Lagerstroemia hypoleuca	Andaman Crape Myrtle	Lythraceae
Lagerstroemia microcarpa	Benteak	Lythraceae
Lagerstroemia speciosa	Jarul	Lythraceae
Machilus macrantha		Lauraceae
Madhuca indica	Mahua	Sapotaceae
Melanorrhoea usitata	Burmese Lacquer tree	Anacardiaceae
Mesua ferrea	Nagkesar	Clusiaceae
Michelia glabra		Magnoliaceae
Mimusops elengi	Bullet wood	Sapotaceae
Ougeinia oojeinensis	Sandan	Fabaceae
Palaquium ellipticum	Indian Gutta Parcha tree	Sapotaceae
Parashorea stellata		Dipterocarpaceae
Pentace burmannica		Tiliaceae
Pentace griffithi		Tiliaceae
Phoebe hainsiana	Angare	Lauraceae
Poeciloneuron indicum	Ballagi	Clusiaceae
Proteum serratum	Indian Red pear	Burseraceae
Pterocarpus marsupium	Indian Kinotree	Fabaceae
Radermachera xylocarpa		Bignoniaceae
Shorea robusta	Sal	Dipterocarpaceae
Shorea roxburghii		Dipterocarpaceae

Name	Trade name	Family
Soymida febrifuga	Indian red wood	Meliaceae
Syzygium kanarensis	Rose apple	Myrtaceae
Syzygium cumini	Jaman	Myrtaceae
Tectona grandis	Teak	Verbenaceae
Terminalia arjuna	Arjuna	Combretaceae
Terminalia crenulata		Combretaceae
Terminalia manii	Black Chuglam	Combretaceae
Terminalia paniculata		Combretaceae
Toona sinensis	Hill toon	Meliaceae
Toona ciliata	Toon	Meliaceae
Vitex altissima	Milla	Verbenaceae
Xylia xylocarpa	Jambu, Irul	Mimosaceae

Medicinal plants

It is estimated that about 3000 species of Indian flowering plants are of potential medicinal value, of which *ca* 1300 species are extensively used in different systems of medicine, such as Ayurveda, Siddha, Unani, and Allopathy (Sharma & Singh, 2001). The Himalaya, especially the western Himalaya and the Western Ghats are exceptionally rich in medicinal plants. The preparations of *Allium sativum*, *Aloe barbadensis* and *Panax* spp., which are found in the Indian flora, are among the ten most widely selling herbal medicines in developed countries (Kamboj, 2000). India is the largest grower of *Plantago ovata* (Psyllium) and *Cassia senna* (Senna) and one of the largest grower of *Ricinus communis* (Castor) plants. Some of the plants, like *Glycyrrhiza glabra, Commiphora wightii, Plantago ovata, Aloe barbadensis* and *Azadirachta indica* are used in the modern medicine. The plants, like *Glycyrrhiza glabra, Piper longum, Adhatoda zeylanica, Withania somnifera, Cyperus rotundus, Tinospora cordifolia, Berberis aristata, Tribulus terrestris, Holarrhena antidysenterica* and *Boerhavia diffusa* have been used in 52-141 herbal formulations and the triphala (*Terminalia chebula, T. bellerica* and *Phyllanthus emblica*) alone have been used in as many as 219 formulations. The most widely used medicinal plants are given in Table-III.

Table III
Major Indian medicinal plants used in three indigenous systems of medicine

Name	Trade name	Family
Achyranthes aspera	Apamarga	Amaranthaceae
Acorus calamus	Vacha	Araceae
Aloe spp.	Kumari	Liliaceae
Andrographis paniculata	Kalmegh	Acanthaceae
Asparagus adscendens	Mushali	Liliaceae
Asparagus racemosus	Shatavari	Liliaceae
Azadirachta indica	Neem	Meliaceae
Bacopa monnieri	Brahmi	Scrophulariaceae
Bauhinia variegata	Kachnar	Caesalpiniaceae
Bergenia ligulata	Pashan bheda	Saxifragaceae
Boerhavia diffusa	Punarnava	Nyctaginaceae
Cassia senna	Senna	Caesalpiniaceae
Catharanthus roseus	Sadavahar	Apocynaceae
Clerodendrum serratum	Bharangi	Verbenaceae
Commiphora wightii	Gugul	Burseraceae
Convolvulus pluricaulis	Shankhapushpi	Convolvulaceae
Crateva nurvala	Varuna	Capparidaceae
Dioscorea bulbifera	Vidarikand	Dioscoreaceae
Embelia ribes	Vidanga	Myrsinaceae
Gymnema sylvestre	Madhunashni	Asclepiadaceae
Hedychium spicatum	Shathi	Zingiberaceae
Holarrhena antidysenterica	Kutaja	Apocynaceae
Mesua ferrea	Nagkesar	Clusiaceae
Nardostachys grandiflora	Jatamansi	Valerianaceae
Ocimum basilicum	Tulsi	Lamiaceae
Podophyllum hexandrum	Podophyllum	Podophyllaceae
Phyllanthus amarus	Bhumyamalika	Euphorbiaceae
Phyllanthus emblica	Amla	Euphorbiaceae

Name	Trade name	Family
Picrorrhiza kurrooa	Kutki	Scrophulariaceae
Piper longum	Pippali	Piperaceae
Pluchea lanceolata	Rasna	Asteraceae
Psoralea corylifolia	Bakuchi	Papilionaceae
Rauvolfia serpentina	Sarpgandha	Apocynaceae
Saraca indica	Ashoka	Caesalpiniaceae
Saussurea costus	Kushtha	Asteraceae
Sida sp.	Bala	Malvaceae
Strychnos nux-vomica	Nux vomica	Loganiaceae
Symplocos racemosa	Lodhra	Symplocaceae
Terminalia arjuna	Arjuna	Combretaceae
Terminalia chebula	Harad	Combretaceae
Tinospora cordifolia	Guduchi	Menispermaceae
Tribulus terrestris	Gokshura	Zygophyllaceae
Valeriana jatamansi	Tagar	Valerianaceae
Vitex negundo	Nirgundi	Verbenaceae
Withania somnifera	Ashwagandha	Solanaceae

Edible plants

(a) ***Cereals and millets*** **:** One of the most fundamental contributions of the flowering plants for the mankind is the supply of food. All the cereals are the members of the family Poaceae that have been domesticated for their starchy grains. The family Poaceae has the maximum number of domesticated species followed by families, like Fabaceae, Rosaceae, Solanaceae, Asteraceae, Cucurbitaceae, etc. Out of the total *ca* 17000 species of flowering plants, nearly 3000 are regularly exploited for food (cereals, pulses, fruits, vegetables, beverages, etc.) but only 15-20 have become the crops of major economic importance. The "big three" cereals (*Triticum* spp., *Zea mays*, *Oryza* spp.) account for nearly 75 per cent of India's, cereal supply while the pseudocereals (*Fagopyrum esculentum*, species of *Chenopodium* and *Amaranthus*) and others (*Hordeum vulgare, Avena sativa, Secale cereal, Eleusine coracana, Panicum* *miliaceum, Setaria italica, Echinochloa* sp., *Sorghum* spp. *Pennisetum* spp.) account only for the remaining 25 per cent supply.

(b) ***Pulses*** : Nearly 20 species, all belonging to family Fabaceae, provide grain legumes or pulses, which are only second to the cereals as a source of human food with *Cicer arietinum* accounting for over 50 per cent of the total production. Other major pulse crops are *Cajanus cajan, Dolichos* spp., *Phaseolus* spp. *Vigna* spp., *Glycine max, Lathyrus sativus, Lens esculenta, Pisum sativum* and *Vicia faba*.

(c) ***Fruits and nuts*** : India is a vast country with diverse geographical and agroclimatic conditions suited for a wide range of fruits growing both as wild and cultivated. Fruit crops considered together, compare favourably with staple agricultural crops in terms of production. The majority of fruits belong to two families, the most important is the Rosaceae to which belong many of the outstanding fruits of temperate zones. The family Rutaceae is the second important and a single genus, *Citrus* contains many fruit bearing species. In addition, there are species in Vitaceae, Musaceae, Arecaceae, Anacardiaceae, Oleaceae, Bromeliaceae, Sterculiaceae, Clusiaceae, Tiliaceae, Sapindaceae, Lauraceae, Myrtaceae, Punicaceae, Rhamnaceae Moraceae, Cucurbitaceae, Annonaceae, Caricaceae, etc. which also provide fruits with prized flavour and aroma.

Nuts, unlike most other fruits, are generally rich in oils and fats, and contain moderate amount of carbohydrates and proteins. These are mostly products of dicotyledonous trees or shrubs. Some principal nut yielding species are : *Anacardium occidentale, Aleurites moluccana, Buchanania angustifolia, Castanea sativa, Cola acuminata, Corylus avellana, Juglans regia, Pistacia vera, Prunus communis, Terminalia catappa, Trapa bispinosa, Euryale ferox,* etc.

(d) ***Vegetables*** : Vegetables also form a major part of the diet of millions of people and are source of much needed vitamins and minerals. More than 1200 species of both cultivated and wild herbaceous plants are regularly consumed as basic food or like fruits. They belong to different families of flowering plants of which four stand out. They are Brassicaceae, Solanaceae, Cucurbitaceae and Fabaceae, followed by Convolvulaceae, Euphorbiaceae, Dioscoreaceae, Araceae, Liliaceae, Chenopodiaceae, Apiaceae, Amaranthaceae, Asteraceae, Polygonaceae, Malvaceae, etc. The edible part may be swollen underground tubers, roots or rhizomes (*Solanum tuberosum, Ipomoea batatas, Manihot esculenta, Dioscorea* spp., *Colocasia* spp., *Allium* spp., *Beta vulgaris, Brassica rapa, Daucus carota, Raphanus sativus*, etc.); stems or foliage (*Apium graveolens, Asparagus officinalis, Brassica* spp., *Lactuca sativa, Rheum rhaponticum, Spinacia oleracea*, etc.) or fruits and seeds (*Lagenaria siceraria, Luffa* spp., *Cucurbita* spp., *Citrullus* spp., *Cucumis* spp., *Benincasa hispida, Momordica charantia, Trichosanthes* spp., *Capsicum* spp., *Solanum melongena, Lycopersicon esculentum, Hibiscus esculentus*, etc.).

(e) ***Beverages*** : The three major non-alcoholic beverages (tea, coffee and cocoa) are obtained from *Camellia sinensis*, *Coffea arabica* and *Theobroma cacao*. Apart from these, the fresh sap from *Borassus flabellifer, Phoenix sylvestris* and the liquor prepared from the flowers of *Madhuca longifolia* are also well known beverages obtained from flowering plants. Saps obtained from some species of *Arundinaria* and *Bambusa* and seeds of *Oryza* and *Eleusine* spp. are used for making alcoholic drinks.

(f) ***Sugars, starches and cellulose products*** : Sugar, which is so important in the manufacture of alcoholic beverages, soft drinks, ice-creams, confectionery and in canning industry, is mainly obtained from the culms of *Saccharum* spp. and the roots of *Beta vulgaris*. A small portion of the sugar is also obtained from : *Acer saccharum, Arenga pinnata, Borassus flabellifer, Cocos nucifera, Phoenix sylvestris, Sorghum vulgare* var. *saccharatum*. Cereals are the basic source of our starchy foods but *Solanum tuberosum, Ipomoea batatas, Dioscorea alata, Manihot esculenta* and *Musa sapientum* form important costitutents in the diet of people living in regions not well suited for growing cereals. Some other species constituting important source of starch are *Colocassia esculenta, Xanthosoma sagittifolium, Maranta arundinacea* and *Metroxylon sagu*.

In India many rural communites, particularly the tribals, obtain considerable part of their daily food from wild plants, like *Ceropegia bulbosa* (central India and Western Ghats), *Pandanus andamanesium, P. tectorius, Artocarpus incisa, Dioscorea glabra, Tacca* *leontopetaloides* (Andaman & Nicobar), *Codonopsis ovata* (Himalaya), *Ardisia* sp., and *Meliosoma pinnata* (North-east), *Eremurus himalaicus*, *Origanum vulgare*, *Urtica hyperborea* (western Himalaya) and *Sesuvium portulacastrum* (Coastal areas).

Paper and pulp

Over 30 species, belonging mainly to Poaceae, are used for manufacturing of paper. The dominant species providing pulp for paper are species of *Bambusa, Arundinaria, Dendrocalamus, Themeda, Chloris, Cymbopogon, Erianthus, Phalaris*, etc. Some other species, like *Ailantus integrifolia, Eulaliopsis binata, Canarium euphyllum, Daphne papyracea, Caltha edulis, Populus ciliata, Rhizophora apiculata*, etc. also provide raw material for paper industry. The wood of many trees like, *Boswellia serrata*, is the source of cellulose which is very important to man for manufacture of a vast array of paper products.

Fibres and flosses

At present there are *ca* 2000 flowering plant species belonging to such dominant families as Poaceae, Arecaceae, Musaceae, Malvaceae, Linaceae, Tiliaceae, Leguminosae, Bombacaceae, Cannabinaceae, etc. which provide fibres of economic importance. The wealth of fibres has been in use for meeting local and industrial needs of the people. The major soft fibres of commercial importance are provided by *Linum usitatissimum, Corchorus capsularis, C. olitorius, Cannabis sativa, Crotalaria juncea, Hibiscus cannabinus, H. sabdariffa, Boehmeria nivea, Helicteres isora*, etc.

The commercially important surface fibres are provided by a variety of plants, like *Gossypium* spp., *Ceiba pentandra, Bombax ceiba, B. insigne, B. malabaricum, Cochlospermum gossypium, C. religiosum, Cocos nucifera*, etc.

Monocotyledonous families, like Poaceae (*Eulaliopsis binata, Dinochloa andamanica, Phragmites karka, Themeda* spp., species of *Dendrocalamus, Sehima, Saccharum, Sorghum, Arundinaria, Bambusa, Chimonobambusa*); Cyperaceae (*Cyperus corymbosus*); Arecaceae (*Borassus flabellifer, Caryota urens, Calamus* spp.); Liliaceae (*Agave sisalana, Yucca gloriosa*); Musaceae (*Musa textilis*) and Pandanaceae (*Pandanus odoratissimus*) yield fibres used for plaiting, rough weaving and fibres for mats, baskets, paper, ropes, cordages, brushes, etc.

Vegetable oils

A large number of species in the Indian flora provide both fatty and essential oils. Though over 100 species of flowering plants, whose seeds yield fatty oils, are used mainly in cooking, soaps, varnishes and paints but only 10-12 species, namely *Cocos nucifera, Gossypium* spp., *Helianthus annuus, Linum usitatissimum, Olea europea, Sesamum orientale, Ricinus communis, Glycine max, Brassica juncea, B. nigra, Arachis hypogea* and *Carthamus tinctorius,* provide commercially important oils. Some other less important wild species whose seeds are used for extraction of fatty oils are; *Calophyllum inophyllum, Pongamia pinnata, Actaea acuminata, Prinsepia utilis, Sorbus aucuparia, Derris indica, Madhuca longifolia, Shorea robusta, Schleichera oleosa, Garcinia indica, Actinodaphne hookeri, Prunus* spp., etc.

About 370 species of flowering plants have been exploited for providing essential oils used largely in perfumery, flavouring agents and medicine. Some dominant essential oil yielding plants are : *Acorus calamus, Pimpinella anisum, Thymus vulgaris, Santalum album, Vetiveria zizanioides, Azadirachta indica, Aquillaria malaccensis, Myristica fragrans, Bursera penicillata, Cinnamomum camphora,* species of *Cymbopogon, Boswellia, Citrus, Eucalyptus, Gaultheria, Jasminum, Pelargonium, Mentha, Lavandula, Carum, Rosa,* etc.

Spices, condiments and flavouring agents

Over 70 species of both cultivated and wild Indian plants are used as spices in India but the major ones are obtained from *Piper nigrum, Elettaria cardamomum, Zingiber officinale, Curcuma longa, Eugenia caryophyllus, Myristica fragrans, Cinnamomum zeylanicum* and *Capsicum annuum. Piper nigrum* (Pepper) referred to as the king of spices or the black gold of India is the most important spice. Some other important minor spice yielding plants are *Pimpinella anisum, Carum copticum, Apium graveolens, Coriandrum sativum, Cuminum cyminum, Anethum sowa, Foeniculum vulgare, Trigonella foenum-graecum, Brassica juncea, Nigella sativa, Amomum* spp., *Murraya koenigii, Vanilla planifolia, Crocus sativus, Allium* spp. and *Mentha* spp.

Gums and resins

Gums, which find uses in various industries because of their adhesive properties, are known to be produced by *ca* 125 species of flowering plants. But a few members of the families, like Leguminosae (*Acacia senegal* and other *Acacia* spp., *Astragalus fatmensis, A. gummifer, Ceratonia siliqua*); Sterculiaceae (*Sterculia urens*); Cochlospermaceae (*Cochlospermum religiosum*) and Combretaceae (*Anogeissus pendula*) produce them more freely and have comparatively more commercial significance.

About 140 species belonging mostly to families Leguminosae (*Copaifera* spp., *Daniella thurifera, Kingiodendron pinnatum, Myroxylon* spp., *Trachylobium verrucosum;* Dipterocarpaceae (species of *Dipterocarpus, Shorea, Hopea, Vatica*) and Burseraceae (species of *Boswellia, Canarium, Commiphora, Proteum* and *Bursera gummifera*) yield resins. The family Apiaceae is known for providing scented and medicinal resins (*Dorema ammoniacum, Centella asiatica, Ferula* spp.). The families like Euphorbiaceae, Styracaceae, Moraceae, Clusiaceae, Apocynaceae, Anacardiaceae, Solanaceae, Cannabinaceae, Arecaceae, etc. also have species which provide resins.

Rubber, used in over 50,000 products directly or indirectly, is indispensable in modern industrial society. Over 2000 species of flowering plants under 80 families, confined mostly to tropical areas, are known to produce rubber. In India, over 70 species have been exploited from time to time as source of rubber but the principal rubber producing species belong to the families Euphorbiaceae (*Hevea brasiliensis, Manihot* spp.); Moraceae (*Castilla elastica, Ficus elastica*); Asteraceae (species of *Taraxacum, Parthenium, Solidago*); Asclepiadaceae *(Cryptostegia grandiflora, Asclepias* spp.); Apocyanaceae (*Couma macrocarpa, Funtumia elastica*) and Sapotaceae (*Palaquium gutta, Mimusops balata*). Of all the commercially exploited species *Hevea brasiliensis* is most important yielding over 95 per cent of total Indian production of natural rubber, which incidentally is less than 3 per cent of the world production.

The wax derived from the leaves of the palm, *Copernicia cerifera* (Arecaceae) and the stem of *Euphorbia antisyphilitica* (Euphorbiaceae) is widely used in the manufacture of candles and polishes.

Tannins and dyes

About 550 species of flowering plants yield vegetable tannins and dyes which unquestionably are as old as civilization itself, having been used for preparing leather from animal hides and skins and for colouring purposes. Natural tannins occur commonly among several dicot families of the most notable being the Leguminosae (*Acacia nilotica, A. senegal, A. mearnsii, Prosopis chilensis, Cassia auriculata, Cassia javanica*); Anacardiaceae (*Schinopsis lorentzii, Rhus* spp.); Myrtaceae (*Eucalyptus* spp.); Polygonaceae (*Rumex hymenosepalus*); Rhizophoraceae (*Rhizophora mucronata, R. apiculata, Ceriops tagal, Bruguiera* spp.); Combretaceae (*Terminalia* spp., *Anogeissus* spp.); Sonneratiaceae (*Sonneratia* spp.). Leaf-galls and nut-galls (*Quercus* spp. and *Pistacia vera*) are also rich source of tannins. The wood of *Schinopsis lorentzii* form the single largest source of tannins. The monocots in general are poor source of tannins with the exception of the family Arecaceae (*Areca catechu* and *Phoenix sylvestris*).

The most priced natural dyes are obtained from *Bixa orellana, Acacia catechu,* and *Pterocarpus santalinus.* Some other plant species which once dominated the trade in dye stuffs are *Artocarpus heterophyllus, Caesalpinia sappan, Acacia* spp., *Mallotus philippinensis, Morinda* spp., *Butea monosperma, Erythrina* spp., *Carthamus tinctorius, Crocus sativus, Lawsonia inermis, Uncaria gambier, Indigofera* spp., etc.

Fodder plants

Nearly 1250 species of flowering plants belonging to the families Poaceae (*Avena sativa, Brachiaria mutica, Cenchrus* spp., *Chloris* spp., species of *Arundinaria, Bambusa, Dendrocalamus, Panicum, Pennisetum, Cenchrus, Sorghum, Cynodon, Enteropogon, Heteropogon, Sehima, Eragrostis, Sporobolus, Tripsacum,* etc.) and Leguminosae (species of *Cajanus, Centrosema, Crotalaria, Dolichos, Medicago, Phaseolus, Trifolium, Vicia, Vigna, Desmodium, Indigofera, Acacia, Albizia, Bauhinia, Cassia,* etc). are the source of fodder. Some other plants providing fodder are the species of *Grewia, Ficus, Prosopis, Terminalia, Ziziphus, Brassica, Ipomoea, Digera, Boehmeria, Quercus, Atriplex,* etc.

Poisonous plants

Over 2000 species of Indian flowering plants are known to contain various types of substances which are poisonous to man and cattle (*Aconitum ferox, Atropa belladonna, Calotropis procera, Papaver somniferum, Cannabis sativa, Ammannia baccifera*, etc.); to fish (*Albizia procera, Kayea assamica, Securinega leucopyrus, Anamirta cocculus, Anagallis arvensis, Casearia* spp.); to insects (*Acorus calamus, Azadirachta indica, Cymbopogon nardus, Derris elliptica, Chrysanthemum cinerarifolium, Ricinus communis, Carum carvi*, etc.); to bees (*Orophea katschallica*) and to herbs (*Amorpha fruticola, Anabasis aphylla*, etc.). Some species have proven fumitory (*Nicotiana* spp., *Erythroxylum coca, Cannabis sativa*, etc.) and masticatory (*Areca catechu, Nicotiana tabacum, Piper betle, Cola nitida*,etc.) properties.

Plants in Indian religion and culture

A very wide range of flowering plants (*ca* 700) are exploited for personal adornments at festivals, for religious and traditional purposes and these associations can be traced from prehistoric to modern time in an unbroken line. Many tree species like *Ficus religiosa, Shorea robusta, Mangifera indica, Saraca asoca*, etc. are known to be associated with folk songs and folk tales. A large number of plants or their leaves, fruits or flowers figure in various religious rituals from birth to death. Some such plants are *Ficus religiosa, F. benghalensis, Melia azedarach, Ocimum* spp., *Cocos nucifera, Areca catechu, Piper betle, Oryza sativa, Mangifera indica, Desmostachya bipinnata, Curcuma domestica, Sesamum indicum, Butea monosperma, Pandanus* sp., *Michelia champaca, Jasminum* sp., *Musa* sp. and bamboos. A few flowering plants like, *Nerium* sp., *Syzygium* sp., *Jasminum* sp. and *Rosa* spp., *Curcuma longa, Lawsonia inermis, Citrus* sp. and *Pterocarpus santalinus* find prominent place in woman's personal decorations. Many like *Zea mays* (Minjar fair, Himachal); *Papaver somniferum*, (Mandsor fair, Madhya Pradesh); *Acacia nilotica* (Mamulian fair, Uttar Pradesh); *Hordeum vulgare, Triticum vulgare, Cicer arietinum, Brassica campestris* and *Zea mays* (Daur, Durra festival, Kumoan) are associated with fairs and festivals in different areas. A few trees (*Aegle marmelos, Anthocephalus chinensis, Borassus flabellifer*, etc.) depict floral motifs based on legends while others, like *Saraca asoca, Bombax ceiba, Mesua ferrea, Mimusops elengi*, etc. are tree motifs identified with women.

Apart from individual plants, patches of vegetation are preserved on religious grounds and are known as sacred groves. There are hundreds of such groves confined mainly to Khasia and Jaintia hills, Western ghats and Central India. Sacred groves believed to be the abodes of certain deities or spirit, also harbour hundreds of rare and unique plants like *Kunstleria keralensis*, *Nostolachma jenkinsii*, *Syzygium travancoricum*, besides serving the function of preserving the genetic diversity of common species of *Tectona*, *Quercus*, *Pyrus*, *Manglietia*, *Prunus*, etc. (Nayar, 1996; Rao, 1994).

Some species of flowering plants growing in India, represent National floral emblems. For example *Papaver somniferum* (Belgium and Switzerland); *Punica granatum* (Spain); *Iris germanica* (France); Cacti (Mexico), etc.

Ornamental plants

There are many well known groups of flowering plants which have a great potential for their exploitation as ornamentals. The adoption of such wild ornamental plant species will not only enrich our ornamental collection but will also help greatly in providing them effective conservation and protection. Some of such potential ornamental resources, like *Butea monosperma* (loaded with bright red flowers), *Cassia fistula* (yellow flowers), *Ougeinia oojeinensis* (pink flowers); *Nyctanthes arbor-tristis* (scented pinkish white flowers), *Bombax ceiba* (pink red flowers); and *Acacia*, *Albizia*, *Mimosa*, etc. (coloured globular heads) provide eye catching sights in the deciduous forests during their leafless period. The orchids, both epiphytic and terrestrial are among the most important ornamental plant species prized as ornamentals all over the world for their beautiful and long lasting flowers. Some such species belong to the genera *Aerides*, *Arundina*, *Calanthe*, *Pleione*, *Coelogyne*, *Dendrobium*, *Paphiopedilum*, *Phaius*, *Renanthera*, *Vanda*, *Rhynchostylis*, *Habenaria*, etc. Plants of family Araceae, with multicoloured, snake hood-like spathes are also source of pleasure. Rhododendrons mostly confined to Himalaya, particularly eastern Himalaya, are also among the popular flowering trees/shrubs having high ornamental value.

Members of the family Zingiberaceae *(Hedychium, Alpinia, Costus, Mantisia)*, are also well known for their etheral beauty and enchanting fragrance. Begonias and *Impatiens* are also ideal and have delicate and variously coloured flowers with velvety foliage.

Many other flowering plants, like species of *Pterocarpus, Thespesia, Bauhinia, Woodfordia, Nymphaea, Nelumbo, Rosa, Geranium, Bergenia, Caltha, Erigeron, Fritillaria, Delphinium, Primula, Corydalis, Impatiens*, etc. are a source of pleasure with their enchanting beauty when in bloom. Similarly, species of *Albizia, Azadirachta, Cassia, Barringtonia, Delonix, Ficus, Lagerstroemia, Altsonia, Peltophorum, Polyalthia, Pongamia, Syzygium, Swietenia, Cinnamomum*, etc. are well known as avenue trees. Among the climbers, species of *Ipomoea, Thunbergia, Aristolochia, Hedera, Combretum, Rhaphidophora* can be trained as ornamental climbers.

Wild relatives of cultivated plants

India is also acknowledged as one of the world's 12 Vavilovian centres of origin and diversification of cultivated plants known as the "Hindustan Centre of origin of crop plants" (Vavilov, 1951). At least 167 species of important agri-horticulatural crops and 320 species of their wild relatives belonging to 116 genera and 48 families, are known to have originated here (Arora & Nayar, 1984). Within each of these species, the diversity of varieties is astonishing. For example, there were possibly an estimated 50,000 to 60,000 land-races 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. These species offer invaluable source of genetic material required for breeding and genetic engineering towards the improvement and development of newer crop varieties. The maximum diversity is encountered in humid tropical and sub-tropical regions of the country. Their diversity and distribution in different phytogeographical regions is shown in Table-IV. India's rich germplasm resources belong to the following crop categories: cereals and millets (51), legumes (31), fruits (109), vegetables (54), oil seeds (12), fibre plants (24), spices and condiments (27) and others like tea, coffee, tobacco, sugarcane, etc (12).

Table IV
Distribution of wild relatives of crop plants in different phytogeographical regions of India (after Arora, 1991).

Phytogeographic region	No. of Species represented	Genera represented
Western Himalaya	125	*Pyrus, Prunus, Sorbus, Rubus, Ribes, Hordeum, Elymus, Eryemopyrum, Avena, Aegilops, Allium, Lepidium, Carum, Linum, Cicer, Cucumis.*
Eastern Himalaya	82	*Pyrus, Prunus, Sorbus, Rubus, Ribes, Hordeum*
North-eastern region	132	*Citrus, Musa, Mangifera, Docynia, Elaeocarpus, Myrica, Morus, Vitis, Coix, Digitaria, Vigna, Canavalia, Mucuna,* Tuberous types, *Trichosanthes, Momordica, Cucumis, Solanum, Brassica, Corchorus, Piper, Amomum, Alpinia, Curcuma, Zingiber, Saccharum, Oryza.*
Gangetic plains	66	*Emblica, Syzygium, Artocarpus, Ziziphus*
Indus/N.W. Plains	45	*Ziziphus, Carissa, Capparis, Cordia, Grewia, Cucumis, Citrullus, Momordica, Sesamum*
Malabar/Western Peninsular region/ Western ghats	145	*Artocarpus, Garcinia, Syzygium, Diospyros, Euphoria, Mimusops, Mangifera, Spondias, Vitis, Chionachne, Trilobachne, Polytoca, Hygroryza, Oryza, Vigna, Atylosia, Dolichos, Mucuna, Abelmoschus, Solanum, Luffa, Cucumis, Momordica, Trichosanthes,* Tuberous types, *Sesamum, Curcuma, Piper, Myristica, Cinnamomum, Zingiber, Saccharum*

Phytogeographic region	No. of Species represented	Genera represented
Deccan/Eastern Peninsular region/ Eastern Ghats	91	*Artocarpus, Garcinia, Syzygium, Diospyros, Mimusops, Mangifera, Spondias, Vitis, Hygroryza, Oryza, Vigna, Atylosia, Dolichosa, Mucuna, Sesamum, Saccharum.*

DIVERSITY IN SOME MAJOR GROUPS

Bamboos

Bamboos are woody grasses belonging to family Poaceae and play an important role, both in economy and ecology of area. Bamboos form an important constituent of deciduous and evergreen forests occurring from tropical plains to high mountainous, temperate Himalayan regions up to 4000 m. About 12 per cent of the recorded forest area is covered by bamboo forests. North eastern India constitute *ca* 66 per cent while the rest of India accounts for only 34 per cent of the growing stock. As per latest records, 15 genera and 63 species out of 18 genera and *ca* 130 species, are represented in the North-east India (Biswas, 1988; Rao, 1993; Naithani, *per lit.*). *Bambusa* with *ca* 21 species and *Dendrocalamus* (14 spp.), *Arundinaria* (2), *Melocalamus* (3) are dominant genera distributed throughout India. The genera *Phyllostachys* (4), *Schizostachyum* (15), *Gigantochloa* (8) and *Melocanna* (2) are confined to North-east India. *Melocanna baccifera* (=*M. bambusoides*) which is a non-clump forming bamboo, alone accounts for 20 per cent of growing stock in this area. *Dinochloa* (Andaman & Nicobar Islands), *Ochlandra* (South India), *Pseudoxytenanthera* (western India) *Sinarundinaria* (Himalaya and South India) are other dominant genera.

Dendrocalamus strictus and *Bambusa bambos* are the commonest species in the hot and dry areas, while at higher altitudes, bamboos in the genera *Arundinaria, Thamnocalamus, Himalayacalamus, Yushania* and *Borrinda* are common in natural temperate forests across much of the Himalayan range. *Phyllostachys bambusiodes* is a climbing bamboo of rare occurrence in Eastern Himalaya. Commercially, *Bambusa arundinacea, B. balcooa, B. nutans, B. tulda, Dendrocalamus* *hamiltonii*, *Thamnocalamus flaconeri* and *T. spathiflorus* are more important.

Palms

Palms are the most fascinating group of plants that have attracted the attention of man all over the world. Because of their usefulness to mankind and characteristic appearance, they occupy a position of primacy among all other groups of plants. In India, the palms are represented by about 92 species and 21 genera in the wild and semi wild state beside two species i.e. *Cocos nucifera* and *Areca catechu* which are extensively cultivated (Basu & Chakraverty, 1994). Barring a few species, the palms are predominant in peninsular India, North-eastern India and Andaman & Nicobar islands. The genera, like *Areca, Pinanga, Calamus, Bentinckia, Caryota* and *Corypha* are among the conspicuous palm genera in peninsular India and the genus *Calamus* is most dominant. The genus *Phoenix* is extensive in the deciduous forests, while *Borassus flabellifer* is quite conspicuous along the coastal plains. *Hyphaene dichotoma* and *Bentinckia condapanna* are endemic to Western ghats. Similarly, the most widespread genera of palms in eastern and North-eastern India are *Calamus, Daemonorops, Plectocomia, Arenga, Areca, Wallichia, Caryota, Phoenix, Livistona, Licuala, Pinanga*. *Cocos nucifera* and *Areca catechu* are cultivated in the plains. In Andaman and Nicobar islands, palm genera *Areca, Bentinckia, Calamus, Daemonorops, Licuala, Corypha, Phoenix, Pinanga* are common in all types of forests. The genus *Korthalsia* is confined to these islands. *Phoenix sylvestris* is dominant in semiarid western parts of India and Gangetic plains. In the estuarine mangrove forests, *Nypa fruticans* and *Phoenix paludosa* occur as pure stands. *Trachycarpus takil*, a rare and cold tolerant palm is confined to Kumaon hills in Uttaranchal only (Singh *et al.*, 1995).

Orchids

Orchids having showy and long lasting flowers are a well known group of plants belonging to the family Orchidaceae. In India, the group is represented by about 1229 species under 184 genera (Karthikeyan, 2000). Of these *ca* 657 species in 86 genera are epiphytes and 484 species in 82 genera are terrestrial. Two genera, i.e. *Cymbidium* and *Liparis* have both terrestrial and epiphytic species. A few genera such as *Aerides, Bulbophyllum* and *Coelogyne* have some species with lithophytic habit.

Some genera like *Galeola, Cyrtosia, Aphyllorchis*, etc. are saprophytic. The genus *Dendrobium* with *ca* 102 species is the largest genus followed by *Bulbophyllum* (97), *Habenaria* (72), *Eria* (53), *Oberonia* (53) and *Liparis* (45). The Himalaya, particularly the eastern Himalaya (Sikkim and Arunachal Pradesh) is the richest region having *ca* 876 species in 151 genera followed by Western Ghats with *ca* 315 species in 75 genera. *Herminium monorchis* recorded from Sikkim at 4500 m is the highest altitudinal range limit for orchid distribuiton in India. The genera, like *Didiciea, Risleya* and *Bulleyia* have special preference for high altitudes. The orchid trade is a lucrative industry in many western and some of the south Asian countries, like Singapore and Thailand. But this natural resource is largely untaped in our country.

Others

The diversity in Rhododendrons which have *ca* 97 taxa in India, with all but one species occurring in the Himalaya, is very interesting. Similarly, the diversity in the Hedychiums with *ca* 40 species, Primulas with 135 species, *Pedicularis* with 95 species, *Corydalis* with 53 species, *Geranium* with 32 species, *Impatiens* with 205 speciès and *Ficus* with 100 species is highly appreciable (Rao & Hajra, 1986; Singh & Hajra, 1996).

Plant curiosities

The rich and diverse flora of India, harbours many biologically interesting and curious plants. The flora represents *ca* 40 species of insectivourous plants belonging to families Lentibulariaceae (*ca* 36 spp.), Droseraceae (3 spp.) and Nepenthaceae (1 sp.). Over 130 species are parasitic and belong mainly to families Orobanchaceae (*ca* 54 spp.), Loranthaceae (46 spp.), Santalaceae (10 spp.), Cuscutaceae (12 spp.), Balanophoraceae (6 spp.) and Rafflesiaceae (2 spp.). Among some rare and interesting root parasites, mention may be made of *Sapria himalayana*, the largest root parasite and *Mitrastemon yamamotoi* with only the flowers representing the whole plant and projecting from the roots of the host plant. *Rhopalocnemis phalloides, Balanophora dioica, Boschniakia himalaica* and *Agenetia indica* are some other root parasites of great scientific interest. Similarly, species of *Cuscuta, Viscum, Loranthes and Arceuthobium* are dominant stem parasites. There are about 7 species which grow saprophytically and the interesting among them are *Monotropa uniflora, Epipogeum roseum* and *Galeola falconeri*, the last being the tallest orchid in India. *Christolea himalayensis*, occurring at 6300, shows the highest altitude record for a flowering plant.

Primitive flowering plants

Indian region, particularly the Noth-eastern states, has a large number of primitive flowering plants, rendering this region as the cradle of flowering plants (Takhtajan, 1969). Some dominant genera of primitive flowering plants are *Magnolia, Manglietia, Michelia, Talauma* (Magnoliaceae); *Tetracentron* (Tetracentraceae); *Alphonsea, Annona, Desmos, Fissistigma, Melodorum, Miliusa, Orophea, Unona, Uvaria* (Annonaceae); *Knema, Myristica* (Myristicaceae); *Cryptocarya, Dehaasia, Endiondra, Lindera, Litsea, Machilus, Persea, Phoebe* (Lauraceae); *Chloranthus, Sarcandra* (Chloranthaceae).

DIVERSITY UNDER EXTREME ENVIRONMENTS

Unlike many bacteria and fungi, flowering plants cannot tolerate extremes of high temperature but do occur under extremely hostile surroundings such as hot and cold deserts, water logged conditions, coastal habitats, metalliferous soils and spoil heaps of old mines.

Hot deserts

The desert environment is characterised by high atmospheric temperature, low and erratic rainfall, high wind velocity, low relative humidity, high evaporation and lack of perennial water resources. All these factors are responsbile for scanty vegetation. A common morphological feature of desert plants is succulence of above ground parts and special structural modifications (thick epidermis, sunken stomata), reduction in size or absence of leaves and enormous extent of root development. The common shrubs growing in these areas are *Calligonum polygonoides, Commiphora wightii, Clerodendrum phlomidis, Haloxylon salicornicum, Lycium barbatum, Ziziphus nummularia, Tecomella undulata*. Only few tree species, like *Prosopis cineraria, Salvadora oleoides, Acacia senegal*, etc. are found growing in these areas.

Some other characteristic low herbaceous plants growing in such environment are *Indigofera argentea, Melhania denhamii* and species of *Citrullus*. On some low sandy dunes, there are also some characteristic associations of *Crotalaria burhia*, *Leptadenia pyrotechnica* and *Aerva* spp.

Cold deserts

The cold deserts of North-West Himalayan ranges characterized by extremely low temperature (-45°C) and less precipitation (10-70 mm), extend from 4500 m to 6000 m and are covered with sparse and mostly herbaceous to bushy species. Over 500 species belonging to genera, like *Arenaria*, *Thylacospermum*, *Nepeta*, *Schizonepeta*, *Pedicularis*, *Primula*, *Tanacetum*, *Caragana*, *Cicer*, *Stipa*, *Carex*, *Kobresia*, *Elymus*, *Hordeum*, *Acantholimon*, etc. are found growing in these areas of trans Himalayan belt. These plants survive the adverse ecological conditions by special adaptations. Species of *Androsace*, *Saxifraga*, *Rhodiola*, *Thylacospermum* and *Arenaria* form dense, spherical globose, cushions where several hundred plants aggregate together. One cushion of *Arenaria* or *Thylacospermum* measuring 30 cm takes as many as 150 years to grow. The species, like *Saussurea gossypiphora* look like snow balls due to dense, white and woolly hairs which cover the entire plant and protect it from cold wind and snow and keep them warm. The dense woolly hairs act as a sort of thermal insulation. The "hot house" plants, like *Rheum nobile* and *Saussurea obvallata*, have their inflorescence sheltered by leafy bracts that can be compared to glasses of a hot house. The flowers open inside the bracts where the insects also take shelter for warmth and at the same time pollinate the flower.

Some cold desert plants like, *Lancea tibetica*, *Gentianella thomsonii*, *Taraxacum bicolor* are significantly reduced and often barely 1-2 cm tall with a solitary flower, whereas the underground tap root in these species may be up to 30 cm deep. *Thermopsis inflata*, *Microula tibetica*, *Hedinia tibetica*, etc. have a deep penetrating permanent rootstock from which annual branches are produced with leaves and flowers in clusters just above the stones or rocks. A few woody plants found in the cold arid region belong to *Caragana versicolor*, *Hippophae rhamnoides*, *Myricaria rosea* and *Lonicera hispida* forming dense bushes with woody branches barely exceeding 30 cm. The only naturally occurring tree species found in this region is *Juniperus macropoda*, which grows in Lahaul area.

Salinity

In the salt desert of the Rann of Kutch where the aridity caused by low rainfall and extremely high or low temperature is compounded by high salinity in the soil due to seasonal ingression of sea, resulting in a severe problem in absorption of water and curtailing productivity. The plants that survive high salinity are called halophytes. Among these, members of Chenopodiaceae are characteristic, especially the species of *Atriplex*, collectively called saltbush and show high accumulation of ions against concentration gradient. The vegetation here consists of typical salt, marsh-salt bush community of halophytes. Some species typical of such habitat are *Cressa cretica, Haloxylon recurvum, H. salicornicum, Tamarix indica, Salvadora persica, Suaeda fruticosa, Atriplex* spp., *Capparis decidua, Juncus maritimus* and *Lycium barbarum*. Several useful species have also been introduced to Indian saline soils for meeting fodder and fuel requirements and stabilizing mineral soils.

Mangroves are the plants that inhabit coastal regions and estuaries and have become adapted to survive under inundated salt water conditions. Some are viviparous and shed their germinated fruits in tidal waters to facilitate their establishment. Physiologically, mangroves not only face the problem of absorption of water from highly saline conditions but suffer from insufficiency of oxygen in their roots. The angiospermous mangroves which are ecologically very important as they prevent coastal erosion, produce characteristic vertical roots which grow in a negatively geotropical manner above the water level and serve the purpose of aeration (Pneumatophores). India represents about 7 per cent of the world's mangroves and 80 per cent of them are confined to Sunderbans and Andaman & Nicobar islands. The remaining are scattered in the coastal areas of Andhra Pradesh, Tamil Nadu, Orissa, Maharashtra, Gujarat, Goa and Karnataka. Some of the dominant mangrove species are *Rhizophora mucronata, R. apiculata, R. stylosa, Bruguiera gymnorrhiza, B. parviflora, Ceriops tagal, Avicennia marina, A. officinalis, Sonneratia* spp., *Heritiera fomes, Lumnitzera* spp., *Xylocarpus* spp., etc. The shrubby *Aegialitis rotundifolia* and *Acanthus ilicifolius* are common on poor saline plains. The herbaceous succulent halophytes are represented by *Suaeda brachiata, Sesuvium portulacastrum, Salicornia brachiata* and *Aegiceras corniculatus*. *Nypa fruticans* and *Phoenix paludosa* are among the characteristic mangrove palms.

Aquatic Plants

Over abundance of water leads to several problems in plants. Yet about 2 per cent of all flowering plants known in the world live in water and more than 50 percent of these are represented in the Indian subcontinent (Lavania *et al*, 1990). In aquatic plants, the photosynthetically active parts are submerged in water or float on the surface permanently or at least for several months each year (Cook *et al.*, 1974). Notable modifications of aquatic plants include a poor root system, high reduction in mechanical tissues, development of large air spaces and a high propensity for vegetative propagation.

The Indian aquatic plants belong mostly to families Alismataceae (8 spp.), Hydrocharitaceae (13 spp.), Najadaceae (7 spp.) Nymphaeaceae (7 spp.), Podostemaceae (24 spp.), Lemnaceae (14 spp.), Ceratophyllaceae (3 spp.), Potamogetonaceae (18 spp.). The Indian aquatic flora is highly diversified varying from free aquatic forms (*Eichhornia crassipes, Pistia stratiotes, Wolffia microscopica, W. globosa,* etc.); Rooted aquatics with their foliage floating (*Nymphaea nouchali, N. stellata, Euryale ferox,* etc.); submerged aquatics (*Vallisneria spiralis, Hydrilla verticillata, Najas graminea,* etc.) and emergent aquatics (*Scirpus maritimus, Cyperus articulatus, Sagittaria trifolia,* etc.) and Marsh plants (*Ranunculus scleratus, Hydrolea zeylanica, Panicum paludosum,* etc.). The aquatic flora play a great role as a water purifier by absorbing heavy metals, e.g. *Ceratophyllum demersum* (Chromium), *Bacopa monnierii* (Copper and Cadmium), etc. *Limosella aquatica, Hippuris vulgaris,* etc. occur in subalpine-alpine lakes.

Metallophytes

Some plants accumulate a wide spectrum of non-essential elements at concentrations several hundered fold higher than in the soil or water. Plant communities and populations of individual species growing on metalliferous soil, mine tailings and abandoned mines have been identified. It is possible to associate indicator species that reflect the concentration of a metal in the soil. This branch has been helpful in prospecting for minerals, bioremediation and recovery of contaminated soil into productive lands.

Some species of flowering plants that grow on metalliferous soils accumulate large amounts of metals in their roots and reflect the levels of metal present in the soil (indicators). Species, like *Impatiens balsamina, Vernonia cinerea, Hyptis suaveolens, Holarrhena antidysenterica, Croton roxburghii* for copper and *Astragalus* spp. are proven indicators for Uranium (Arey, 1977; Venkatesh, 1964, 1966). Species which accumulate metals in the above ground parts, like leaves far in excess of that present in the soil are called 'Hyperaccumulators' and are of tremendous importance. For example, species, like *Talinum portulacifolium, Tephrosia villosa, Rhus mysorensis, Bouchea marrubifolia* have been identified to accumulate Copper (Tiagi & Aery, 1986). Similarly, the species like *Impatiens balsamina, Triumfetta pentandra, Crotalaria linifolia, Kickxia ramosissima, Celosia argentea, Lindenbergia muraria,* and *Bidens biternata* constitute important vegetational units and show the highest consistency and fidelity on soil with Zinc deposits (Tiagi & Aery, 1985). *Waltheria indica* (Copper and Zinc mineralization), *Holarrhena antidysenterica* and *Nyctanthes arbor-tristis* (Copper, Lead, Zinc mineralization) and *Cometes surattensis, Casearia elliptica* and *Grewia tiliaefolia* (Lead mineralization) also exhibit high concentration of many base elements (Gandhi & Aswathanarayana, 1975; Tiagi & Aery, 1981; Ravikiran & Bedi, 1984). The list of hyperaccumulating plants is growing steadily. Among the hyperaccumulating plants, species of Brassicaceae are predominant in the temperate regions, whereas the Euphorbiaceae (*Sebertia acuminata*) represents their counter parts in the tropics (Baker & Brooks, 1989).

HIGH IMPACT SPECIES

Keystone species

The presence of keystone taxa (Paine, 1969) promotes the presence of a number of other taxa in a biological community. The concept which was restricted to predators of competitive dominance in a community has in a recent review (Power & Mills, 1995) been expanded to include any species with an impact on its community or ecosystem. For example, the presence of *Ficus* species in the tropical forests, providing fruit to birds and mammals during the pinch period, qualifies them to be called keystone species. However, given our very limited knowledge of community interactions, it is doubtful, if we can effectively identify such keystone species in thousands of contexts in which they occur.

The central core of the keystone concept is that only one or a few species have uniquely important effects on the community or ecosystems by virtue of unique traits or attributes. Removal of a keystone species results in dramatic changes in the functional properties of the ecological system (e.g. changes in diversity, abundance, habitat structure, etc.).

Keystone species have been demonstrated from a wide variety of ecosystems, trophic levels and taxa, though their pivotal role can be appreciated only during their absence. Nevertheless, species of palms and fig trees maintain almost all the vertebrate frugivores in tropical rain forests during those few months of the year when other tree species are not in fruit. Similarly, species like *Syzygium cumini, Memecelon gracile, Cullenia exarillata, Olea dioica, Dillenia bracteata, Artocarpus heterophylla, Artocarpus hirsuta, Mangifera indica* also perform key functions in the tropical rain forests. Keystone species play crucial role in the conservation of biodiversity through key functions they perform in the ecosystem. *Flemingia vestita* which is a less known plant is grown in the mixed cropping systems in North-east India for its proteinaceous edible tuber. This legume species beside enriching the soil with nitrogen also provides a food supplement during lean seasons (Ramakrishnan, 1994; Ramakrishnan *et al.*, 1994). Similarly, dominant tree species, like *Engelhardtia spicata, Echinocarpus dasycarpus, Syzygium cumini, Drimycarpus racemosus* perform the key functions of nutrient conservation in the sacred groves of North-eastern India. Many species of bamboos (*Dendrocalamus hamiltonii, Bambusa tulda, B. khasiana*) and *Alnus nepalensis* are now known to play a key role in conservaiton of Nitrogen, Phosphorus and Potassium in the jhum fallows. Such species help in rehabilitating ecosystems (Ramakrishnan, 1992).

Exotic/invasive species

The great diversity in climate and microhabitats have favoured the establishment of a large number of alien weeds in India from all regions of the world particularly Mexico, South America, Tropical Africa and Eurasian regions. They were brought either as ornamentals and later became a part of Indian flora (*Lantana camara, Ageratum conyzoides, Eupatorium adenophorum, Tithonia tagetifolia, Jatropha gossypifolia, Opuntia elatior,* etc.) or as impurities with seeds of cultivated plants (*Stellaria media, Spergula arvensis, Sagina apetala, Anagallis* *arvensis, Convolvulus arvensis, Trigonella corniculata,* etc.). After primary establishment, they got spread to all parts as a result of deforestation, shifting agriculture, faulty pasturage, sale and introduction of impure seeds, construction of roads, railways and other developmental activities. The families, like Asteraceae, Amaranthaceae, Fabaceae, Malvaceae, Tiliaceae, Sterculiaceae, Rubiaceae, Acanthaceae, Euphorbiaceae, Lamiaceae, Scrophulariaceae, Cyperaceae and Poaceae are the dominant families in the Indian weed flora.

The Asteraceous weeds, like *Eupatorium* spp., *Parthenium hysterophorus, Mikania micrantha, Erigeron karvinskianus, Conyza bonariensis, Xanthium strumarium* and *Tridax procumbens,* in association with several other weeds, like *Amaranthus spinosus, Cassia tora, C. occidentalis, Cannabis sativa, Chenopodium ambrosioides, Euphorbia prostrata, Oxalis* spp. *Argemone mexicana, Lantana camara, Calotropis* spp. *Cyperus* spp. and several grasses have threatened the native vegetation in many parts of India. Recently introduced *Parthenium hysterophorus* has spread to all agricultural fields, fallows, railway and roadsides, forested and forest cleared areas. *Eupatorium odoratum* and *E. adenophorum* (Himalayan region and Western ghats), *Mikania micrantha* (forests in North-east) and *Croton bonplandianum* have also become established on Indian soil abundantly. Similarly, *Eichhornia crassipes, Pistia stratiotes* and others have posed a serious threat to native aquatic flora.

CONSERVATION FOCUS SPECIES

A large number of plant species are distributed in the different phytogeographic regions which flag conservation efforts. Broadly there are two general categories.

Umbrella/Flagship species

Umbrella species have large occupancy area and their sufficiently wide habitat requirements bring other species under protection. Flagship species are popular, charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action. Some examples of such species in Indian flora from Andaman & Nicobar Islands include *Dipterocarpus griffithii, D. turbinatus, Planchonia andamanica,* *Hopea odorata, Pterocarpus dalbergioides, Canarium euphyllum, Ailanthus kurzii,* etc.

Similarly, a few examples of such charistmatic species from Western Ghats are *Dipterocarpus indicus, Kingiodendron pinnatum, Cinnamomum malabaricum, Acrocarpus fraxinifolius, Diospyros assimilis, Vateria indica, Antiaris toxicaria, Humboldtia brunonis, Pterocarpus santalinus,* etc. Himalaya also abounds in a number of such species. Species, like *Artocarpus chasma, Dipterocarpus retusus, Shorea robusta, Schima wallichii, Exbucklandia populnea, Acer hookeri, Litsea thompsonii, Juglans regia, Quercus spicata, Rhododendron* and orchid species act as flagship/umbrella species in eastern Himalaya while the same is true for *Anogeissus latifolia, Bischofia javanica, Ougeinia oojeinensis, Pyrus pashia, Grewia oppositifolia, Holoptelea integrifolia, Aesculus indica, Juglans regia, Betula utilis,* all *Quercus* and *Rhododendron* spp. in western Himalaya.

Endemic Plants

Indian angiospermic flora is further characterized by high endemism, which is next to Australia only. The factors responsible for such a high degree of endemism are (i) The high mountainous barrier in the North, (ii) Oceanic barrier in the peninsular region and (iii) the extreme hot and arid conditions in the West, which have effectively prevented the migration or the intermingling of floristic elements of other regions. Besides, the humid tropical conditions met in the Western ghats and the North-eastern region have provided conducive conditions for the evolution of newer taxa, thus contributing to higher endemism in these regions. About 33 per cent of Indian flowering plants or *ca* 5725 species and 147 genera are regarded as endemic to India, largely occurring in the three geographical divisions i.e. The Himalayan, Peninsular and Andaman & Nicobar islands (Nayar, 1996). Acanthaceae and Poaceae have the highest number of endemic genera (17 each), whereas genera *Pteracanthus* and *Nilgirianthus* have highest number of endemic species (20 each). Of the 5725 endemic species, 3471 species, (*ca* 20 per cent) are found only in Himalaya, 2051 species (12 per cent) in the peninsular India and only 239 (1.5 per cent) in Andaman & Nicobar Islands. Out of the 147 endemic genera only 15 genera are widely distributed throughout the country, while 71 genera are endemic to Himalaya, 60 to Peninsular India (*Frerea, Hubbardia,* *Indopoa, Janakia, Nilgirianthus, Santapaua, Silentvalleya,* etc.) and one genus i.e. *Pubistylus* is endemic to Andaman & Nicobar islands. Of the 71 Himalayan endemic genera, 42 are confined to eastern Himalaya (*Biswarea, Bryocarpum, Jejosephia, Pauia,* etc.), while only 12 genera (*Arcyosperma, Kashmiria, Parrotiopsis,* etc.) are confined to western Himalaya. The endemic generic category of peninsular India, unlike Himalaya, is a diverse assemblage of herbs (Poaceae), shrubs or undershrubs (*Meteoromyrtus, Utleria*), climbers (*Decalepis*) and trees (*Erinocarpus, Otonephelium*). Endemic species are however increasingly recognised as being an important focus for conservation attention as the threats to the narrow ranged species become more apparent. Furthermore, endemic species are the major components of hot spots of diversity and form the basis of selective priority conservation areas. It is interesting to note that eastern Himalaya and Western Ghats, which are recognised as two of the eighteen hot spots in the world (Myers, 1988) contain approximately 4900 endemic species i.e. over 84 per cent of the endemic species in less than 4 per cent of the total land area of the country. Some of the important endemic flowering plants of India are given in Table V.

The eastern Himalaya, western Himalaya and Western Ghats are considered as three Mega centres of endemism in Indian flora. Apart from that, about 26 more areas in different parts of the country (Table VI) have also been recognised as microcentres of endemism. The families, like Berberidaceae (98 per cent), Saxifragaceae (92 per cent), Ranunculaceae (72 per cent) and Rosaceae (70 per cent), etc. are dominant in endemics in Himalaya while the families Melastomataceae (56 per cent), Balsaminaceae (44 per cent), Acanthaceae (38 per cent) and Asclepiadaceae (32 per cent) dominate in peninsular India.

Threatened species

The general term "threatened" has been used to refer to a species that is known to be rare, threatened by various causal factors or whose population is declining. The information on the status, habitat, ecology, distribution and conservation requirements of threatened species is provided by the series of Red Data Books published by Botanical Survey of India. Such an assessment is essential for setting up priorities of species conservation and also to monitor the effectiveness of recovery efforts.

Table V
Some endemic plants of India

Name	Family	Distribution
Aconitum balfouri	Ranunculaceae	Western Himalaya
Aconitum deinorrhizum	Ranunculaceae	Western Himalaya
Amomum fenzlii	Zingiberaceae	Nicobar Islands
Andrographis rothii	Acanthaceae	South Western Ghats
Argyrolobium album	Fabaceae	Himachal Pradesh
Astragalus kashmirensis	Fabaceae	Western Himalaya
Bentinckia condapanna	Arecaceae	Agasthimalai, Palni Hills
Bentinckia nicobarica	Arecaceae	Nicobar Islands
Buchanania barberi	Anacardiaceae	South Western Ghats
Cajanus cajanifolius	Leguminosae	Eastern Ghats
Christolea stewartii	Brassicaceae	Western Himalaya
Cinnamomum riparium	Lauraceae	South Western Ghats
Corallocarpus conocarpus	Cucurbitaceae	Rajasthan
Corydalis duthei	Fumariaceae	Western Himalaya

Name	Family	Distribution
Curcuma decipiens	Zingiberaceae	South Western Ghats
Cyathopus sikkimensis	Poaceae	Sikkim
Dalbergia coromandeliana	Leguminosae	Eastern Ghats
Dipterocarpus mannii	Dipterocarpaceae	Assam
Dipterocarpus andamanicus	Dipterocarpaceae	Andaman Islands
Elaeocarpus sikkimensis	Elaeocarpaceae	Sikkim
Elaeocarpus venustus	Elaeocarpaceae	South Western Ghats
Embelia microcalyx	Myrsinaceae	Nicobar Islands
Eugenia discifera	Myrtaceae	South Western Ghats
Frerea indica	Asclepiadaceae	North Western Ghats
Glochidion calocarpum	Euphorbiaceae	A. & N. Islands
Goniothalamus rhynchanthus	Annonaceae	South Western Ghats
Hardwickia binata	Leguminosae	Western Ghats
Hopea glabra	Dipterocarpaceae	South Western Ghats
Hubbardia heptaneuron	Poaceae	South Western Ghats
Litsea laevigata	Lauraceae	Western Himalaya
Mangifera andamanica	Anacardiaceae	Andaman Islands

Name	Family	Distribution
Microschoenus duthiei	Cyperaceae	Western Himalaya
Miliusa tectona	Annonaceae	A. & N. Islands
Mucuna minima	Leguminosae	Chotanagpur Plateau
Myristica connarioides	Myristicaceae	A & N Islands
Neolitsea andamanica	Lauraceae	A & N Islands
Nepenthes khasiana	Nepenthaceae	Jaintia and Garo Hills, Meghalaya
Nilgirianthus reticulatus	Acanthaceae	North Western Ghats
Orophea katschallica	Annonaceae	Andamans
Oryza indandamanica	Poaceae	A & N Islands
Oryza nivara	Poaceae	Maharashtra
Paphiopedilum druryi	Orchidaceae	Agasthimalai Hills, Kerala
Pauia belladona	Solanaceae	Arunachal Pradesh
Piper ootacamundense	Piperaceae	Nilgiri Hills
Poeciloneuron indicum	Clusiaceae	South Western Ghats
Prunus himalaica	Rosaceae	Sikkim
Pterocarpus santalinus	Leguminosae	South Eastern Ghats
Ranunculus palmatifidus	Ranunculaceae	Western Himalaya

Name	Family	Distribution
Rhamnus purpurea	Rhamnaceae	Western Himalaya
Rhododendron subansiriense	Ericaceae	Arunachal Pradesh
Rhododendron concinnoides	Ericaceae	Arunachal Pradesh
Shorea tumbuggaia	Dipterocarpaceae	Eastern Ghats
Sorghum deccanense	Poaceae	Maharashtra
Strychnos narcondamensis	Loganiaceae	Andaman Islands
Syzygium andamanicum	Myrtaceae	Andaman Islands
Syzygium travancoricum	Myrtaceae	South Western Ghats
Terminalia mannii	Combretaceae	Nicobar Islands
Trachycarpus takil	Arecaceae	Kumaon hills, U.P.
Trichosanthes anamalaiensis	Cucurbitaceae	South Western Ghats
Trilobachne cookei	Poaceae	Central Western Ghats
Vanilla andamanica	Orchidaceae	Andaman Islands
Xanthophyllum burkillii	Xanthophyllaceae	Arunachal Pradesh

Table VI
Microcentres of endemic plants in India

Karakoram and Ladakh of Kashmir Himalaya
Kumaon-Garhwal Himalaya
Siwaliks
Terai
Sikkim Himalaya
Arunachal Pradesh of Eastern Himalaya
Lushai hills
Tura-Khasi hills
Aravalli hills
Chotanagpur plateau
Panchmarhi-Satpura ranges
Simlipal and Jeypore hills
Bastar and Koraput hills
Visakhapatnam hills and Araku Valley
Tirupati-Cuddappa hills
Marathwada hills
Saurashtra-Kutch
Mahabaleshwar-Khandala ranges of Western Ghats
Agumbe-Phonda ranges of Western Ghats
Ratnagiri and Kolaba ranges of Western Ghats
Nilgiris, Silent Valley and Wyanad of Western Ghats
Anamalais of Western Ghats
Palni-Yercaud
Kalakad and Agastyamalai hills of Western Ghats
Andaman Islands
Great Nicobar Islands

The rich diversity of flowering plants in India, highlighted in the preceding pages is however not exhaustive as over 30 per cent of the area of our country, including that in the Himalaya, Western Ghats and Andaman & Nicobar islands, still remain to be floristically explored and inventorised. This is fully borne out by the fact that after the monumental *Flora of British India* by Sir. J.D. Hooker (1872-1897), over 2500 taxa, either new to science or new to the present political boundary of India, including a few dozens of new genera and two families, i.e. Hydatellaceae and Clethraceae have been added to Indian flowering plants only (Sharma & Singh, 2001). On the other hand, a number of species today are under considerable degree of threat due to various factors, both natural and man-made. While natural causes including factors, like natural calamities, natural competetion, biological imparity of a species, etc. have contributed to some extent towards the depletion of certain species e.g. *Eremostachys superba, Frerea indica,* it is the man-made threats, like clearance of prime forests for agriculture, mining, urbanisation, industrialisation, grazing, over-exploitation of components of floristic diversity and introduction of alien species which have severely threatened many of our wild species. It is estimated that while *ca* 26106 plant species are globally threatened (WCMC, 1992), at least 1500-1700 species of flowering plants in India are threatened with extinction. About 17 species, like *Coelogyne treutleri, Pleione lagenaria, Carex repanda, Hedychium marginatum, Sterculia khasiana* (from eastern Himalaya and N.E. India); *Microschoenus duthiei* (from western Himalaya); *Ophiorrhiza brunonis, Wendlandia angustifolia* (from South India); and *Psychotria tylophora* (from Andaman & Nicobar Islands), etc., have become extinct, while another 45 species are also possibly extinct as all attempts to relocate them for past hundred years have failed so far (Jain & Sastry, 1984; Nayar & Sastry, 1987, 1988, 1990). Some critically threatened flowering plants in Indian flora are given in Table VII.

Table VII
Some critically threatened plants of India

Name	Family	Distribution
Abutilon ranadei	Malvaceae	WG
Aconitum balfouri	Ranunculaceae	WH
Aconitum chasmanthum	Ranunculaceae	WH
Aconitum deinorrhizum	Ranunculaceae	WH
Aconitum falconeri	Ranunculaceae	WH
Aconitum ferox	Ranunculaceae	NE
Aconitum violaceum	Ranunculaceae	WH

Name	Family	Distribution
Acranthera tomentosa	Rubiaceae	NE
Aquilaria agallocha	Thymelaeaceae	NE
Aristolochia griffithii	Aristolochiaceae	NE
Atropa acuminata	Solanaceae	WH
Beilschmiedia pseudomicroptera	Lauraceae	NE
Bentinckia condapanna	Arecaceae	WG
Bentinckia nicobarica	Arecaceae	A & N
Berberis aristata	Berberidaceae	WH
Buchanania platyneura	Anacardiaceae	A & N
Calamus delaceratus	Arecaceae	A & N
Calanthe whiteana	Orchidaceae	NE
Ceropegia fantastica	Asclepiadaceae	WG
Ceropegia huberi	Asclepiadaceae	WG
Ceropegia lawii	Asclepiadaceae	WG
Ceropegia maccannii	Asclepiadaceae	WG
Ceropegia panchganiensis	Asclepiadaceae	WG
Ceropegia pusilla	Asclepiadaceae	WG
Ceropegia sahyadrica	Asclepiadaceae	WG
Coptis teeta	Ranunculaceae	NE
Corypha macropoda	Arecaceae	A & N
Crinum brachynema	Amaryllidaceae	WG
Crinum eleonorae	Amaryllidaceae	WG
Cryptocoryne cognata	Araceae	WG
Cymbidium hookerianum	Orchidaceae	NE
Cypripedium cordigerum	Orchidaceae	WH
Cypripedium elegans	Orchidaceae	Himalaya
Cypripedium himalaicum	Orchidaceae	Himalaya
Cypripedium tibeticum	Orchidaceae	EH
Dactylorhiza hatagirea	Orchidaceae	WH

Name	Family	Distribution
Dendrobium incurvum	Orchidaceae	A & N
Dioscorea deltoidea	Dioscoreaceae	WH
Dipteris wallichii	Dipteridaceae	NE
Eremostachys superba	Lamiaceae	WH
Farsetia macrantha	Brassicaceae	WG
Gentiana kurroo	Gentianaceae	WH
Habenaria andamanica	Orchidaceae	A & N
Jurinea dolomiaea	Asteraceae	WH
Kaempferia siphonantha	Zingiberaceae	A & N
Korthalsia rogersii	Arecaceae	A & N
Livistona jenkinsiana	Arecaceae	NE
Mangifera andamanica	Anacardiaceae	A & N
Naravelia laurifolia	Ranunculaceae	A & N
Nardostachys grandiflora	Valerianaceae	NE, WH
Panax pseudo-ginseng	Araliaceae	NE
Paphiopedilum druryi	Orchidaceae	NE, WG
Paphiopedilum fairieanum	Orchidaceae	EH
Paphiopedilum hirsutissimum	Orchidaceae	EH, NE
Paphiopedilum insigne	Orchidaceae	NE
Paphiopedilum spicerianum	Orchidaceae	NE
Paphiopedilum venustum	Orchidaceae	NE
Paphiopedilum villosum	Orchidaceae	NE
Paphiopedilum wardii	Orchidaceae	EH
Picrorrhiza kurrooa	Scrophulariaceae	WH
Podophyllum hexandrum	Podophyllaceae	NE, WH
Psilostachys sericea	Amaranthaceae	WG
Psychotria pendula	Rubiaceae	A & N
Pterocarpus santalinus	Fabaceae	WG
Pycnarrhena longifolia	Menispermaceae	A & N

Name	Family	Distribution
Renanthera imshootiana	Orchidaceae	NE
Rheum nobile	Polygonaceae	NE, WH
Sapria himalayana	Rafflesiaceae	NE
Saussurea costus	Asteraceae	WH
Sesbania concolor	Fabaceae	WG
Shorea tumbuggaia	Dipterocarpaceae	WG
Swertia chirayita	Gentianaceae	NE, WH
Terminalia pallida	Combretaceae	WG
Tetracentron sinense var. himalense	Tetracentraceae	NE
Tephrosia axillaris	Fabaceae	WG
Vanda coerulea	Orchidaceae	NE, WH

NE = North eastern India including eastern Himalaya,; WH = Western Himalaya; WG = Western Ghats; A & N = Andaman & Nicobar islands

REFERENCES

Acry, N.C. 1977. Studies on the Geobotany of Zawar Mines. *Geobios* **4**: 225-228.

Anonymous. (1948-1976). *The Wealth of India* I-XI. CSIR, New Delhi.

Arora, R.K. 1991. Plant diversity in Indian gene centre. In: Paroda, R.S. and R.K. Arora (eds.) *Plant genetic resources : Conservation and Management.* 25-54. IBPGR, New Delhi.

Arora, R.K. and R. Nayar 1984. Wild relatives of crop plants in India. *NBPGR Sci. Monograph* **7**: 90.

Baker, J.M. and R.R. Brooks 1988. Botanical exploration for minerals in humid tropics. *Journ. Biogeography* **15**: 221-229.

Basu, S.K. and R.K. Chakraverty 1994. *A manual of cultivated palms in India.* BSI, Calcutta.

Bisby, S.C, N.J. Collar, M.J. Crossby, M.F. Heath, C. Imboeden, J.H. Johnson, A.J. Land, A.J. Stattessfied and S.J. Thisgood (eds.) 1992. *Putting Biodiversity on the map : Priority areas for Global conservation.* ICBP, Cambridge, England.

Biswas, S. 1988. Studies on Bamboo distribution in North-eastern region of India. *Indian For.* **114**: 514-531.

Cook, C.D., B.J. Gut, E.M. Rix, J. Schneller and M. Seitz 1974. *Water plants of the world.* W. Junk, The Hague.

Gandhi, S.M. and U. Aswathanarayana 1975. A possible base-metal indicator plant from Mamandur, South India. *Jour. Geochem. Explo.* **4**: 247-250.

Groombridge, B. (ed.) 1992. *Global Biodiversity status of Earth's living resources.* WCMC, Chapman & Hall, London.

Hajra, P.K., R.R. Rao, D.K. Singh and B.P. Uniyal (eds.) 1995a. *Flora of India* 12. (*Asteraceae : Anthemidae Heliantheae*). **BSI**, Calcutta.

Hajra, P.K., R.R. Rao, D.K. Singh and B.P. Uniyal (eds.) 1995b. *Flora of India* 13. (*Asteraceae : Inuleae Vernonieae*). BSI, Calcutta.

Hajra, P.K., B.D. Sharma and M. Sanjappa (eds.) 1996. *Flora of India, Introductory volume,* Part-I. BSI, New Delhi.

Hajra, P.K., V.J. Nayar and P. Daniel (eds.) 1997. *Flora of India* 4. (*Malpighiaceae : Dichapetalaceae*). BSI, New Delhi.

Hooker, J.D. (1872-1897). *The Flora of British India.* vols. 1-7. London.

Jackson, N.E. 1994. Preservation of rice genes. *Nature* **371**: 470.

Jain, S.K. and A.R.K. Sastry (eds.) 1984. *Indian Plant Red Data Book-* I. BSI, Howrah.

Kamboj, V.P. 2000. Herbal Medicine. *Curr. Sci.* **78**(1): 35-38.

Karthikeyan, S., S.K. Jain, M.P. Nayar and M. Sanjappa 1989. *Florae Indicae Enumeratio : Monocotyledonae.* BSI, Calcutta.

Karthikeyan, S. 2000. A statistical analysis of flowering plants of India. In: Singh, N.P., D.K. Singh, P.K. Hajra and B.D. Sharma (eds.) *Flora of India, Introductory Volume.* Part-II. pp.201-217. BSI, New Delhi.

Krishnamurthy, T. 1993. *Minor Forest products of India.* New Delhi.

Lavania, G.S., S.C. Paliwal and B. Gopal 1990. Aquatic vegetation of Indian subcontinent In : Gopal, B. (ed.) *Ecology and management of aquatic vegetation in the Indian subcontinent.* pp. 29-76. Academic Press, London.

Mc Neely, J.A., K.R. Miller, W.V. Reid, R.A. Mittermeier and T.B. Werner (eds.) 1990. *Conserving the world's Biological Diversity.* IUCN, Switzerland.

Mudgal, V. and P.K. Hajra (eds.) 1997-1999. *Floristic Diversity and Conservation Strategies in India* I-III. Dehra Dun.

Naithani, H.B. 1990. *Flowering plants of India, Nepal & Bhutan.* Dehra Dun.

Nayar, M.P. 1996. *Hotspots of Endemic Plants of India, Nepal and Bhutan*. TBGRI, Thiruvananthapuram.

Nayar, M.P. and A.R.K. Sastry (eds.) 1987-1990. *Red Data Book of Indian Plants* I-III. BSI, Howrah.

Paine, R.T. 1969. A note on trophic complexity and community Stability. *Amer. Nat.* **103**: 91-93.

Powers, M.E. and L. Mills 1995. The keystone cops meet in Hilo. *Trends in Ecology and Evolution* **10**: 182-184.

Ramakrishnan, P.S. 1992. *Shifting Agriculture and sustainable Development of North Eastern India*. UNESCO MAB Series, Paris.

Ramakrishnan, P.S. 1994. The Jhum agroecosystem in North eastern India: a case study of the biological management of soils in a shifting agricultural system. In : Wooner, P.L. and M.J. Swift (eds.) *The Biological Management of tropical fertility*. pp. 189-207. U.K.

Ramakrishnan, P.S., A.N. Purohit, K.G. Saxena and K.S. Rao (eds.) 1994. *Himalayan Environment and Sustainable development*. INSA, New Delhi.

Rao, R.R. 1993. Floristic diversity of Eastern Himalaya a National Heritage for conservation In: Dhar, U. (ed.) *Himalayan Biodiversity Conservation Strategies*. pp. 133-151. Himviksas, Nainital.

Rao, R.R. 1994. *Biodiversity in India (Floristic Aspects)*. Dehra Dun.

Rao, R.R. and P.K. Hajra 1986. Biological diversity of the Eastern Himalayas in a conservation prespective. *Proc. Nat. Acad. Sc.* (Suppl.) : 103-125.

Ravikiran, M. and S.J. Bedi 1984. *Cometes surattensis* Burm. var. *ambajiensis* Bedi & Madala as an indicator of Copper- Lead - Zinc - mineralization. *Jour. Geochem. Explor.* **20**: 47-53.

Samaddar, U.P. and B. Roy 1997. *Additional Elements in Indian Flora* I. BSI, Calcutta.

Sathish Kumar, C. and K.S. Manilal 1994. *A Catalogue of Indian Orchids*. Dehra Dun.

Sharma, B.D. and N.P. Balakrishnan (eds.) 1993. *Flora of India* 2. (*Papaveraceae Caryophyllaceae*). BSI, New Delhi.

Sharma, B.D., N.P. Balakrishnan, R.R. Rao and P.K. Hajra (eds.) 1993. *Flora of India* 1. (*Ranunculaceae Bacidayceae*). BSI, New Delhi.

Sharma, B.D. and M. Sanjappa (eds.) 1993. *Flora of India* 3. (*Portulacaceae Ixonanthaceae*). BSI, New Delhi.

Sharma, J.R. and D.K. Singh 2001. Status of Plant Diversity in India : An overview. In: Roy, P.S., S. Singh and A.G. Toxopeus (eds.) *Biodiversity and Environment*. pp. 69-105. IIRS, Dehra Dun.

Singh, D.K. and P.K. Hajra 1996. Floristic Diversity. In: Gujral, G.S. and V. Sharma (eds.), *Changing perspectives of Biodiversity Status in Himalaya*. pp. 23-38. British Council Division, New Delhi.

Singh, D.K., S. Singh and S.K. Murti 1995. *Trachycarpus takil* Becc. (Arecaceae) a rare endemic palm of Kumaon Himalaya, India. *Indian J. For.* **18:** 332-336.

Singh, N.P., D.K. Singh, P.K. Hajra and B.D. Sharma (eds.) 2000. *Flora of India, Introductory Volume*, Part II. BSI, New Delhi.

Shiva, M.P. 1998. *Inventory of Forest Resources for Sustainable Management & Biodiversity Conservation*. New Delhi.

Takhtajan, A. 1969. *Flowering Plants, origin and dispersal*. Tr. Jeffery, Edinburgh.

Tiagi, Y.D. and N.C. Aery 1981. Biogeochemical studies in Zinc deposits area of Zawar mines, Rajasthan, India. *Proc. Inc. Nat. Sci. Acad.* **47:** 887.

Tiagi, Y.D. and N.C. Aery 1985. Plant indicators of heavy metals. *Proc. Symp. Biommitoring of state of Environment*. pp. 207-222. New Delhi.

Tiagi, Y.D. and N.C. Aery 1986. Biogeochemical studies at the Khetri copper deposits of Rajasthan, India. *Jour. Geochem. Explor.* **26**: 267-274.

Udvardy, M.D.F. 1975. *A classification of the biogeographical provinces of the World.* IUCN occasional papers 18. Morges, Switzerland.

Uniyal, B.P. and R. Mathur 1994. Monotypic genera of Angiosperms in Indian flora : need for conservation. *Bull. Bot. Surv. India* **36**: 169-177.

Vavilov, N.I. 1951. The origin, variation, immunity and breeding of cultivated plants. *Chron. Bot.* **13**: 1-364.

Venkatesh, V. 1964. Geobotanical methods of mineral prospecting in India. *Ind. Miner.* 18.

Venkatesh, V. 1966. Geobotany in mineral exploration. *Steel Mines Rev.* **6**: 3-5.

POACEAE

V.J. Nair
Sharmila Thomas

Poaceae undoubtedly form one of the most fascinating families of flowering plants exceeding all others in their paramount uses, variety and value of their products and in the number of individuals. Grasses and bamboos belong to this family. They form a natural homogeneous group of plants with remarkable diversity playing a significant role in the lives of human beings and animals. Grasses cover all conceivable habitats suitable for growth of plants, from sea level to an altitude of 5000 m or more and are found in deserts as well as alpine areas. They may be annuals or perennials, and range in size from our humble *Poa annua* of a few centimeters to the arboreal giants such as *Dendrocalamus* amongst the bamboos of the tropics measuring to a height of 25 m or more. Most grasses can tolerate long periods of drought. It is a very successful family in which the following three themes constantly recur : their adaptability to changeable environments; their ability to co-exist with grazing herbivores and man; and their possessing of a distinctive life form in which fidelity to a single architectural scheme is counterbalanced by the endless ingenuity of its variations (Clayton & Renvoize, 1986).

Bamboos form a distinct group of grasses with woody stems and culms. They occur in temperate and tropical regions of Asia as well as Central and South America. These are plants that prefer moist and shady conditions in forests or forest margins. They themselves also form forests. Most of the bamboos are monocarpic, flowering only once in their lifetime after a long span of life making the conventional use of floral characters unpracticable for their classification. Synchronous flowering of all the bamboos of a species within a region is another significant character of many species.

GRASSES AND GRASS-LIKE PLANTS

Juncaceae and Cyperaceae have some morphological similarities with grasses. However, grasses can be distinguished from species of these families by various characters. Poaceae has small, insignificant, microscopic perianth segments called lodicules, usually two in number and hidden by lemma and palea. Similarly, this family usually has an indehiscent, one-seeded fruit called caryopsis. Whereas, Juncaceae has six, conspicuous perianth segments and the fruit is a dehiscent capsule. Cyperaceae has flowers enclosed in a single bract, and usually three angled and solid stems. Here the ligules are frequently absent and the fruit usually is an achene and never a caryopsis. In grasses, on the other hand, the flower is enclosed in lemma and palea, the stems are cylindrical or flattened, usually hollow between the joints, the ligules nearly always present and the fruit usually a caryopsis. Clayton and Renvoize (1986) points out that the similarity between Poaceae and Cyperaceae is not a matter of kinship but is actually due to convergence.

AGROSTOLOGY IN INDIA

Rheede in his monumental work, *Hortus Malabaricus* (1678 - 1703) includes 20 plates of grasses. In Hooker's *Flora of British India* (1897), only 13 of these have been mentioned. Two of Rheede's illustrations are of bamboos. These are at present known by the names *Bambusa arundinacea* and *Ochlandra scriptoria.*

Grasses, like *Cynodon dactylon*, *Desmostachya bipinnata* and species of bamboos have been in use in religious ceremonies since long. The medicinal properties of *Cymbopogon* and *Vetiveria* are mentioned in some Indian works of 17th and 18th centuries.

Griffith (1834) described the grasses of jheels of Sylhet district (now in Bangladesh). This is one of the earliest works on the grasses of British India. Other important early contributions on Indian Agrostology include those of Symmonds (1886), Duthie (1883, 1886, 1888), Coldstream (1889) and Lisboa (1896). However, the greatest contribution of this period is the consolidated account on grasses available in *The Flora of British India* (Hooker, 1897). Various regional floras like *Bengal Plants* (Prain, 1903), *Flora of Bombay Presidency* (Cooke, 1908), *Botany of Bihar and Orissa* (Mooney, 1950) and *Flora of Madras Presidency* (Fischer, 1934) also contain excellent accounts on Poaceae of the respective areas. Blatter and McCann (1935) gave an account of *Bombay Grasses*. Bor (1940) is responsible for the account on grasses in the *Flora of Assam*. His major contribution, however, is the consolidated work, *Grasses of Burma, Ceylon, India and Pakistan*. His other important publications include revisionary accounts on *Aleuropus, Arundinella, Aristida, Cymbopogon,* *Digitaria* and *Hystrix*. Several other notable contributions on Indian grasses have appeared before and after the publication of Bor's work. Kapadia (1945), and Desai and Murthy (1950) published accounts on the grasses of Junagadh and Dharwar respectively. Raizada, Jain and Bharadwaj (1961, 1964) studied the grasses of Upper Gangetic Plains. Chowdhury's (1959, 1961) accounts are on the grasses of West Bengal. Other important recent works on grasses of India include, *Grasses of Marathwada* (Patunkar, 1980); *Grasses of Madhya Pradesh* (Roy, 1984); *Grasses of Maharashtra* (Deshpande & Singh, 1986); *Flora of Kerala Grasses* (Sreekumar & V.J. Nair, 1991); *Grasses of North-east Inidia* (Shukla, 1996) and *Grasses and Bamboos of India* (Maulik, 1997). Jain and associates (1967, 1970, 1972, 1975, 1984) made some important revisionary studies on *Cynodon, Oropetium, Manisuris, Arthraxon,* Garnotieae and Isachneae.

Muktesh Kumar (1993) gives an excellent review on the status of Bamboo Taxonomy in India. Roxburgh (1814) enumerated 7 species of bamboos. *Bambuseas Monographic Exponit* of Ruprecht (1839), containing information on 67 species in 9 genera, is one of the best known early revisions on this group. Munro's (1868) *Monograph of Bambusaceae* with 170 species in 20 genera gave a foundation to the present knowledge on this group. Camus (1913) authored yet another revision on this group of plants. Beddome (1873) and Kurz (1878) are some of the other early contributors on the taxonomy of bamboos of India. The detailed account on bamboos by Gamble (1896) remained the main source to determine the Indian bamboos till recently. However, two compilations on bamboos of our country with updated nomenclature have appeared recently : *A Monograph on Bamboos* (Tewari, 1992) and *Bamboos of India A compendium* (Seethalakshmi & Mukteshkumar, 1999).

THE GRASS PLANT

Habitat

Grasses are found in a wide variety of habitats. They cover vast regions of the globe and are cosmopolitan. They are absent only in regions that are too cold to support the growth of flowering plants. Some species are found in saline, nutrient poor or water-logged soil, while others have been known to adapt to large quantities of toxic metals such as Lead, Zinc, Copper or Nickel concentrated in soil. Some species, like *Spinifex littoreus, Halopyrum mucronatum* and *Holcolemma canaliculatum* prefer seashores, whereas for certain others like *Isachne fischeri* and *Poa alpina* high hills are the most suitable habitats. *Lasiurus sindicus* and *Dactyloctenium sindicum* are arid zone grasses. At the same time some grasses, like *Leersia hexandra*, *Panicum paludosum*, *Limnopoa meeboldii*, *Coix lacryma-jobi* and *Oryza rufipogon* form components of aquatic or marshy vegetation.

Some of the annuals growing in arctic and desert regions complete their life cycles within one or two months. Perennial habit, other than in short-lived perennials of some tropical genera and ramblers, can be recognized by the presence of shoot innovations. Most prennials flower every year. But monocarpic bamboos remain in vegetative condition for several years, and in certain cases this period can be even up to 150 years. After that they produce flowers and fruits (once in their life time) and die thereafter.

Morphology

Root, culm and sheath: The fibrous root system is relatively shallow, usually penetrating not more than 2 m and often less than 1 m (Troughton, 1957). Some grasses are stoloniferous or rhizomatous. In erect grasses, other than many bamboos, branching is usually restricted to lower nodes. Prostarte grasses branch and rebranch throughout and produce grassy mats on the ground. Two types of branching are seen extravaginal and intravaginal, the latter being the commonest. Culms may be hollow at the internodes but at times may be solid, especially in Chloridoideae and Panicoideae (Brown *et al.*, 1959). The leaf is usually with a striate, smooth, hairy or glabrous sheath. In some cases, like species of *Glyceria, Bromus* and *Festuca,* the sheath margins are connate in various degrees but normally these are free in most of the grasses. Leaf-blade is usually attached directly to the sheath but in a few cases, like *Spodiopogon* a petiole-like structure is evident. Culm sheaths, often with rudimentary lamina that are usually deciduous, form an important feature in bamboos. The general appearance, size, texture and shape of the culm sheaths and their blades afford good characters for identification. The ligule usually found at the junction of the sheath and blade is unique in that it is not homologous with any other organ (Philipson, 1935). Ligules can be membranous or in the form of a row of hairs or may be absent as in the case of some species of *Echinochloa*.

Inflorescence and spikelet: Inflorescence type is quite variable, ranging from an open contracted or spiciform panicle or a single raceme with spikelets on one side, opposite sides or all around the rhachis; to a panicle with racemes arranged digitally or scattered on an axis.

The unit of a grass inflorescence is a spikelet. The basic structure of a typical spikelet is very simple - a central axis called rhachila on which 2 empty glumes and many fertile glumes (lemma) are arranged distichously. Each lemma is opposed by a smaller glume-like structure called palea. Lemma and palea enclose a unit analogous to a floret, consisting of reduced perianth lobes called lodicules (usually 2 in number), stamens and ovary. Lodicules are supposed to force open the florets at the time of anthesis. Three lodicules are found in bamboos. In some grasses these may be rarely absent. Usually the number of stamens are 1 to 3 or it may be six in some bamboos. *Ochlandra* is exceptional with some species having as many as 50-120 stamens. Styles are usually 2, but in some cases, like *Pseudodanthonia* it may be three. *Duthiea, Zea* and *Nardus* have only one style each. Even though the grass spikelet has a standard form and has a basic simplicity, nature during the evolutionary process has added to, deleted from, and modified various components of it in various permutations and combinations to create a wide variety of forms. This has made the study of grasses an extremely interesting and challenging task.

Fruit: The grass fruit is usually a caryopsis in which the pericarp is thin and firmly adherent to the seed. But utricles with free soft pericarp and achenes with free hard pericarp are also rarely met with.

Pollination

Grasses are generally wind pollinated. Bews (1929) points out, "they (the grasses) are in many ways the most successful under modern conditions of all flowering plants and this is particularly interesting in view of the fact that they are wind pollinated" The grass flowers are small, drab and not fragrant, as they do not need to attract insect and bird pollinators, with some exceptions like cleistogamous flowers. However, bees and other insects have been observed feeding on pollen, but their contribution to pollination would appear to be very little (Bogdon, 1962). *Chrysopogon fulvus* is known to be visited by pollen collecting bees (Hole, 1911). *Cynodon dactylon* and species of *Urochloa* and *Setaria* are reported to be visited by bees. Grass pollen is the shortest lived among all Angiosperms and remains viable only for a few hours in open air and its effective pollination distances are measurable in tens of metres (Jones & Newel, 1946, 1948).

Dispersal

The dispersal unit or diaspore in Poaceae is more often a false fruit incorporating various parts of the spikelet or inflorescence (Clayton & Renvoize, 1986). Sometimes a caryopsis or very rarely a seed also form means of dispersal.

Most of the data on fruit dispersal is rather speculative and based on anecdotal observations. Still the adaptive significance of dispersal mechanism may give a clue to the understanding of diversity of grasses. Various extensive reviews on dispersal in plants include many examples of grasses (Ridley, 1930; Pijl, 1982; Howe & Smallwood, 1982; Kubitzki, 1983; Sorenso, 1986).

Many grasses have specialised mechanisms for dispersal. Some false fruits have awns that propel the fruit along the ground by hygroscopic flexing and coiling. Various other types of spikelet and inflorescence modifications also help in effective dispersal. Many grass diaspores are light, and as the grasses as a whole occupy windy open habitats, wind also form an important agent of dispersal.

Analysis of seed shadows (Harper, 1977) including those of grasses show that in almost all species most of the seeds are dispersed very close to the maternal plant, large number of which are wasted. Long distance dispersal, which is more significant for evolutionary changes, usually takes place through birds and aircrafts. In certain grasses insect dispersal is also noticed.

Many of the structures borne on diaspores namely awns, hairs, etc. readily catch on to or adhere to fur, clothing, skin or feathers of passing animals and birds promoting successful dispersal and establishment (Ridley, 1930). Grazing and browsing animals also ingest mature diaspores accidentally or intentionally along with the foliage. Blunt diaspores of species of genera, like *Panicum, Urochloa,* etc. pass through the digestive tracts of mammals and birds. Many of these escape destruction thus favouring effective dispersal. The beed-like swelling at the base of the diaspore of *Eriochloa* and rhachillar wings of *Ichnanthus* swells at maturity of caryopsis due to the production of abundant oil droplets and function as elaisome (lipid-containing diaspore appendage) which is used as food by ants. The small crest on the upper florets in *Cyrtococcum* also appears to be an elaisome. However, there is not much evidence to show whether ants feeding on elaisomes really effect any dispersal. In *Setaria verticillata* the retrorsely barbed bristles help in getting the diaspores dispersed by the passing animals. In *Spinifex littoreus* the white globular infructescence or the plant itself get detached from the stem or roots and readily get blown over the sand and even across water. Seeds are dropped in this way perhaps miles away from the parent plant and thus the plant spread along sandy coasts. Another method of dispersal also is reported in this plant. In this mode the female spikelets get detached from the spherical inflorescence and get attached to the pungent rhachis segment filled with aerenchyma. The pungent rhachis is presumed to aid the burial of the diaspore in the sand.

Origin

Grasses have very meagre fossil records, making information on their origin obscure. According to some authors, the broadly tropical distribution of their nearest living relatives like Joinvilleaceae, Flagellariaceae and Restionaceae suggests a tropical origin (Dahlgren & Rasmussen, 1983; Anton & Ciocucci, 1984). Thomasson (1980), in an excellent review of palaeoagrostology, reports that supposed grass macrofossils are of doubtful validity. Grass type pollen reported by some workers in all probability are referable to Restionaceae. Authentic records of grass pollen occurred in Palaeocene and Oligocene. There are records of occurrence of caryopsis and cuticle in Eocene (Daghlian, 1981). Non ruminent type of *Artiodactyla* appears in early Tertiary and various fragmentary evidences available suggest the existence of grasses during this period. Animals of Bovinae arose during Miocene and seem to have co-evolved with grasses. The discovery of fossil grass fruits under the tongue bone of Miocene Rhinoceros from the Great Plains of North America (Voorhies & Thomasson, 1979) suggests that the family Poaceae has been strongly influenced by herbivorous animals. Tsvelev (1983) considers the adaptation to wind pollination as a factor that considerably influenced earliest evolution and later differentiation of Poaceae.

GRASSES AND THE GRASSLANDS

One of the reasons for the great importance of the grass family is that it provides the grasslands which occupy a third of land's surface (Schantz, 1954). According to one estimate 3.9 per cent of the total area of our country is occupied by grasslands. At the state level this figure is as high as 13.3 per cent in Sikkim or as low as 1 per cent in other states of eastern India. The grasslands of India are of great diversity. These include semiarid grasslands of Deccan peninsula, water-logged grasslands of Terrai belt, the rolling shola grasslands of hilltops of Western Ghats and the high altitude temperate-alpine grasslands of Himalaya. Based mainly on species dominance the following major types of grasslands are recognized in our country.

Sehima - Dichanthium type of grasslands with grasses, like *Sehima nervosum*, *Heteropogon contortus*, *Dichanthium annulatum* and *Themeda quadrivalvis* as the key species is quite common in peninsular India.

In the Western ghats, *Chrysopogon Arundinella* and *Andropogon polyptychus - Eulalia phaeothrix* types are frequently seen. *Andropogon lividus*, *Arundinella purpurea*, *Arundinella setosa*, *Bothriochloa insculpta*, *Eragrostis nigra*, *Chrysopogon zeylanicus*, *Ischaemum indicum*, *Tripogon bromoides*, etc. are found in these types of grasslands. Nilgiris has a rare species *Eriochrysis rangacharii* which is an indicator of the presence of peaty undrained soil.

Dichanthium Cenchrus - Lasiurus type of grasslands are common in northern parts of Gujarat, Rajasthan, western Uttar Pradesh, Delhi and semiarid Punjab. This type has *Dichanthium annulatum*, *Cenchrus ciliaris*, *Cenchrus biflorus* and *Lasiurus sindicus* as its main components.

Phragmites Saccharum Imperata is an important category of grasslands in India, covering alluvial plains of West Bengal. The main species in this type are *Phragmites australis*, *Saccharum spontaneum*, *Imperata cylindrica* and *Desmostachya bipinnata*.

Themeda Arundinella Bothriochloa is another important type of grassland found in India. It is spread over northern plains to the outer humid mountains and in Assam, Manipur, West Bengal, Uttar Pradesh, Himachal Pradesh and Jammu & Kashmir. The main species of such grasslands are: *Themeda anathera*, *Arundinella bengalensis*, *Bothriochloa bladhii*, *B. pertusa* and *Heteropogon contortus*.

Temperate-alpine grasslands form a distinct and important group. They cover higher altitudes of Jammu & Kashmir, Uttar Pradesh, Himachal Pradesh, West Bengal, Sikkim and Arunachal Pradesh. The alpine and subalpine grasslands of Garhwal and Kumaon region are generally located in altitudes above 3500 m. In Kashmir they are locally known as "Margs" and are observed usually above the tree line and below the snow line and are dominated by grasses, like *Danthonia cachemyriana*, *Stipa orientalis*, *Agrostis munroana*, *Calamagrostis decora*, *Dactylis glomerata*, etc.

Clayton and Renvoize (1986) points out that the classical climax concept is difficult to be applied to grasslands as some form of disclimax usually operate thereby leaving the nature of the true climatic climax in doubt. According to them the most important moderating factors in a grassland ecosystem are fire, grazing and human interference.

DIVERSITY

From a numerical stand point, the family Poaceae is the third largest in the world genus-wise behind Asteraceae and Orchidaceae. When number of species is taken into consideration its place is fifth after Asteraceae, Orchidaceae, Leguminosae and Rubiaceae (Good, 1953). In India its position is first closely followed by Orchidaceae (1229 spp.), Leguminosae (1192 spp.), Asteraceae (800 spp.), Rubiaceae (616 spp.) and Cyperaceae (545 spp.). There is no unanimity of opinion regarding the characters, contents and names of subfamilies and tribes as well as the circumscription of some genera and species. This has resulted in some confusion on the numerical strength of the various taxa under this family. According to Clayton and Renvoize (1986) this family has about 10,000 species in the world under 651 genera, 40 tribes and 6 subfamilies.

Based on a recent estimate (Karthikeyan *et al.*, 1989) India has about 16,800 species of flowering plants of which about 1291 are grasses. Karthikeyan (*l.c.*) recognised 263 genera of grasses in India. In a recent work on grass genera of the world, Clayton and Renvoize (*l.c.*) do not recognise the separate status of some genera included by Karthikeyan *et al.*, like, *Anisolytron, Crithodium, Deyeuxia, Diectomis, Diplachne, Elytriga, Eremopogon, Euchlaena, Paracolpodium, Piptatherum, Pseudobrachiaria, Pseudopogonatherum, Robynsiochloa, Sclerostachya,* etc. Similarly the separate treatment in this work of some bamboo genera like *Chimonocalamus, Drepanostachyum, Himalayacalamus, Neomicrocalamus, Pleioblastus* and *Yushania* also does not find acceptance in Clayton and Renvoize's work. Holttum (1956) considers the bamboo genus *Oxytenanthera* to be monospecific restricted to Africa. Majumdar (in Karthikeyan *et al., l.c.*) transferred all Indian and Sri Lankan species treated under *Oxytenanthera* to a new genus *Pseudotenanthera,* which is a superfluous name for *Pseudoxytenanthera.* Clayton and Renvoize (*l.c.*) do not recognise both these genera and consider the species under them to belong either to *Gigantochloa* or *Dendrocalamus.* All these new concepts reduce the number of grass genera in India to 249. Out of these 12 genera, namely *Aira, Avena, Bouteloua, Cortaderia, Cynosurus, Hilaria, Holcus, Lagurus, Lamarckia, Secale, Sorghastrum* and *Trichloris* are represented in India by only cultivated species.

Table I shows the various Indian grass genera, their species-wise strength in the world and India and the number of endemic species of each genus in India. This also gives the percentage of Indian species to world species and endemic species in India to total Indian species for each genus.

These genera belong to 25 tribes. All the six subfamilies recognised by Clayton and Renvoize (*l.c.*) are represented in India.

There is some confusion about the number of species and genera of bamboos available in India. According to Mukteshkumar (1993) there are 136 species belonging to 21 genera. Majumdar (in Karthikeyan *et al., l.c.*) includes only about 100 species. The higher number given by Mukteshkumar (*l.c.*) may be due to inclusion of cultivated bamboos also. Majumdar (in Karthikeyan *et al., l.c.*) has also reduced some existing species names to synonymy. More than 50 per cent of the bamboo species in India are distributed in the North-east and Bengal. Peninsular India, W Himayalan foothills, North and central Indian plains and Andaman & Nicobar Islands are some of the other bamboo rich areas.

Table I
Indian Grass Genera - Number of species in world, in India, endemic species in India and their percentage

Names of genus	Species in world	Species in India	% Indian to world species	Endemic in India	% Endemic to total Indian species
1	2	3	4	5	6
Acrachne	4	3	75.00	2	56.70
Acroceras	19	3	33.30		
Aegilops	21	1	4.80		
Aeluropus	4	1	25.00		
Agropyron	15	2	13.30		
Agrostis	220	22(1)	10.00	7	31.30
Aira	8	(1)	12.50		
Alloteropsis	5	2	40.00		
Alopecurus	36	6	16.70		
Andropogon	100	7(2)	7.00	2	28.60
Anthoxanthum	18	4(1)	22.20	3	75.00

1	2	3	4	5	6
Apluda	1	1	100.00		
Apocopis	15	4	26.70	1	25.00
Aristida	250	10	4.00	3	30.00
Arrhenatherum	6	1	16.70		
Arthraxon	10	6	60.00		
Arundinaria	50	2	4.00		
Arundinella	50	20	40.00	12	60.00
Arundo	3	1	33.30		
Avena	25	(5)	20.00		
Axonopus	110	2	1.80		
Bambusa	120	18	19.00	6	33.30
Bhidea	2	2	100.00	2	100.00
Bothriochloa	25	14	56.00	8	57.00
Bouteloua	24	(3)	12.50		
Brachiaria	100	21	21.00	7	33.30
Brachypodium	16	2	12.50		

1	2	3	4	5	6
Briza	20	3	15.00		
Bromus	150	16	10.66		
Calamagrostis	85	9	10.58	1	11.10
Capillipedium	14	8	57.00	6	75.00
Castellia	1	1	100.00		
Catabrosa	2	1	50.00		
Catapodium	2	1	50.00		
Cenchrus	22	8	36.40	2	25.00
Centotheca	4	1	25.00		
Centropodia	4	1	25.00		
Chandrasekharania	1	1	100.00	1	100.00
Chimonobambusa	10	1	10.00		
Chionachne	7	2	28.60		
Chloris	55	9(1)	16.40	1	11.00
Chrysopogon	26	16	61.50	4	25.00
Cleistachne	1	1	100.00		

1	2	3	4	5	6
Coelachne	10	3	30.00	1	33.30
Coelachyrum	8	1	12.50		
Coelorhachis	21	3	14.30		
Coix	5	4	80.00		
Colpodium	19	4	21.00		
Cortaderia	24	(1)	4.17		
Crypsis	8	1	12.50		
Cyathopus	1	1	100.00	1	100.00
Cymbopogon	40	20	50.00	3	15.00
Cynodon	8	4	50.00		
Cynosurus	8	(2)	25.00		
Cyrtococcum	11	7	64.00	1	14.30
Dactylis	1	1	100.00		
Dactyloctenium	3	3	100.00		
Danthonia	20	2	10.00		
Danthonidium	2	1	50.00	1	100.00

1	2	3	4	5	6
Dendrocalamus	36	10	27.80	3	30.00
Deschampsia	40	2	5.00		
Desmostachya	1	1	100.00		
Deyeuxia	200	8	4.00	2	25.00
Dichaetaria	1	1	100.00		
Dichanthium	20	10	50.00	6	60.00
Digitaria	230	25(3)	11.00	2	18.00
Dignathia	5	1	20.00		
Dimeria	40	35	88.00	27	77.00
Dinebra	3	1	33.00		
Dinochloa	26	6	23.00	3	50.00
Duthiea	3	1	33.00		
Echinochloa	40	6(1)	15.00		
Ehrharta	35	1	2.86		
Eleusine	9	2	22.00		
Elymus	150	15	10.00		

1	2	3	4	5	6
Elionurus	15	1	6.67		
Elytrophorus	2	1	50.00		
Enneapogon	28	4	14.28		
Enteropogon	17	3	17.60	1	33.30
Eragrostiella	5	5	100.00	1	20.00
Eragrostis	350	30(6)	8.60	4	13.30
Eremochloa	9	1	11.10		
Eremopoa	4	2	50.00		
Eremopyrum	5	3	60.00		
Eriachne	40	1	2.50		
Eriochloa	30	2	6.60		
Eriochryisis	7	1	14.30	1	100.00
Euclasta	2	1	50.00	1	100.00
Eulalia	30	15	50.00	3	20.00
Eulaliopsis	2	2	100.00	1	50.00
Festuca	450	27	6.00	5	18.50

1	2	3	4	5	6
Garnotia	20	10	50.00	3	30.00
Germainia	9	1	11.00		
Gigantochloa	15	3	20.00		
Glyceria	40	2	5.00		
Glyphochloa	8	8	100.00	8	100.00
Gymnopogon	15	1	6.60		
Hackelochloa	2	2	100.00		
Halopyrum	1	1	100.00		
Helictotrichon	100	3(1)	3.00	2	66.70
Hemarthria	12	5	41.67	1	20.00
Hemisorghum	2	1	50.00		
Heteropholis	5	1	20.00		
Heteropogon	6	6	100.00	3	50.00
Hierochloe	30	3	10.00	1	33.30
Hilaria	9	(1)	11.00		
Holcolemma	4	1	25.00		

1	2	3	4	5	6
Holcus	6	(2)	33.33		
Hordeum	40	5(2)	12.50		
Hubbardia	1	1	100.00	1	100.00
Hygroryza	1	1	100.00		
Hymenachne	5	2	40.00	1	50.00
Hyparrhenia	55	3(1)	5.45	1	33.30
Hystrix	9	1	11.00		
Ichnanthus	33	1	3.00		
Imperata	8	1	12.50		
Indopoa	1	1	100.00	1	100.00
Isachne	100	30	30.00	18	60.00
Ischaemum	70	46	65.70	35	76.00
Iseilema	20	6	30.00	4	66.67
Jansenella	1	1	100.00		
Kengia	10	2	20.00		
Koeleria	35	2	5.70		

1	2	3	4	5	6
Lagurus	1	(1)	100.00		
Lamarckia	1	(1)	100.00		
Lasiurus	1	1	100.00		
Leersia	18	2	11.00		
Leptaspis	5	1	20.00		
Leptochloa	40	6	15.00		
Leptothrium	2	1	50.00		
Lepturus	8	2	25.00		
Leymus	40	1	2.50		
Limnopoa	1	1	100.00	1	100.00
Littledalea	3	1	33.30		
Lolium	8	5	62.50		
Lophatherum	2	1	50.00		
Lopholepis	1	1	100.00		
Lophopogon	3	3	100.00	3	100.00
Lygeum	1	1	100.00		

1	2	3	4	5	6
Manisuris	1	1	100.00	1	100.00
Melanocenchris	3	3	100.00		
Melica	80	5	6.25		
Melinis	11	1	9.00		
Melocanna	2	2	100.00		
Microcalamus	1	1	100.00		
Microchloa	6	2	33.30		
Microstegium	15	6	40.00	2	33.30
Milium	4	1	25.00		
Miscanthus	20	5	25.00	1	20.00
Mnesithea	5	5	100.00	1	20.00
Muhlenbergia	160	3(1)	1.87		
Myriostachya	1	1	100.00		
Neyraudia	2	2	100.00		
Ochlandra	11	10	90.90	10	100.00
Ochthochloa	1	1	100.00		

1	2	3	4	5	6
Ophiuros	5	4	80.00	1	25.00
Oplismenus	5	3	60.00		
Orinus	2	1	50.00		
Oropetium	6	3	50.00	2	66.70
Oryza	20	8	40.00	3	37.50
Oryzopsis	35	6	17.00		
Ottochloa	4	1	25.00		
Oxytenanthera	2	1	50.00		
Panicum	480	34	7.00	9	26.50
Parahyparrhenia	5	1	20.00	1	100.00
Parapholis	6	1	16.67		
Paspalidium	40	3	7.50		
Paspalum	330	7(3)	2.00	1	
Pennisetum	80	12(4)	14.30		
Perotis	10	2	20.00		
Phacelurus	9	2	22.00		

1	2	3	4	5	6
Phaenosperma	1	1	100.00		
Phalaris	15	2(3)	13.30		
Phippsia	3	1	33.30		
Phleum	15	3(1)	20.00		
Phragmites	4	2	50.00		
Phyllostachys	45	2	4.40	1	50.00
Poa	500	55	11.00	8	14.50
Pogonachne	1	1	100.00	1	100.00
Pogonatherum	4	4	100.00	1	25.00
Polypogon	18	2	11.00		
Polytoca	2	1	50.00		
Polytrias	1	1	100.00		
Pommereulla	1	1	100.00		
Porteresia	1	1	100.00		
Pseudanthistiria	4	4	100.00	2	50.00
Pseudechinolaena	7	1	14.30		

1	2	3	4	5	6
Pseudodanthonia	2	1	50.00	1	100.00
Pseudodichanthium	1	1	100.00	1	100.00
Pseudoraphis	6	3	50.00	1	33.30
Pseudosorghum	2	1	50.00		
Pseudoxytenanthera	4	4	100.00	3	75.00
Puccinellia	80	6	7.50		
Recemobambos	19	3	15.80	1	33.30
Rhynchelytrum	14	1	7.00		
Rostraria	10	3	30.00		
Rottboellia	4	2	50.00	1	50.00
Saccharum	40	14(3)	35.00		
Sacciolepis	30	4	13.00		
Schismus	5	2	40.00		
Schizachyrium	60	6	10.00	1	16.70
Schizostachyum	65	16	24.70	8	50.00
Schoenefeldia	2	1	50.00		

1	2	3	4	5	6
Sclerachne	1	1	100.00		
Sclerochloa	2	1	50.00		
Secale	4	(2)	50.00		
Sehima	5	3	60.00	1	33.30
Setaria	100	12(4)	12.00		
Silentvalleya	1	1	100.00	1	100.00
Sinarundinaria	50	21	42.00	9	42.90
Sorghastrum	16	(1)	6.25		
Sorghum	20	6(2)	30.00		
Spartina	15	1	6.67		
Sphaerocaryum	1	1	100.00		
Spinifex	4	1	25.00		
Spodiopogon	9	4	44.40	2	50.00
Sporobolus	160	19(1)	11.88	1	5.30
Stenotaphrum	7	1	14.30		
Stipa	300	25	8.30		

1	2	3	4	5	6
Stipagrostis	50	4(1)	8.00		
Streptogyna	2	1	50.00		
Tetrapogon	5	2	40.00		
Thamnocalamus	7	3	42.90	1	33.30
Thelepogon	1	1	100.00		
Themeda	20	17	85.00	6	14.30
Thuarea	2	1	50.00		
Thyrsostachys	2	1	50.00		
Thysanolaena	1	1	100.00		
Trachys	1	1	100.00		
Tragus	7	1	14.00		
Trichloris	2	(2)	100.00		
Tricholaena	4	1	25.00		
Trikerata	2	1	50.00		
Trilobachne	1	1	100.00	1	100.00
Triplopogon	1	1	100.00	1	100.00

1	2	3	4	5	6
Tripogon	30	12	40.00	8	66.70
Tripsacum	13	1	7.70		
Trisetaria	15	1	6.67		
Trisetum	70	7	10.00	2	28.60
Triticum	20	2(1)	10.00		
Urochloa	12	2	16.67		
Urochondra	1	1	100.00		
Vetiveria	10	2	20.00	1	50.00
Vossia	1	1	100.00		
Vulpia	24	5	20.80		
Zea	5	2	40.00		
Zenkeria	5	4	80.00	2	
Zizania	3	1	33.30		
Zoysia	10	1	10.00		

(Numbers in the bracket indicate the cultivated species).

One hundred and five genera of Indian grasses are represented by only one species each. The genus *Poa* (55 species) has the maximum number of species. Other genera with 25 or more species are *Ischaemum* (46 species), *Dimeria* (35 species), *Panicum* (34 species), *Isachne* (30 species), *Eragrostis* (30 species), *Festuca* (27 species), *Stipa* (25 species) and *Digitaria* (25 species).

Maximum degree of species diversity of grasses is found in peninsular India with more than 50 per cent of the Indian total. In this area Tamil Nadu alone has about 460 species. The North-east India is another grass rich area with about 480 species.

ECONOMIC IMPORTANCE

Grasses are of great economic potential. Some are highly ornamental. Pastures provide grazing land for livestock and rice fields and corn fields provide grains to feed the world. All our staple crops rice, wheat, oats, rye, barley, maize, sorghum, millet and sugar cane are grasses. According to an estimate, 70 per cent of the farmlands of the World are cultivated with crop grasses. Grain of rice plant is the staple food of more than half the world's population. Sugar cane in addition to providing sugar is used for the production of bioalcohol. In Brazil and U.S.A., more than 11 million cars are run using bioalcohol - petrol mixture.

Many grasses are well-known for their fodder value. A list of some of the important grass species that are reputed in our country for their fodder value are given below:

Alloteropsis cimicina, *Andropogon ascinoides*, *A. lividus*, *A. pumilus*, *Bouteloua aristidoides*, *B. curtipendula*, *B. gracilis*, *Brachiaria brizantha*, *B. lata*, *B. miliiformis*, *B. mutica*, *B. ramosa*, *B. reptans*, *B. semiverticillata*, *Bothriochloa caucasica*, *Capillipedium assimile*, *Cenchrus biflorus*, *C. ciliaris*, *C. pennisetiformis*, *C. prieurii*, *Chrysopogon fulvus*, *C. lanceolarius*, *C. orientalis*, *C. polyphyllus*, *Dichanthium annulatum*, *D. aristatum*, *Echinochloa colona*, *Eriochloa nubica*, *Euchlaena mexicana*, *Eulalia trispicata*, *Iseilema anthephoroides*, *I. laxum*, *Lasiurus sindicus*, *Leersia hexandra*, *Muhlenbergia duthieana*, *Panicum atrosanguineum*, *P. maximum*, *P. miliaceum*, *P. distichum*, *P. notatum*, *P. plicatulum*, *P. scrobiculatum*, *P.*

urvillei, *Paspalidium punctatum*, *Pennisetum purpureum*. *P. ramosum*, *Polytoca digitata*, *Sacciolepis myosuroides*, *S. interrupta*, *Sehima ischaemoides*, *S. sulcatum*, *Spodiopogon dubius*, *Stenotaphrum dimidiatum*, *Thelepogon elegans*, *Tricholaena teneriferae*, *Urochloa trichopus*, etc.

Species of *Panicum*, *Lasiurus*, *Cenchrus*, etc. are good sand binders. Grasses are extensively used for reclaiming wastelands and degraded soil. They make very good turf and lawns. *Cynodon dactylon* is the most common lawn grass. *Agrostis canina*, *A. tenuis*, *Axonopus compressus*, *A. affinis*, *Cynodon barberi*, *Chrysopogon aciculatu*, *Digitaria didactyla*, *Oplismenus burmannii*, *Pennisetum clandestinum*, *Polytrias amaura*, etc. are also some of the grasses used for making lawns in different parts of India.

Some grasses are of medicinal value and certain others yield essential oils, a few of which are commercially exploited. Species of *Cymbopogon*, *Vetiveria*, etc. contain valuable essential oils.

Indigenous grasses, like *Coix lacryma-jobi*, *Digitaria compacta*, *Setaria italica*, *Echinochloa crus-galli*, *Eleusine coracana*, *Panicum miliaceum*, etc. are cultivated on a very limited scale for their edible grains in some areas. These and wild grasses, like *Dactyloctenium aegyptium*, *Ischaemum rugosum*, *Echinochloa colonum*, *Oryza rufipogon*, *Sacciolepis indica*, *Setaria pumila*, etc. provide food grains for certain tribal populations during times of scarcity. Additional information on similar plants and detailed evaluation of their economic potential and nutritive value may be useful.

Species of *Themeda*, *Saccharum*, *Eulaliopsis*, *Arundo* and *Phragmites* have proven quality for the manufacture of paper pulp. Grasses are put to a number of other uses, such as making brooms and for matting and thatching purposes. Species of *Andropogon*, *Imperata*, *Desmostachya*, *Saccharum*, etc. are commonly used for thatching in some areas. *Saccharum spontaneum* and *Desmostachya bipinnata* are at times used for rope making. In Mizoram and parts of Meghalaya most of the huts are constructed using culms of *Arundo donax*, *Phragmites karka*, *Themeda arundinacea*, *Themeda villosa*, *Imperata cylindrica* and some thin bamboo species.

Bamboos are also economically very important. The types with long and strong stems and wide diametre are prefered for construction purposes. Tender shoots of some bamboos are eaten. The grains of *Bambusa tulda* are eaten during times of scarcity in the North-east India. Bamboos can be used for making roofs, central frame of walls of houses, baskets, mats, fencing, tree guards, fishing rods, walking sticks, flutes, rafts, yokes, ladder, etc. Slender as well as split and flattened culms of the bamboos, *Arundinaria khasiana* and *Melocanna* spp., especially *Melocanna baccifera* are commonly used to make the central frame of walls, that are plastered on both sides, in various parts of North-east India. Bamboos form the major source for paper pulp.

PHYTOGEOGRAPHICAL AFFINITIES

Jain (1986) states that among the wide species of grasses of India 81 show affinity with Irano-Turanian, 50 with Sino-Japanese, 29 with Indo-Chinese and 28 with Euro-Siberian floras. Some of the African elements of Poaceae found in India include: *Bothriochloa insculpta*, *Brachiaria eruciformis*, *Cenchrus prieurii*, *C. setigerus*, *Cleistachne sorghoides*, *Dignathia hirtella*, *Dinebra retroflexa*, *Enteropogon prieurii*, *Eragrostis macilenta*, *E. viscosa*, *Eremopogon foveolatus*, *Oryza glaberrima*, *Panicum coloratum*, *P. hippothrix*, *Pennisetum clandestinum*, *P. pedicellatum*, *Schoenefeldia gracilis*, *Setaria homonyma* and *Stipagrostis hirtigluma*.

The grass flora of India shows some similarity to that of some of our neighbouring countries. Some examples of such species restricted to India and some of the adjoining countries are given here. *Eulalia pallens* is a Chinese element found in India. *Hackelochloa porifera* is distributed in India, China and Myanmar. *Hystrix duthiei* has its distribution in India, China and Nepal.

Grasses common to Sri Lanka and India

Andropogon lividus, *Apocopis courtallumensis*, *A. mangalorensis*, *Bothriochloa ischaemum*, *Brachiaria remota*, *B. setigera*, *Coelachyrum lagopoides*, *Cymbopogon zeylanicus*, *Cyrtococcum deccanense*, *Dichaetaria wightii*, *Digitaria griffithii*, *D. wallichiana*, *Dimeria avenacea*, *D. ceylanica*, *D. gracilis*, *D. lehmanii*, *D. pubescens*, *D.*

thwaitesii, *D. trimenii*, *Eragrostis walkeri*, *E. maderaspatana*, *Eulalia thwaitesii*, *Garnotia courtallensis*, *G. exaristatus*, *G. fergusonii*, *G. scoparia*, *Helictotrichon asperum*, *Hemisorghum venustum*, *Isachne walkeri*, *Ischaemum commutatum*, *I. mangaloricum*, *I. semisagittatum*, *I. zeylanicolum*, *Iseilema laxum*, *Lopholepis ornithocephala*, *Melanocenchris monoica*, *Panicum gardeneri*, *P. miliaceum*, *P. sparcicomum*, *Parahyparrhenia umbellata*, *Setaria plicata*, *Sinarudinaria walkeriana*, *Sporobolus maderaspatanus*, *S. tremulus*, *Themeda cymbaria*, *T. tremula*, *Tripogon bromoides*, *Zenkeria stapfii*, etc.

Grasses common to Myanmar and India

Andropogon ascinoides, *Anthoxanthum clarkei*, *Arundinella hookeri*, *Chionachne semiteres*, *Chrysopogon aciculatus*, *Coelorhachis khasiana*, *Cynodon barberi*, *Dendrocalamus hookeri*, *Enteropogon monostachyos*, *Saccharum rufipilum*, *Eulalia fimbriata*, *E. manipurensis*, *Germainia khasiana*, *Gymnopogon delicatulus*, *Ischaemum lacei*, *Microchloa kunthii*, *Microstegium ciliatum*, *Oryza rufipogon*, *Panicum incomtum*, *Polytoca digitata*, *Saccharum wardii*, *Schizostachyum helferi*, *Setaria forbesiana*, *Sinarundinaria elegans*, *Sporobolus capillaris*, *S. tetragonus*, *Themeda caudata*, *Thyrsostachys oliveri*, *T. siamensis*, etc.

Grasses common to Nepal and India

Agropyron thomsonii, *Agrostis hookeriana*, *A. inaequiglumis*, *Arthraxon sikkimensis*, *Arundinaria racemosa*, *Calamagrostis garhwalensis*, *Chrysopogon gryllus*, *Cymbopogon microtheca*, *C. pendulus*, *Deyeuxia pulchella*, *Dimeria fuscescens*, *Eulalia staintonii*, *Garnotia polypogonoides*, *Isachne sikkimensis*, *Sinarundinaria maling*, etc.

Grasses common to Pakistan, Nepal and India

Agrostis nervosa, *Oryzopsis gracilis* and *Sinarundinaria falcata*.

Grasses common to Myanmar, Sri Lanka and India

Centotheca lappacea, *Chionachne koenigii*, *Eragrostis bifaria*, *Hemarthria compressa*, *Iseilema prostratum*, *Pogonatherum paniceum*, *Pseudoraphis brunoniana*, *Schizachyrium sanguineum*, *Spinifex littoreus*, *Sporobolus wallichii*, etc.

Grasses common to Bhutan, Nepal and India

Sinarundinaria intermedia, *S. pantlingii*, *Thamnocalamus falconeri*, *T. spathiflorus*, etc.

Grasses common to Bhutan and India

Anthoxanthum hookeri, *Dendrocalamus sikkimensis*, *Kengia gatacrei*, *Saccharum sikkimense*, *Schizostachyum capitatum*, *S. latifolium*, *Sinarundinaria hookeriana*, *Thamnocalamus aristatus*, etc.

Grasses common to Pakistan and India

Colpodium himalaicum, *Saccharum filifolium*, *Helictotrichon virescens*, *Leersia hackelii*, *Melanocenchris jacquemontii*, *Melica onoei*, *Oryzopsis lateralis*, *Pennisetum hohenackeri*, *Poa setulosa*, *Saccharum macratherum*, *Stipagrostis pogonoptila*, *Trachynia distachya*, *Trisetum clarkei*, etc.

ENDEMISM

Grasses exhibt a fairly good degree of endemism in India. According to Nayar (1980) there are about 141 endemic genera belonging to 47 families in India. Out of this 15 are grass genera. This works out to be about 11 per cent of the total endemic genera of India. According to Karthikeyan (1983), Shukla (1983) and Jain (1986) the number of endemic grass genera in India is 16. The endemic genus *Lophopogon* does not find a place in these accounts. Of the genera mentioned by these authors *Pseudodanthonia* is now known to have an additional species distributed in Western China. Similarly *Normanboria* also has to be removed from the list as this generic name is now-a-days treated as a synonym of *Acrachne* that has also distribution outside India. Sreekumar and V.J. Jair (1991) has added two more generic names *viz. Indochloa* and

Isachnochloa to the list of Jain (1986) making the number 18. These two genera according to the present concepts are synonymous to the widely distributed *Euclasta* and *Microstegium* respectively. Most of the endemic grass genera are restricted in distribution to peninsular India. Table II gives a clear picture of the distribution pattern of grass genera endemic to India. It will be interesting to note that most of these (8) belong to the tribe Andropogoneae.

Ochlandra with 10 endemic species in India just missed the status of an endemic genus of India because of the occurrence of *Ochlandra stridula* in Sri Lanka which again is an endemic species to that country. Other examples of grass genera with restricted distribution in India and some of the neighbouring countries are: *Hygroryza, Zenkeria, Dichaetaria, Pommereulla, Lopholepis* (all in India and Sri Lanka); *Pseudoxytenanthera* and *Trachys* (India, Sri Lanka and Myanmar); *Melocanna* and *Porteresia* (India and Myanmar) and *Trikeraia* (India and Tibet). In addition to the 15 endemic grass genera cited above there are 73 more genera with some of their species endemic to India.

Jain (1986) points out that approximately 430 species and varieties of grasses are reported in literature as endemic to the present boundaries of India and that due to the availability of additional information many of these are to be deleted from the list. According to him over 350 taxa of grasses are endemic to Indian boundaries, and of these 172 occur in peninsular India, 56 in the North-east, 30 in the North-west, 12 in the lower Gangetic plain, 5 in the western and arid regions, 4 in Andaman & Nicobar Islands and 50 spread to more than one regions. During the past 14 years after the publication of the above account much more information on the distribution of grasses have accumulated. Many new species also have been described during the period. This has necessitated deletion of some more names from the old lists and at the same time a few others (new species) had to be added to it. An assessment done during the preparation of this account resulted in identifying 315 species as endemic to Indian region (Table III). Majority of these (176 species) occur in peninsular India. North-east India has the second place in the degree of endemism of grass species as has also been observed by Jain (*l.c.*). Out of the 88 genera that have endemic species, 36 are with only one endemic species each. Five genera namely *Ischaemum* (35 spp.), *Dimeria* (27 spp.), *Isachne* (18 spp.), *Arundinella* (12 spp.) and *Ochlandra* (10 spp.) have ten or more endemic species each.

Table II
Distribution of endemic grass genera in India

Name	Tribe	No. of species	Distribution
1. *Bhidea*	Andropogoneae	2	Kerala, Maharashtra
2. *Chandrasekharania*	Arundinelleae	1	Kerala
3. *Cyathopus*	Aveneae	1	Sikkim
4. *Danthonidium*	Arundineae	1	Kerala, Maharashtra
5. *Glyphochloa*	Andropogoneae	8	Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu
6. *Hubbardia*	Hubbardieae	1	Karnataka (in the spray zone of Gersoppa falls)
7. *Indopoa*	Eragrostideae	1	Peninsular India
8. *Limnopoa*	Isachneae	1	Kerala
9. *Lophopogon*	Andropogoneae	3	Bihar, Madhya Pradesh, Peninsular India
10. *Manisuris*	Andropogoneae	1	Andhra Pradesh, Karnataka, Manipur, Tamil Nadu

Name	Tribe	No. of species	Distribution
11. *Pogonachne*	Andropogoneae	1	Maharashtra
12. *Pseudodichanthium*	Andropogoneae	1	Maharashtra
13. *Silentvalleya*	Andropogoneae	1	Kerala
14. *Trilobachne*	Andropogoneae	1	Gujarat, Maharashtra
15. *Triplopogon*	Andropogoneae	1	Maharashtra

Table III
Endemic grass species of India and their distribution

Name	Distribution
Acrachne henrardiana	Tamil Nadu
Acrachne sundararajii	Tamil Nadu
Agrostis brachiata	Bihar, West Bengal
Agrostis peninsularis	Kerala, Tamil Nadu
Agrostis schmidii	Tamil Nadu (Nilgiris)
Agrostis sikkimensis	Sikkim, West Bengal
Agrostis triaristata	Sikkim, West Bengal
Agrostis tungnathii	Uttaranchal
Agrostis wardii	Manipur
Andropogon longipes	Tamil Nadu (Nilgiris)
Andropogon pumilus	Maharashtra, Madhya Pradesh
Anthoxanthum borii	Kerala, Tamil Nadu
Anthoxanthum flexuosum	Sikkim
Anthoxanthum sikkimense	Sikkim
Apocopis vaginata	Bihar, Madhya Pradesh, Uttar Pradesh, Tamil Nadu
Aristida redacta	Karnataka, Madhya Pradesh, Maharashtra, Uttar Pradesh, Rajasthan, Tamil Nadu, West Bengal
Aristida stocksii	Gujarat, Karnataka, Maharashtra
Arthraxon jubatus	Maharashtra
Arundinella cannanorica	Kerala
Arundinella ciliata	Karnataka, Kerala, Maharashtra, Tamil Nadu
Arundinella decempedalis	Arunachal Pradesh, Assam, Manipur, Meghalaya, Sikkim, West Bengal
Arundinella intricata	Arunachal Pradesh, Meghalaya
Arundinella khaseana	Arunachal Pradesh, Assam, Meghalaya, Nagaland

Name	Distribution
Arundinella mesophylla	Kerala, Tamil Nadu
Arundinella nervosa	Karnataka, Kerala, Maharashtra, Meghalaya, Tamil Nadu
Arundinella purpurea	Karnataka, Kerala, Tamil Nadu
Arundinella setosa	Tamil Nadu (Nilgiris)
Arundinella spicata	Maharashtra
Arundinella tuberculata	Madhya Pradesh, Maharashtra
Arundinella vaginata	Kerala, Tamil Nadu
Bambusa balcooa	Assam, West Bengal
Bambusa cacharensis	Assam
Bambusa jaintiana	Meghalaya
Bambusa khasiana	Manipur, Meghalaya
Bambusa pallida	Arunachal Pradesh, Assam, Meghalaya, Nagaland, Sikkim, Tripura
Bambusa pseudopallida	Assam
Bhidea burnsiana	Maharashtra, Kerala
Bhidea fischeri	Kerala
Bothriochloa compressa	Western India
Bothriochloa concanensis	Maharashtra
Bothriochloa foulkesii	Tamil Nadu (Nilgiris)
Bothriochloa jainii	Maharashtra
Bothriochloa kuntzeana	Bihar, Kerala, Madhya Pradesh, Tamil Nadu, Uttar Pradesh
Bothriochloa longifolia	Tamil Nadu
Bothriochloa parameswaranii	Kerala
Bothriochloa woodrowii	Maharashtra
Brachiaria chennaveeraiana	Rajasthan
Brachiaria hybrida	Karnataka
Brachiaria kurzii	Andhra Pradesh, Bihar, Madhya Pradesh, Tamil Nadu, Uttar Pradesh
Brachiaria munae	Karnataka, Tamil Nadu

Name	Distribution
Brachiaria nilagirica	Tamil Nadu
Brachiaria semiundulata	Kerala, Maharashtra, Tamil Nadu
Brachiaria stapfiana	Karnataka
Calamagrostis nagarum	Kerala, Nagaland
Capillipedium filiculme	Maharashtra, Tamil Nadu, Uttar Pradesh
Capillipedium huegelii	Bihar, Kerala, Madhya Pradesh, Maharashtra
Capillipedium magdalenii	Karnataka
Capillipedium nagense	Nagaland
Capillipedium planipedicellatum	Manipur
Capillipedium pteropechys	Nagaland
Cenchrus glaucus	Tamil Nadu
Cenchrus rajasthanensis	Rajasthan
Chandrasekharania keralensis	Kerala
Chloris wightiana	Tamil Nadu
Chrysopogon hackelii	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Uttar Pradesh
Chrysopogon hamiltonii	Bihar
Chrysopogon pseudozeylanicus	Karnataka
Chrysopogon tadulingamii	Kerala
Coelachne minuta	Maharashtra
Cyathopus sikkimensis	Sikkim
Cymbopogon coloratus	Peninsular India
Cymbopogon osmastonii	Uttar Pradesh
Cymbopogon travancorensis	Kerala, Tamil Nadu
Cyrtococcum longipes	Karnataka, Kerala, Sikkim, Tamil Nadu
Danthonidium gammiei	Kerala, Maharashtra
Dendrocalamus patellaris	Assam, Nagaland, West Bengal
Dendrocalamus sahnii	Arunachal Pradesh

Name	Distribution
Dendrocalamus somdevai	Western Himalaya
Deyeuxia borii	Meghalaya, Nagaland
Deyeuxia elatior	Arunachal Pradesh, Meghalaya
Dichanthium armatum	Maharashtra
Dichanthium maccanii	Maharashtra
Dichanthium oliganthum	Maharashtra, Tamil Nadu
Dichanthium panchganiense	Maharashtra
Dichanthium paranjpyeanum	Maharashtra
Dichanthium tuberculatum	Madhya Pradesh, Maharashtra
Dichanthium duthieanum	Uttar Pradesh
Digitaria jubata	Meghalaya
Dimeria balakrishnaniana	Tamil Nadu
Dimeria bialata	Kerala, Tamil Nadu
Dimeria blatteri	Maharashtra
Dimeria borii	Kerala
Dimeria chelariensis	Kerala
Dimeria connivens	Bihar, Kerala, Madhya Pradesh, Orissa
Dimeria copeana	Kerala
Dimeria deccanensis	Kerala, Tamil Nadu
Dimeria eradii	Kerala
Dimeria fischeri	Kerala, Tamil Nadu
Dimeria hohenackeri	Kerala, Tamil Nadu
Dimeria idukkiensis	Kerala
Dimeria jainii	Kerala
Dimeria kanjirapallilana	Kerala
Dimeria keralae	Kerala
Dimeria kollimalayana	Tamil Nadu
Dimeria lawsonii	Kerala, Tamil Nadu
Dimeria mahendragiriensis	Orissa

Name	Distribution
Dimeria mooneyi	Orissa, South India
Dimeria namboodiriana	Kerala
Dimeria orissae	Orissa, Tamil Nadu
Dimeria raizadae	Kerala
Dimeria santapaui	Karnataka
Dimeria sivarajanii	Kerala
Dimeria sreenarayanii	Kerala
Dimeria stapfiana	Maharashtra
Dimeria woodrowii	Maharashtra
Dinochloa gracilis	Meghalaya
Dinochloa indica	Assam
Dinochloa nicobariana	Andaman & Nicobar Islands
Enteropogon coimbatorensis	Tamil Nadu
Eragrostis leioptera	Assam, Meghalaya, Orissa, West Bengal
Eragrostis dayanandanii	Tamil Nadu
Eragrostis deccanensis	Karnataka, Tamil Nadu
Eragrostis rottleri	Tamil Nadu
Eragrostis santapaui	Karnataka
Eriochrysis rangacharii	Tamil Nadu
Euclasta clarkei	Bihar, Rajasthan
Eulalia hirtifolia	Himachal Pradesh, Sikkim, Uttaranchal
Eulalia mollis	West to central Himalaya
Eulalia wightii	Tamil Nadu
Eulaliopsis duthiei	Uttar Pradesh
Festuca asthenica	North-west Himalaya
Festuca cuminsii	Sikkim
Festuca leptopogon	Meghalaya, Nagaland, Sikkim, West Bengal
Festuca nandadevica	Western Himalaya

Name	Distribution
Festuca undata	Arunachal Pradesh, Sikkim, West Bengal
Garnotia arborum	Karnataka, Maharashtra
Garnotia elata	Karnataka, Kerala, Tamil Nadu
Garnotia puchiparensis	Kerala
Glyphochloa acuminata	Karnataka, Kerala, Maharshtra, Tamil Nadu
Glyphochloa divergens	Kerala
Glyphochloa forficulata	Karnataka, Maharshtra, Tamil Nadu
Glyphochloa goaensis	Goa
Glyphochloa mysorensis	Karnataka
Glyphochloa ratnagirica	Maharashtra
Glyphochloa santapaui	Maharashtra
Glyphochloa talbotii	Maharashtra
Helictotrichon polyneurum	Tamil Nadu
Helictotrichon schmidii	Tamil Nadu
Hemarthria hamiltoniana	Uttar Pradesh
Heteropogon fischerianus	Tamil Nadu
Heteropogon melanocarpus	Central India and Upper Gangetic Plain
Heteropogon ritchiei	Bihar, Gujarat, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh
Hierochloe khasiana	Meghalaya
Hubbardia heptaneuron	Karnataka
Hymenachne assamica	Assam, Bihar, Manipur, Meghalaya, Nagaland
Indopoa paupercula	Peninsular India
Isachne angladei	South India
Isachne bicolor	Maharashtra
Isachne borii	Maharashtra
Isachne bourneorum	South India

Name	Distribution
Isachne clarkei	Meghalaya, Nagaland, Sikkim
Isachne deccanensis	Tamil Nadu
Isachne dimyloides	Sikkim
Isachne elegans	Karnataka, Maharashtra
Isachne fischeri	Kerala
Isachne gracilis	Karnataka, Madhya Pradesh, Maharashtra
Isachne henryi	Kerala
Isachne lisboae	Karnataka, Maharashtra
Isachne meeboldii	Karnataka
Isachne mysorensis	Karnataka
Isachne oreades	Tamil Nadu
Isachne setosa	Karnataka, Kerala, Tamil Nadu
Isachne swaminathanii	Maharashtra
Isachne veldkampii	Karnataka
Ischaemum agastyamalayanum	Kerala
Ischaemum bolei	Maharashtra
Ischaemum bombaiensis	Madhya Pradesh, Maharashtra, Rajasthan
Ischaemum calicutensis	Kerala
Ischaemum cannanorensis	Kerala
Ischaemum copeanum	Kerala
Ischaemum diplopogon	Maharashtra
Ischaemum duthiei	Bihar, Himachal Pradesh, Madhya Pradesh, West Bengal
Ischaemum elimalayanum	Kerala
Ischaemum flumineum	Maharashtra, Tamil Nadu
Ischaemum hirtum	Meghalaya, Bihar
Ischaemum hubbardii	Meghalaya
Ischaemum huegelii	Maharashtra
Ischaemum impressum	Maharashtra, Rajasthan

Name	Distribution
Ischaemum jayachandranii	Kerala
Ischaemum keralense	Kerala
Ischaemum kingii	Maharashtra, Rajasthan
Ischaemum koenigii	Tamil Nadu
Ischaemum kumarakodiensis	Kerala
Ischaemum lisboae	Maharashtra, Tamil Nadu
Ischaemum malabaricum	Kerala
Ischaemum nairii	Kerala
Ischaemum nilagiricum	Kerala, Tamil Nadu
Ischaemum pappinisseriensis	Kerala
Ischaemum quilonensis	Kerala
Ischaemum raizadae	Maharashtra
Ischaemum rangacharianum	Kerala, Maharashtra, Tamil Nadu
Ischaemum ritchiei	Karnataka, Maharashtra
Ischaemum raui	Kerala
Ischaemum santapaui	Maharashtra
Ischaemum tadulingamii	Kerala
Ischaemum thomsonianum	Karnataka, Kerala, Tamil Nadu
Ischaemum travancorense	Kerala
Ischaemum tumidum	Kerala, Maharashtra
Ischaemum vembanadense	Kerala
Iseilema anthephoroides	Karnataka, Kerala, Maharashtra, Tamil Nadu
Iseilema holei	Bihar
Iseilema hubbardii	Madhya Pradesh
Iseilema venkateswaralui	Andhra Pradesh
Limnopoa meeboldii	Kerala
Lophopogon duthiei	Madhya Pradesh
Lophopogon kingii	Bihar

Name	Distribution
Lophopogon tridentatus	Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu
Manisuris myuros	Andhra Pradesh, Karnataka, Manipur, Tamil Nadu
Microstegium borianum	Meghalaya
Microstegium falconeri	N.W. Himalaya
Miscanthus wardii	Assam
Mnesithea clarkei	Bihar, Gujarat, Karnataka, Madhya Pradesh
Ochlandra beddomei	Kerala, Tamil Nadu
Ochlandra ebracteata	Kerala
Ochlandra scriptoria	Karnataka, Kerala, Tamil Nadu
Ochlandra setigera	Kerala, Tamil Nadu
Ochlandra sivagiriana	Kerala, Tamil Nadu
Ochlandra soderstromiana	Kerala, Tamil Nadu
Ochlandra spirostylis	Kerala
Ochlandra talbotii	Karnataka
Ochlandra travancorica	Kerala, Tamil Nadu
Ochlandra wightii	Kerala, Tamil Nadu
Ophiuros bombaiensis	Maharashtra, Tamil Nadu
Oropetium roxburghianum	Andhra Pradesh, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu
Oropetium villosulum	Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Orissa
Oryza indandamanica	Andaman & Nicobar Islands
Oryza jeyporensis	Orissa
Oryza malampuzhaensis	Kerala, Tamil Nadu
Panicum deccanense	Maharashtra
Panicum fischeri	Tamil Nadu
Panicum gerardii	South India

Name	Distribution
Panicum humidorum	Assam, Meghalaya, Nagaland, Kerala, West Bengal
Panicum incisum	Arunachal Pradesh, Assam, Nagaland
Panicum johnii	Maharashtra
Panicum khasianum	Meghalaya, Nagaland, West Bengal
Panicum nehruense	Rajasthan
Panicum paianum	Maharashtra
Parahyparrhenia bellariensis	Tamil Nadu
Paspalum canarae	Kerala, Tamil Nadu
Phyllostachys mannii	Arunachal Pradesh, Assam, Meghalaya
Poa gamblei	Tamil Nadu
Poa gammieana	Sikkim
Poa jaunsarensis	Jammu & Kashmir, Uttaranchal
Poa khasiana	Arunachal Pradesh, Meghalaya, Nagaland, West Bengal
Poa polyneuron	Sikkim
Poa pseudamoena	Uttaranchal (Kumaon)
Poa rhadina	Uttaranchal (Tehri Garhwal)
Poa wardiana	Assam
Pogonachne racemosa	Maharashtra
Pogonatherum rufo-barbatum	Arunachal Pradesh, Manipur, Meghalaya, Orissa
Pogonatherum santapaui	W. Himalaya
Pseudanthistiria hispida	Central India, Gujarat, Karnataka, Kerala, Maharashtra
Pseudanthistiria intermedia	Maharashtra
Pseudodanthonia himalaica	Uttaranchal (Chakrata)
Pseudodichanthium serrafalcoides	Maharashtra
Pseudoraphis minuta	Assam, Bihar, Orissa, West Bengal

Name	Distribution
Pseudoxytenanthera bourdillonii	Kerala
Pseudoxytenanthera ritcheyi	Karnataka, Kerala, Maharashtra
Pseudoxytenanthera stocksii	Goa, Karnataka
Racemobambos clarkei	Manipur, Sikkim
Racemobambos mannii	Arunachal Pradesh, Assam, Meghalaya
Rottboellia goalparensis	Assam
Schizachyrium sudhanshui	Karnataka
Schizostachyum beddomei	Manipur, Tamil Nadu
Schizostachyum fuchsianum	Arunachal Pradesh, Manipur, Nagaland
Schizostachyum kurzii	Andaman & Nicobar Islands
Schizostachyum mannii	Arunachal Pradesh, Manipur, Meghalaya
Schizostachyum pallidum	Arunachal Pradesh, Manipur, Meghalaya, Nagaland
Schizostachyum polymorphum	Arunachal Pradesh, Assam, Manipur, Nagaland
Schizostachyum rogersii	Andaman & Nicobar Islands
Schizostachyum seshagirianum	Arunachal Pradesh
Sehima notatum	Uttar Pradesh
Silentvalleya nairii	Kerala
Sinarundinaria anceps	Uttaranchal
Sinarundinaria hirsuta	Manipur, Meghalaya
Sinarundinaria hookeriana	Arunachal Pradesh
Sinarundinaria jainiana	Sikkim, West Bengal
Sinarundinaria longispiculata	Mizoram
Sinarundinaria polystachya	West Bengal
Sinarundinaria rolloana	Nagaland
Sinarundinaria suberecta	Arunachal Pradesh, Meghalaya, Sikkim

Name	Distribution
Sinarundinaria wightiana	Tamil Nadu
Sorghum deccanense	Madhya Pradesh, Central India
Spodiopogon jainii	Madhya Pradesh
Spodiopogon rhizophorus	Gujarat, Karnataka, Kerala, Maharashtra, Rajasthan, Tamil Nadu
Sporobolus hajrae	Tamil Nadu
Thamnocalamus prainii	Meghalaya, Nagaland
Themeda dacruzii	Uttaranchal
Themeda huttonensis	Nagaland
Themeda mooneyi	Orissa
Themeda sabarimalayana	Kerala
Themeda saxicola	Orissa
Themeda strigosa	Assam, Bihar, Maharashtra, West Bengal
Trilobachne cookei	Gujarat, Maharashtra, Nager Haveli
Triplopogon ramosissimus	Maharashtra
Tripogon ananthaswamianus	Kerala
Tripogon capillatus	Bihar, Karnataka, Kerala, Maharashtra, Orissa
Tripogon jacquemontii	Karnataka, Maharashtra, Rajasthan
Tripogon lisboae	Gujarat, Maharashtra, Rajasthan
Tripogon narayanii	Kerala
Tripogon polyanthus	Maharashtra
Tripogon pungens	Tamil Nadu
Tripogon wightii	Andhra Pradesh, Tamil Nadu
Trisetum micans	Uttaranchal (Tehri Garhwal)
Trisetum scitulum	Sikkim
Vetiveria lawsonii	South India
Zenkeria jainii	Kerala
Zenkeria sebastinei	Tamil Nadu

THREATENED SPECIES AND CONSERVATION

Various natural and anthropogenic factors have resulted into many grassland area's depauperisation or destruction. Severe destruction caused to the natural vegetation and especially to the bamboo forests in North east India due to '*Jhum*' (shifting) cultivation is very well known. People who indulge in this practice prefer secondary growth of bamboos rather than other types of forests as it is comparatively easier to cut, dry and finally burn them to get plenty of ash that enriches the soil and make it much more useful for cultivation. During earlier days there used to be very long gaps of a considerable number of years between one *Jhumming* and the next one in the same area and as such there was enough time for satisfactory natural regeneration in such areas. But due to population pressure the *Jhum* cycles have become considerably reduced to a dangerous level. In Meghalaya it is now reduced to 4 to 5 years whereas in Mizoram and Tripura it is 5 10 years. The condition in Nagaland is slightly better with a *Jhum* cycle of 6 15 years.

Overgrazing, natural calamities like forest fires, floods, etc., and various socio-economic developmental activities are the other factors threatening grasslands. Many swamps get reclaimed for agriculture leading to the depletion of typical swamp grasses, like *Phragmites australis*, *Saccharum griffithii*, *Vetiveria zizanoides*, etc. in their natural habitats.

A number of endemic species are known only by their Type collections indicating their rarity. Jain (1986) lists about 120 endemic species that are rare. Karthikeyan (1983) also gives a similar list that contains about 90 species. *Acrachne henrardiana*, *Eragrostis rottleri*, *Eriochrysis rangacharii*, *Limnopoa meeboldii*, *Poa gamblei*, *Trisetum micans*, etc. are some of the very rare grasses. Type collection of *Hubbardia heptaneuron*, the only species of the tribe Hubbardieae, is from the spray zone of Gersoppa falls in Karnataka. Till recently it could not be collected from anywhere else and was presumed to have been extinct. The fact that another grass *Limnopoa meeboldii*, also presumed to be extinct for quite sometime was relocated from a place away from the type locality, a few years back, suggests the need for intensive explorations to assess the present status of many of these very rare plants. In the Western Ghats most of the interesting plant species belonging to various families are discovered from areas in and around grasslands. This is an important fact that emphasises the need for detailed study and conservation of the grassland ecosystems.

REFERENCES

Achariar, K.R. and C.T. Mudaliar 1921. *A Handbook of South Indian Grasses*. Madras.

Adams, D.E., W.E. Perkins and J.R. Estes 1981. Pollination systems in *Paspalum dilatatum* Poir. an example of insect pollination in a temperate grass. *Amer. J. Bot.* **68**(3): 389-394.

Anton, A.M. and Cocucii 1984. On the pollen morphology and phylogeny of the Restionales and Poales. *Grana* 24: 65-76.

Beddome, R.H. 1873. *The Flora Sylvatica for Southern India*. 3 Vols. (Reprint edn. 1978). International Book Distributors. Dehra Dun.

Berg, R.Y. 1981. The role of ants in seed dispersal in Australian lowland heathland. In: Specht, R.I. (ed.) *Heathlands and Related Shrublands of the World Analytical Studies*. Elsevier Publishing Company, Amsterdam.

Bews, J.W. 1918. *The Grasses and Grasslands of South Africa*. P. Davies & Sons, London.

Bews, J.W. 1929. *The World's Grasses Their Differentiation, Distribution, Economics and Ecology*. Longman Green & Co., London.

Blake, S.T. 1956. Some features of the grasses and grasslands of Queensland. *Queensl. Natur.* **15**: 61-64.

Blasco, F. 1970. Aspects of the flora and ecology of savannas of the south Indian hills. *J. Bombay Nat. Hist. Soc.* **67**: 522-524.

Blatter, E.J. and C. McCann 1935. *The Bombay Grasses*. Imp. Counc. Agric. India. Delhi.

Bogdan, A.V. 1962. Grass pollination by bees in Kenya. *Proc. Linn. Soc. London*. **173**: 57-60.

Bogdan, A.V. 1977. *Tropical Pastures and Fodder Plants*. Longmans, New York.

Bor, N.L. 1940. *Flora of Assam, 5. Gramineae.* Calcutta.

Bor, N.L. 1941. Some common U.P. Grasses. *Indian For. Rec.* n.s. (Bot.) **2**: 1-220.

Bor, N.L. 1960. *Grasses of Burma Ceylon, India and Pakistan.* Academic Press, London.

Brues, C.T. and B. Beirne 1908. A new fossil grass from the Miocene of Florissant Colorado. *Bull. Wis. Natur. Hist. Soc.* **6**: 170-171.

Brewbaker, J.L. 1959. Biology of the Angiosperm pollen grains. *Indian J. Gen. Pl. Breed.* **19**: 121-130.

Brown, W.V. *et al.* 1959. Grass morphology and systematics : I. The internode. *South-W. Nat.* **4**: 115-125.

Burnes, W. and L.B. Kulkarni 1928. A study of some Indian grasses and grasslands. *Mem. Dept. Agric. I. d. Bot. Ser.* **16**: 101-143.

Camus, E.G. 1913. *Les Bambusees.* Lechevalier, Paris.

Chaudhari, H.N. and D.C. Pal 1978. Less known uses of some of grasses of India. *Bull. Bot. Soc. Bengal* **32**: 48-50.

Chaudhury, A.B. 1939. Grasses and grassland types of central forest division, West Bengal. *Indian For.* **85**: 603-606.

Chaudhuri, A.B. 1960. Common grasses and sedges of Kurseong, Kalimpong and Darjeeling forest division, West Bengal. *Indian For.* **86**: 336-353.

Clayton, W.D. and S.A. Renvoize 1986. *Genera Graminum.* HMSO, London.

Clifford, H.T. 1961. Floral evolution in the family Gramineae. *Evolution* **15**: 455-460.

Clifford, H.T. 1987. Spikelet and floral morphology. In: Soderstrom *et al.* (ed.) *Grass Systematics and Evolution.* Smithsonian Institution, Washington.

Coldstream 1889. *Illustrations of Grasses of South Punjab*. Edinburgh.

Cooke, T. 1908. *Flora of Bombay Presidency*. Bombay.

Cope, T.A. 1982. Poaceae. In: Nasir, E. & S.I. Ali. (eds.) *Flora of Pakistan*. 148. Pakistan Agr. Res. Council, Islamabad.

Dabadghao, P.M. and B.D. Patil 1956. Ecological basis of grassland conservation in India. *J. Soil Water Conser. India* **5**(1): 7-9.

Daghlian, C.P. 1981. A review of fossil records of Monocotyledons. *Bot. Rev*. **47**: 517-555.

Dahlgren, R. and F.N. Rasmussen 1983. Monocotyledons evolution. *Evol. Biol*. **16**: 255-395.

Dasanayake, M.D. *et al*. 1994. *A Revised Handbook to the Flora of Ceylon*. 8. Amerind Publishing Co., New Delhi.

Desai, M.C. and S.N. Murthy 1950. Some grasses of Dharwar Agriculture College Estate. *Dharwar Agr. Coll. Mag*. **4**: 27. 1950.

Deshpande, U.R. and N.P. Singh 1986. *Grasses of Maharashtra an Annotated Inventory*. Pune.

Dewet, J.M.J. 1981. Grasses and the culture history of man. *Ann. Miss. Bot. Gard*. 68: 87-104.

Duthie, J.F. 1883. *A List of Grasses of N.W. India Indigenous and Cultivated*. Roorkee.

Duthie, J.F. 1886. *Illustrations of the Indigenous Fodder Grasses of the Plains of N.W. India*. Roorkee.

Duthie, J.F. 1888. *The Fodder Grasses of Northern India*. Roorkee.

Ellias, M.K. 1942. Tertiary Prairie grasses and other herbs from the high plains. *Geol. Soc. Amer. Spec. Papers* **41**: 1-176.

Fischer, C.E.C. 1934. In: Gamble, J.S., *Flora of the Presidency of Madras*. Madras.

Gamble, J.S. 1896. Bambuseae of British India. *Ann. Roy. Bot. Gard. Calcutta* **7**: 1-133.

Gardner, J.S. 1886. Fossil grasses. *Proc. Geol. Assoc.* **9**: 433-454.

Good, R. 1953. *The Geography of the Flowering Plants*. 2nd ed. Longmans, London.

Gould, F.W. and R.B. Shaw 1988. *Grass Systematics*. 2nd ed. A & M. University Press, Texas.

Griffith, W. 1834. Grasses of jheels of Sylhet. *J. Asiat. Soc. Bengal* **5**: 570.

Guedes, M. and M. Dupuy 1978. Comparative morphology of lodicules in grasses. *Biol. J. Linn. Soc.* **73**: 317-331.

Haines, H.H. 1921-25. *The Botany of Bihar and Orissa*. London (Repr. ed. 1961). BSI, Howrah.

Harper, J.L. 1977. *Population Biology of Plants*. Academic Press, New York.

Hartley, W. 1958. Studies on the origin, evolution and distribution of Gramineae. *Austr. J. Bot.* **6**: 243-357.

Hole, R.S. 1911. On some Indian forest grasses and their ecology. *Indian For. Mem. For. Bot. Ser.* **1**: 1-126.

Holttum, R.E. 1956. Classification of Bamboos. *Phytomorphology*. **6**: 73-90.

Hooker, J.D. 1897. *Flora of British India*. 7. London.

Howe, H.F. and J. Smallwood 1982. Ecology of seed dispersal. *Ann. Rev. Eco. Syst.* **13**: 201-228.

Jain, S.K. 1961. A contribution to the bibliography of Gramineae. *Proc. Nat. Acad. Sci. India* 31B: 316-382.

Jain, S.K. 1967. The genus *Cynodon* Rich. ex Pers. in India. *Bull. Bot. Surv. India* **9**: 134-154.

Jain, S.K. 1967a. Notes on Indian grasses. VII the genus *Oropetium* Trin. in India. *Bull. Bot. Surv. India* **9**: 284-285.

Jain, S.K. 1970. The genus *Manisuris* L. (Poaceae) in India. *Bull. Bot. Surv. India* **12**: 6-17.

Jain, S.K. 1972. The genus *Arthraxon* P. Beauv. (Poaceae) in India. *J. Indian Bot. Soc.* **51**: 165-183.

Jain, S.K. 1986. The grass flora of India a synoptic account on uses and phytogeography. *Bull. Bot. Surv. India* **28**(1-4): 229-240.

Jain, S.K. 1986a. On the status of endemism of some grasses in India. *J. Indian Bot. Soc.* **66**: 237-247.

Jain, S.K. and A.R.K. Sastry (eds.) 1980. *Threatened Plants of India - A state of Art Report.* BSI, Calcutta.

Jain, S.K. and A.R.K. Sastry (eds.) 1983. *Materials for a Catalogue of Threatened Plants of India.* Botanical Survey of India. Calcutta.

Jain,S.K. and D.C. Pal 1975. New species and notes on the genus *Anthoxanthum* L. *J. Bombay Nat. Hist. Soc.* **72**: 9-95.

Jain, S.K., D.K. Banerjee, and D.C. Pal 1975. Grasses of Bihar, Orissa and West Bengal. *J. Bomaby Nat. Hist. Soc.* **72**: 758-773.

Jain, S.K. and R.R. Rao (eds.) 1983. *An Assessment of Threatened Plants of India.* BSI, Howrah.

Jain, S.K. and S.C. Srivastava 1986. Additions to the Grass Flora of India. *J. Econ. Tax. Bot.* **12**(2): 318.

Jansen, D.H. 1984. Dispersal of small seeds by big herbivores. *Amer. Naturalist* **123**: 338-353.

Jansen, P. 1953. Notes on Malaysian grasses 1. *Reinwardtia* **2**:316.

Jirasek, V. and A.M. Jozi Fova 1968. Morphology of lodicules their variability and importance in the taxonomy of the Poaceae family. *Bol. Soc. Arg. Bot.* **12**: 324-349.

Jones, M.D. and L.C. Newal 1946. Pollination cycles and pollen dispersal in relation to grass improvement.*Univ. Nebraska Agric. Exp. Stat. Res. Bull.* 148.

Jones, M.D. and L.C. Newel 1948. Longivity of stigmas and anthers in grasses. *J. Amer. Soc. Agron.* **40**: 195-204.

Kapadia, G.A. 1945. Notes on some grasses from Junagadh. *J. Bombay Nat. Hist. Soc.* **45**: 259-262.

Karthikeyan, S. 1983. Endemic grasses of India with emphasis on rare, indeterminate and extinct species. In: Jain, S.K. & R.R. Rao (eds.) *An Assessment of Threatened Plants of India.* pp. 240-250, BSI, Calcutta.

Karthikeyan, S., S.K. Jain, M.P. Nayar and M. Sanjappa. 1989. *Flora Indicae Enumeratio-Monocotyledonae.* BSI, Calcutta.

Kubitzki, K. 1983. *Dispersal and Distribution : An International Symposium.* Hamberg.

Kurz, S. 1878. *Forest Flora of British Burma.* 2 Vols. Govt. Printing Press, Calcutta.

Lisboa, J.C. 1896. *List of Bombay Grasses and Their Uses.* Bombay.

Majumdar, R. 1956. Studies on the grasses of 24-Parganas (W.B.). *Bull. Bot. Soc. Bengal* **10**: 1-114.

Moulik, S. 1997. *Grasses and Bamboos of India.* Scientific Publishers, Jodhpur.

Mukteshkumar 1993. Status of Bamboo taxonomy in India. *BIC India Bulletin* 3(2): 29-36.

Muller, J. 1981. Fossil pollen records of extant Angiosperms. *Bot. Rev.* **47**: 1-145.

Munro, V. 1868. Monograph of the Bambusaceae. *Trans. Linn. Soc. London* **26**: 1-57..

Nair, V.J. and P.V. Sreekumar 1987. *Eragrostis rottleri* Stapf. In: Nayar, M.P. and A.R.K. Sastry (eds.) *Red Data Book of Indian Plants.* 1: 299. BSI, Calcutta.

Nair, V.J. and P.V. Sreekumar 1987. *Eriochrysis rangacharii* Fischer. In: Nayar, M.P. and A.R.K. Sastry (eds.) *Red Data Book of Indian Plants* 1: 300. BSI, Calcutta.

Nair, V.J. and R. Ansari 1987. *Limnopoa meeboldii* (Fischer) Hubb. In: Nayar, M.P. and A.R.K. Sastry (eds.) *Red-data Book on Indian Plants.* 1: 307-308. BSI, Calcutta.

Naithani, H.B. 1990. Nomenclature of Indian species of *Oxytenanthera* Munro. *J. Bombay Nat. Hist. Soc.* **87**(3): 439-440.

Nayar, M.P. 1980. Endemic flora of Peninsular India and its significance. *Bull. Bot. Surv. India* **22**: 12-23.

Patunkar, B.W. 1980. *Grasses of Marathwada.* Scientific Publishers, Jodhpur.

Philipson, W.R. 1934. Morphology of the lemma in grasses. *New Phytol.* **33**: 559.

Philipson, W.R. 1935. The development and morphology of the ligule in grasses. *New Phytol.* **34**: 310-325.

Pijl, L. van der 1982. *Principles of Dispersal in Higher Plants.* 3rd ed. Springer Verlag, New York.

Pohl, R.W. 1987. Man and the grasses : a history. In: Soderstrom *et al.* (eds.) *Grass Systematics and Evolution.* Smithsonian Institution, Washington.

Prain, D. 1903. *Bengal Plants*. 2. London.

Raizada, M.B., R.C. Bharadwaja and S.K. Jain 1961. Grasses of Upper Gangetic Plains - Panicoideae. Pt. I. *Indian For. Rec. (Bot.)* **4**: 171-277.

Raizada, M.B. and S.K. Jain 1964. Grasses of Upper Gangetic Plains Panicoideae. Pt. II. *Indian For. Rec. (Bot.)* **5**: 151-226.

Rheede, van H.A. 1678-1693. *Hortus Malabaricus*. 12 Volumes. Amsterdam.

Ridley, H.N. 1930. *The Dispersal of Plants Throughout the World*. Reeve & Co., London.

Roxburgh, W. 1814. *Hortus Bengalensis*. Serampore.

Roy, G.P. 1984. *Grasses of Madhya Pradesh*. BSI, Calcutta.

Ruprecht, F.J. 1839. *Bambuseas Monographic Exponit*. Petersburg.

Schantz, H.L. 1954. The place of grasslands in earth's cover of vegetation. *Ecology* **35**: 143-145.

Seethalakshmi, K.K. and M.S. Muktesh Kumar 1999. *Bamboos of India: A Compendium*. INBAR (KFRI), Peechi.

Sekine, Y. 1959. Ligule patterns of Poaceae. *J. Jap. Bot.* **34**: 129-138

Shukla, U. 1983. Endemism in the grass flora of North-east India. In: Jain, S.K. and R.R. Rao (eds.) *An Assessment of Threatened Plants of India*. pp. 138-141. BSI, Howrah.

Shukla, U. 1996. *Grasses of North-Eastern India*. Scientific Publishers, Jodhpur.

Sorenson, A.E. 1986. Seed dispersal by adhesion. *Ann Rev. Eco. Syst.* **17**: 443-463.

Singh, N.P., U.R. Deshpande and R.S. Raghavan 1976. Poaceae of Karnataka State. *Bull. Bot. Surv. India* **18**(1-4): 109-143.

Sreekumar, P.V. and V.J. Nair 1991. *Flora of Kerala Grasses*. BSI, Calcutta.

Symmonds, T.J. 1886. *Indian Grasses*. ed. 2. Madras.

Tanaka, H. 1975. Pollination of some Gramineae. *J. Jap. Bot.* **50**: 25-31.

Tewari, D.N. 1992. *A Monograph on Bamboo*. International Book Distributors, Dehra Dun.

Thomasson, J.R. 1978. Observations on the characteristics of the lemma and palea of the Late Coenozoic grass *Panicum elegans* Elias. *Amer. J. Bot.* **65**: 34-39.

Thomassson, J.R. 1980. Palaeo-agrostology : a historical review. *Iowa State J. Res.* **54**: 301-317.

Toole, E.H. and E. Brown 1946. Final results of the Duvel burried seed experiments. *J. Agric. Res.* **72**: 201-210.

Troughton, A. 1957. The underground organs of herbage grasses. *Comm. Burm. Past. Field Crops Bull.* **44**.

Tsvelev, N.N. 1983. *Grasses of Soviet Union* Part II. (English translation). Amerind Publishing Co., New Delhi.

Ved Prakash and S.K. Jain 1979. Poaceae : Tribe *Garnotieae*. *Fasc. Fl. India* **3**: 1-16. BSI, Calcutta.

Ved Prakash and S.K. Jain 1984. Poaceae : Tribe *Isachneae*. *Fasc. Fl. India* **14**: 1-42. BSI, Calcutta.

Ved Prakash, U. Shukla, D.C. Pal and S.K. Jain 1978. Addition to Indian grass flora in last two decades. *Bull. Bot. Surv. India* **20**: 143-147.

Voorhies, M.R. and J.R. Thomasson 1979. Fossil grass anthoecia within Miocene rhinoceros skeletons - direct evidence of diet in an extinct species. *Science* **206**: 331-333.

D.K. Singh

Saccharum rufipilum

Calamagrostis pseudophragmitis

Saccharum arundinaceum

Dev Raj Agarwal

Vetiveria zizanioides

D.K. Singh

Neyraudia reynaudiana

Dev Raj Agarwal

Melica canescens

ORCHIDACEAE

K. P. Singh
S. Phukan
P. Bujarbarua

Orchidaceae, the one of the largest families of flowering plants, exhibit amazing diversity in size, shape, structure, number, density, colour and fragnance of flowers. Orchids lend beauty and charm to the landscape due to their bewildering variety of flowers. Many species counts are available at world level ranging from 17,500 (Mabberley, 1990) to 30,000-35,000 (Gentry & Dodson, 1987). Dressler (1993) recognized 19,501 species under 803 genera for entire family. According to an IUCN report (Anonymous, 1996), there are about 20,000 species of orchids in the world flora. Further, the additions of more and more new species to the known total every year from all over the world keep changing the statistics of species, thereby indicating the richness and diversity of species within the family.

Majority of the orchid species are distributed between 30° North and South of equator. They grow vigorously under varied environmental conditions. High rainfall (1500-2500 mm per year) distributed over long period from April to October, relative humidity (70-90 per cent) and temperature (10°-25°C) are some of the important factors, which greatly influence the optimum growth of orchids. Other factors, like latitude, altitude and configuration of substratum and density of forests also have combined effect on the growth of orchids. Orchids grow in all terrestrial ecosystems except in polar and desert regions, but their greater diversity is found in tropical regions. *Herminium monorchis*, recorded from North Sikkim at an altitude of 4500 m shows the highest altitudinal limit for orchid distribution in India.

Orchids have fascinated people ever since their discovery by a Greek Philosopher Theophrastus, who referred a group of plants called '*Orchis*' in his book 'Enquary into Plants' The name orchid is derived from the Greek word '*Orchis*' meaning testes and refers to the paired tubers of terrestrial orchid genus '*Orchis*' and other similar genera. These plants bloomed in wild for centuries, and were collected and grown not for their flowers but for the under ground testiculate tubers which were considered to be aphrodisiac.

Orchids by habit are mostly herbaceous plants. Their size normally range from about 10 cm to 1 m. The smallest known orchid is *Oberonia affinis*. Some species of *Taeniophyllum, Pleurothalis, Bulbophyllum* are only few millimeters high, whereas the species of *Vanila* are long vines and may be 30 m or even more long. The *Oberonia affinis* again has flowers less than 1 mm in size, whereas the flowers of Mexican *Sobralia micrantha*, resembling bamboo orchid, is ca 20 cm across. *Grammatophyllum speciosum* is the bulkiest orchid that weighs many tens of kilograms. Plants of *Galeola* and *Grammatophyllum* could be 3-4 m long.

Orchids are mostly perennial plants and occur on variety of substratum as epiphytes (growing on tree trunks), lithophytes or rupicolous (growing on rocks), terrestrials (growing on ground) and saprophytes (growing on decaying matter). While growing as epiphytes orchids do not derive their nutrition from host plant. Instead, they absorb moisture from atmosphere for the survival of plants through a 'velamen' tissue developed in the aerial roots which hang in air or creep on the tree trunks. The nutrient is usually absorbed from humus by normal roots and is prepared through the process of photosynthesis in the leaves.

Orchids are extensively studied group of plants among the angiosperms and numerous publications are available at national and international level. In India, the earliest reference on orchids dates back to vedic period. The people of ancient India were well aware of medicinal properties of orchids. The medicinal values of some orchids including present day *Eulophia dabia, Flickingeria nodosa* and *Malaxis rheedi* were discussed in a classic Indian medicinal treatise the 'Charaka Samhita' written in Sanskrit language by Charaka. This formed the first record of Indian orchids and their uses in Ayurvedic medicine. Indian orchids were first introduced to outside world through the classical work of 'Hortus Malabaricus' by Van Rheede (1678-1693). Based on Rheede's descriptions Linnaeus (1753) gave binomials to many plants including few orchids, which were treated in the composite genus *Epidendrum*. Two ornamental genera *Cymbidium* and *Rhynchostylis* were established solely based on Rheede's (*l.c.*) illustrations. Linnaeus (*l.c.*) in his 'Species Plantarum', included 12 orchid species from India.

The next significant contribution on Indian orchids was made by Lindley (1857), who described 126 species from India based on the collections made by Nathaniel Wallich and others. Roxburgh (1832) gave an account of 57 species from India. Griffith's (1851) posthumous paper contains a long list of orchids, where altogether he described 147 species in 49 genera, recorded mostly from Khasi Hills and its surroundings.

Hooker (1888-1890) for the first time compiled all the taxonomic information available until then on Orchidaceae, as he had a vast field experience and gained deep knowledge of Indian orchids by spending four years in Meghalaya, Sikkim, Nepal and Bengal. He studied live, dried, pickled samples and made numerous illustrations and paintings on the spot. As a result he described about 1600 species from erstwhile British India. This was the beginning of modern study on Indian orchids.

Hooker (1895) later brought out an illustrated account of about 100 species on Indian orchids. Inspired by Hooker's (*l.c.*) work King and Pantling (1898) published beautifully illustrated account on orchids of Sikkim Himalaya. Other important publications at national level were made by Pradhan (1976, 1979), Bose and Bhattacharjee (1980), Abraham and Vatsala (1981) and Satish Kumar and Manilal (1994).

Besides, a number of other accounts on Orchidaceae from various parts of the country were also published. Important contributions from southern India were made by Fischer (1928) and Joseph (1987); Bombay by Blatter and McCann (1931-32) and Santapau and Kapadia (1966); North-West Himalayan orchids by Duthie (1906), Raizada *et al.* (1981), Seidenfaden and Arora (1982), Deva and Naithani (1986), etc.; and those from Eastern India Hegde (1984), Kataki (1984, 1986), Kataki *et al.* (1984), Singh *et al.* (1990), Chowdhery (1998), Hynniewta *et al.*, (2000), Barua (2001), etc.

DIVERSITY

The family Orchidaceae exhibit enormous species diversity in India on account of varied topographical, ecological and climatic conditions. The diversity is also supplemented by numerous species of adjacent and distant regions that are present in Indian flora. A variety of orchids are found mostly in tropical and subtropical forests. The total number of species in Orchidaceae varies according to different authors. Hooker (1888, 1890), described 1600 species from erstwhile British India. Pradhan (1976, 1979) described a total of 810 species from the present boundary of India. Bose and Bhattacharjee (1980) listed 996 species under 162 genera. Subsequently, Jain and Melhotra (1984) also listed about 925 species, distributed in 144 genera. More recently Sathish Kumar and Manilal (1994) recorded 1141 species of orchids under 166 genera from India. It is quite natural that these statistics keep changing in the light of new discoveries, additions and revisions that are made from time to time by various workers. According to the present estimate, based on literature survey and herbarium records, about 1195 species belonging to 177 genera of orchids are recorded from India (Table I). This constitutes 5.98 per cent (out of 20,000) of the world orchid flora and 6.83 per cent (out of 17, 500; Sharma *et al.*, 1997) of the flowering plants of India. An analysis of species diversity within genera presents an interesting data in the country as shown below.

Genera with	1 species	61
Genera with	2 species	30
Genera with	3-5 species	44
Genera with	6-10 species	17
Genera with	11-15 species	7
Genera with	16-25 species	8
Genera with	26-35 species	3
Genera with	36-50 species	2
Genera with	51-100 species	3
Genera with	101-150 species	2

It is observed from the above data that the maximum number of genera of Indian orchids belong to 1, 2, 3-5 and 6-10 species categories. The species diversity at generic level is equally interesting. Genus *Bulbophyllum* shows maximum diversity and is represented by 105 species. It is followed by *Dendrobium* (103 spp.), *Habenaria* (71 spp.), *Eria* (54 spp.), *Oberonia* (52 spp.), *Liparis* (43 spp.), *Coelogyne* (38 spp.), *Eulophia* (29 spp.), *Peristylus* (27 spp.), *Cymbidium* (25 spp.), *Calanthe* (25 spp.), etc.

A region wise analysis of genera and species of family Orchidaceae is also provided herein to throw some light on species diversity of orchids in different parts of the country.

Table I
Distribution of orchid species in India and neibouring countries.

Name of Taxa	Habitat	Status	Peninsular India	N. W. India	Central India	N.E. INDIA Sikkim	Arunachal Pradesh	Assam	Meghalaya	Nagaland	Manipur	Mizoram	Tripura	Andaman & Nicobar	Nepal	Bhutan	Sri Lanka	Myanmar	Thailand	Malaya	China
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ACAMPE																					
A. congesta	E		+														+				
A. ochracea	E		+			+	+	+	+	+	+	+	+		+	+	+	+	+		
A. papillosa	E		+	+	+	+	+	+	+	+	+	+	+		+	+		+	+		
A. praemorsa	E	R	+				+							+	+						
A. rigida	E		+	+		+	+	+	+	+	+				+		+	+	+		+
ACANTHEPHIPPIUM																					
A. bicolor	T	R	+		+												+				
A. striatum	T	R			+	+	+			+					+	+			+		
A. sylhetense	T		+			+	+	+	+		+	+						+	+		+
ACRIOPSIS																					
A. harae*	E	R				+															
A. indica	E	R											+					+	+	+	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ACROCHAENE																					
*A. punctata**	E					+	+		+												
AENHENRYA																					
*A. rotundifolia**	T	R	+																		
AERIDES																					
*A. crispa**	E	R	+																		
*A. emericii**	E	R												+							
A. falcata	E	R				+	+	+													
*A. maculosa**	E		+	+	+																
A. multiflora	E		+	+	+	+	+	+	+	+	+	+	+	+				+	+	+	
A. odorata	E		+	+	+	+	+	+	+	+	+	+	+		+			+	+		
A. vingens	E		+											+			+				
A. rosea	E			+	+		+	+	+	+		+				+		+	+	+	
A. williamsii	E	R					+														
AGROSTOPHYLLUM																					
A. brevipes	E					+	+	+	+	+					+	+			–		
A. callosum	E					+	+	+	+	+	+	+			+	+		+	+		+
*A. flavidum**	E	R							+												
*A. myrianthum**	E	R				+	+														
A. planicaule	E					+	+	+	+	+	+				+	+		+	+	+	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
AMITOSTIGMA																					
*A. puberula**	E	R				+															
ANDROCORYS																					
*A. gracilis**	TE	R				+															
ANIA																					
A. hookeriana	T		+			+	+											+	+		
ANOECTOCHILUS																					
*A. abbreviatus**	T	R	+			+						+									
*A. brevilabris**	T	R				+	+		+							+		+			
*A. clarkei**	T	En				+															
A. crispus	T	R		+		+	+		+	+					+	+					
*A. elatus**	T	R	+																		
A. elwesii	T					+	+	+	+	+	+					+		+	+		
A. grandiflorus	T	R				+	+		+	+		+				+					
*A. griffithii**	T	R								+		+									
A. lanceolatus	T	R				+	+		+						+				+	+	+
A. luteus	T							+		+		+									
*A. nicobaricus**	T	En												+							
A. pamrangianus	T	R							+						+						
A. regalis	T	R	+														+				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
*Anoectochilus roxburghii**	T	R		+		+	+	+	+	+	+	+				+				+	
A. sikkimensis	T					+	+	+	+	+		+									
*A. tetrapterus**	T	En									+										
A. tortus	T	R				+	+	+								+			+		
ANTHOGONIUM																					
A. gracile	T					+	+	+	+	+	+	+			+	+		+	+		
AORCHIS																					
A. roborovskii	T	R		+			+								+	+					
A. spathulata	T	R		+		+									+	+				+	
APHYLLORCHIS																					
*A. alpina**	T	R				+	+														
*A. gallanii**	S	Ex		+																	
A. montana	S		+			+	+	+	+	+		+					+				
*A. parishii**	T	R				+															
*A. vaginata**	T	R							+												
APOSTASIA																					
A. nuda	T	R						+	+									+	+		
A. odorata	T	R					+	+	+										+		
A. wallichii	T	R				+		+	+						+		+	+			

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
APPENDICULA																					
A. cornuta	E					+		+										+	+		+
A. reflexa	E													+			+		+		
ARACHNIS																					
A. flosaeris	E						+	+												+	
A. labrosa	E					+	+	+	+	+					+	+		+			
ARCHINEOTTIA																					
*A. microglottis**		R		+																	
ARUNDINA																					
A. graminifolia	T		+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
ASCOCENTRUM																					
A. ampullaceum	E			+		+	+	+			+	+		+	+	+	+	+	+	+	
A. curvifolium	E	R					+										+	+	+		
A. himalaicum	E						+									+					
A. semiteretifolium	E	R					+														
BHUTANTHERA																					
B. albomarginata	T	R			+	+															
BIERMANNIA																					
*B. bimaculata**		R				+	+														
*B. jainiana**		R					+														

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
*Biermannia quinquecallosa**		R				+															
BRACHYCORYTHIS																					
B. acuta	T	R										+							+	+	
B. galeandra	T	R		+	+				+						+			+			+
Brachycorythis helferi	T	R						+	+			+				+		+	+		
B. iantha	T		+				+	+	+									+			
B. obcordata	T	R	+	+	+		+								+	+		+	+		+
*B. splendida**	T	R	+																		
*B. wightii**	T	R	+															+			
BULBOPHYLLUM																					
*B. acutiflorum**	E		+				+														
B. affine	E			+			+	+	+	+					+	+			+		
*B. agastymalayanum**	E	R	+																		
*B. albidum**	E	R	+																		
B. amplifolium	E	R					+									+		+			+
B. andersonii	E	R				+	+														+
*B. aureum**	E	R	+																		
B. bisetum	E					+	+		+			+			+				+		
B. blepharistes	E	R							+									+	+	+	
B. brienianum	E	R					+									+		+		+	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Bulbophyllum capillipes	E						+	+										+			
B. careyanum	E		+	+		+	+		+		+	+			+	+		+	+		
B. cariniflorum	E		+	+			+		+						+	+					
B. caudatum	E					+	+			+					+						
*B. cauliflorum**	E					+	+		+	+											
*B. clarkeanum**	E	R				+	+														
B. congestum	E	R				+			+							+		+	+		+
*B. cornu-cervi**	E	R				+	+														
B. crassipes	E	R	+			+	+							+				+	+		
B. cupreum	E	R					+											+	+		
B. cylindraceum	E					+	+	+	+	+	+	+				+			+		
B. delitescens	E	R					+	+	+		+										+
*B. depressum**	E	R							+												
B. dyerianum	E	R				+				+					+						
*B. ebulbum **	E	R				+	+														
*B. ellasonotum**	E	R						+													
B. elatum	E	R				+	+			+					+	+					
B. elegans	E	R	+														+				
*B. elegantulum**	E	R	+																		
B. emarginatum	E	R					+									+			+		+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Bulbophyllum eublepharum	E	R				+	+								+						
*B. fimbriatum**	E	R	+																		
B. fischeri	E		+			+	+														
*B. flavidum **	E	R				+															
B. forrestii	E	R						+								+	+		+		
*B. fusco-purpureum **	E	R	+																		
*B. griffithii**	E	R				+	+		+												
B. guttulatum	L			+		+	+	+	+	+					+		+				
B. gymnopus	E					+	+		+	+	+	+				+					
B. gyrochilus	E	T							+										+		
B. hastatum	E	R					+														
B. helenae	E	R		+		+	+		+	+	+	+			+	+		+	+		
B. hirtum	E	R				+	+		+	+		+			+			+	+		
B. hookeri	E			+			+	+		+					+						
B. hymenanthum	E	R				+	+		+												
*B. josephii **	E	R	+																		
*B. kaitense **	E	R	+																		
*B. keralensis **	E	R	+																		
*B. kingii **	E	R				+															
B. khasyanum	E	R			+	+	+		+						+	+		+	+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Bulbophyllum leopardinum	E			+		+	+		+	+	+	+			+	+	+	+	+		
B. lepidum	E	R												+					+	+	
*B. leptanthum**	E	R				+			+												
B. lilacinum	E	R												+							
B. listeri	E	R		+											+	−					
B. lobbii	E	R					+			+	+	+						+	+	+	
B. macraei		R	+				+										+				
B. macranthum	E	R												+				+	+		
B. monanthum	E	R					+		+							+			+		
B. moniliforme	E									+	+	+						+	+		
*B. mysorense**	E	R	+																		
B. neilgherrense	E		+				+		+												
*B. nodosum**	E	Ex	+																		
*B. obrienianum**	E	R					+	+													
B. odoratissimum	E					+	+			+		+			+	+		+	+		
*B. ornatissimum**	E	R				+	+			+											
*B. panigrahianum**	E	R			+																
B. parviflorum	E	R					+											+			
*B. parryae**	E	En										+									
B. pectinatum	E	R						+			+								+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Bulbophyllum penicillium	E					+	+		+	+						+		+			
B. picturatum	E	R										+						+	+		
B. piluliferum *	E	C				+	+														
B. polyrhizum	E	R	+	+	+	+	+			+	+	+			+			+	+		
B. protractum	E	R				+	+		+						+			+	+		
B. proudlockii *	E	R	+	+	+																
B. psychoon *	E	R		+				+													
B. pulchrum *	E	R					+														
B. pusillum	E	R			+	+													+		
B. raui *	E	R		+																	
B. refractum	E			+		+				+		+				+					
B. repens	E			+		+	+		+	+	+	+						+	+		+
B. reptans	E	C		+		+	+	+	+	+	+	+			+			+	+		+
B. retusiusculum	E					+	+		+	+					+	+		+	+	+	+
B. rheedii *	E		+																		
*B. rigidum**	E	R				+															
B. rolfei	E	R					+			+					+	+					
B. rothschildianum *	E	R								+											
B. roxburghii *	E	R			+					+											
B. rufinum	E	R				+							+				+				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Bulbophyllum sarcophyllum	E	R				+	+		+							+					
B. scabratum	E		R				+			+						+					
B. secundum	E			+			+	+		+		+			+			+	+		+
B. sessile	E	R												+				+	+		
B. sikkimensis *	E	R				+	+														
B. silentvalliensis *	E	R	+																+		+
B. spathulatum	E	R				+	+					+						+	+		
B. striatum	E	R				+	+		+						+						
B. tremulum *	E		+																		
B. trichocephallum	E	R					+		+										+		+
B. tricorne	E	R	+						+												
B. triste	E			+	+	+	+	+	+	+	+	+						+			
B. umbellatum	E			+		+			+	+	+	+	+		+	+					
B. viridiflorum	E			+		+	+		+	+		+			+	+					
B. wallichii	E			+		+	+	+		+	+	+			+	+		+	+		
B. xylophyllum	E	R					+					+				+					
B. yoksunense	E	R				+	+								+	+					
BULLEYIA																					
B. yunnanensis	E	R				+	+									+					+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
CALANTHE																					
C. aujonii *	T	R				+															
C. alismaefolia *	T			+		+	+		+												
C. alpina	T	R		+		+	+			+					+						+
C. angusta	T					+	+	+	+	+	+					+			–		+
C. biloba	T					+	+	+		+	+				+			+	–		–
C. brevicornu	T			+		+	+			+	+	–			+						
C. chloroleuca	T					+	+			+					+						
C. clavata	T					+	+	+	+	+								+	+		
C. densiflora	T					+	+	+	+	+	+	+						+			+
C. elytroglossa *	T	R				+															
C. griffithii	T	R					+			+						+					
C. herbacea *	T	R				+	+		+	+											
C. keshabii *	T	R				+															
C. manii	T	R		+		+	+	+	+	+	+	+			+	+			+		+
C. masuca	T		+	+	+	+	+	+	–	+	+	+			+			–	+	–	+
C. pachystalix	T	En		+			+								–						
C. plantaginea	T			+			+			+					–	+					
C. puberula	T			+		+	+		+	+					–	+					
C. purpurea	T	R	+														+				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Calanthe sikkimensis *	T																				
C. tricarinata	T			+		+	+		+	+	+	+			+	+				+	
C. triplicata	T		+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
C. trulliformis	T					+	+								+						
C. uncata *	T	R				+															
C. whiteana *	T	R				+															
CEPHALANTHERA																					
C. damasonium	T	+					+														
C. longifolia	T			+		+	+	+				+			+	-					
C. thomsonii	T	R				+															
CEPHALANTHEROPSIS																					
C. gracilis	T					+	+	+	+		+	+						−	+		+
CERATOSTYLIS																					
C. himalaica	E					+	+	+	+	+	+	−			+	+		+		+	+
C. subulata	E					+	−			+				+					+		
C. teres	E					+	+	+	+							+					-
CHAMAEGASTRODIA																					
C. asrana	S						+														
C. shikokiana	S	R					+														

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
CHEIROSTYLIS																					
C. flabellata	T	R	+				+										+				
C. griffithii	T			+			+	+	+	+					+	+		+	+		
*C. gunnarii**	T	R					+														
C. moniliformis	T	R					+								+	+					
*C. munnacampensis**	T	R					+														
C. parvifolia	T	R	+														+				
C. pusilla Lindl.	T	R					+		+						+						
*C. seidenfadeniana**	T	R	+																		
*C. sessanica**	T	R					+														
*C. sippica**	T	R					+														
CHILOSCHISTA																					
*C. glandulosa**	E	R	+																		
C. lunifera	E		+			+				+	+	+		+	+	+		+	+	+	
C. parishii	E	R					+							+	+	+		+	+		
C. pusilla	E	R	+														+				
C. usneoides	E			+		+			+						+	+				+	
CHRYSOGLOSSUM																					
*C. hallbergii**	T	R	+																		
C. maculatum	T		+														+				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Chrysoglossum ornatum	T	R				+	+								+	+			+	+	
C. robinsonii	T	R					+														
CLEISOCENTRON																					
C. trichromum	E					+	+	+	+	+	+					+					
CLEISOSTOMA																					
C. appendiculatum	E		+		+	+	+			+	+	+						+	+	+	
C. arietinum	E	R						+										+	+	+	
C. aspersum	E			+		+	+		+	+		+						+	+		
C. discolor	E	R	+			+	+												+	+	
C. elegans	E	R												+				+		+	
C. filiforme	E					+	+	+	+	+	+	+	+		+			+	+		
C. paniculatum	E					+	+		+	+	+	+	+						+		+
C. racemiferum	E					+	+	+	+	+	+	+	+		+	+			+	+	
C. sagittiforme	E	R							+										+		+
*C. sikkimensis**	E	R				+															
C. simondii	E	R				+	+												+		
C. striatum	E					+		+		+									+		+
*C. stricolatum**	E													+							
C. subulatum	E					+	+	+	+	+		+						+	+	−	
C. tenuifolium	E	R	+														+		+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
*Cleisostoma tricallosum**	E	R					+														
C. uraiensis	E	R												+							
C. williamsonii	E						+			+				+		+			+	+	+
COELOGLOSSUM																					
C. viride		R		+											+	+					+
COELOGYNE																					
*C. albolutea**	E	Ex																			
*C. arunachalensis**	E	R					+														
C. assamica	E	R						+								+		+	+		+
C. barbata	E						+	+	+	+	+	+				+		+			
C. breviscapa	E		+														+				
C. corymbosa	E					+	+		+	+	+				+	+		+			
C. cristata	E	+		+		+	+		+						+	+					+
C. fimbriata	E			+		+	+	+	+		−		+		+	−		+	+	+	+
C. flaccida	E			−		+	+		+	+	+	+			+			+	+		
C. fuliginosa	E	R					+		+									+			
C. fuscescens	E					+	−		+			+			+	+		+	+		
*C. ghatakii**	E	R									+										
*C. glandulosa**	E	R	+																		
*C. griffithii**	E	R					+			+	+	+									

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
*Coelogyne kajrae**	E	R					+														
*C. hitendrae**	E	R								+											
C. holochila	E	R					+		+			+						+			
C. huettneriana	E	R									+	+									
C. longipes	E					+	+		+	+											
C. micrantha	E						+		+	+	+	+						+			
*C. mossiae**	E	V	+																		
*C. nervosa**	E		+																		
C. nitida	E			+		+	+		+			+			+	+		+	+		
C. occultata	E					+	+			+						+					
C. odoratissima	E	R	+														+				
C. ovalis	E			+		+	+		+	+		+			+	+		−	+		+
C. prolifera	E					+	+	+	+	+		+			+	+		+			
C. punctulata	E					+	+		+		+	+			+	+		+			
C. quadriloba	E	R												+					+		
C. radicosa	E						+														
C. raizadae	E	R				+	+		+	+						+					
C. rigida	E	R					+		+	+								+	+		
C. rossiana	E	V						+				+						+			
C. schultesii	E					+	+	+	+	+	+	−			+	−		+	+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Coelogyne stricta	E			+		+	+	+	+	+	+	+			+	+		+			
C. suaveolens	E						+	+	+		+							+	+		
C. thailandica	E													+					+		
C. treutleri	E	Ex				+															
C. viscosa	E						+	+	+		+	+	+					+	+		
COLLABIUM																					
C. assamicum	T	R						+													+
C. chinense	T	R					+												+		+
CORALLORHIZA																					
*C. anandae**	E	R		+																	
C. trifida	S	R		+		+									+						
CORYBAS																					
C. himalaicus	T	R				+															+
*C. purpureus**	T,E	R							+												
CORYMBORKIS																					
C. veratrifolia	T	R	+			+	+	+				+		+			+	+	+		+
COTTONIA																					
C. peduncularis	E	R	+				+										+				
CREMASTRA																					
C. appendiculata	T	R				+	+	+							+	+			+		+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
CREPIDIUM																					
C. aphylla *	S	R,Th				+	+														
C. saprophyta *	S	R				+	+														
CRYPTOCHILUS																					
C. lutea	E	R		+		+	+		+	+	+				+	+					
C. sanguinea	E	R				+	+		+	+		+			+						
CRYPTOSTYLIS																					
C. arachnites	E	R				+		+	+								+		+		
CYMBIDIUM																					
C. aloifolium	E		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
C. bicolor	E		+	+		+	+								+		+		+	+	
C. cochleare	E	R				+	+			+		+									
C. cyperifolium	T			+		+	+		+	+	+	+			+	+		+	+		+
C. dayanum	E	R				+	+	+										+	+	+	+
C. devonianum	E	R		+		+	+		+			+			+	+			+		
C. eburneum	E	V		+		+	+			+	+	+			+			+	+		+
C. elegans	T,E			+		+	+	+	+	+	+	+			+	+		+			+
C. ensifolium	T					+	+		+			+					+	+	+		
C. erythraeum	E	R				+									+	+		+			+
*C. gammieanum**	E	R				+	+														

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Cymbidium goeringii	T	R					+												+		+
C. hookerianum	E	R, En		+		+	+	+				+			+	+		+	+		+
C. insigne	E	R							+		+								+		+
C. iridioides	E	Th		+		+	+		+	+	+	+			+	+		+			+
C. lancifolium	T					+	+	+	+		+	+			+	+		+	+	+	−
C. lowianum	E, T			+			+		+	+								+	+		+
C. macrorhizon	S			+		+	+	+	+	+		+			+	+		+	+		+
C. mastersii	E, T					+	+	+	+	+	+	+						+	+		
C. munronianum	E					+			+							+					
C. parishii	E	R					+														
C. sinense	T						+		+									+	+		+
C. tigrinum	E	R								+	+							+	+		
C. tracyanum	E					+			+									+	+		+
C. whiteae *	E	En				+															
CYPRIPEDIUM																					
C. cordigerum	T	R		+		+									+	+					+
C. elegans	T	R		+		+									−	+					+
C. guttatum	T					+															
C. himalaicum	T	R		+		+									+	+					
C. macranthon		R		+		+	+								+	+					+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
CYRTOSIA																					
*C. falconeri**	S	R				+	+					+									
C. javanica	S	R					+										+				
C. lindleyana	S	R			+	+	+	+		+	+	+		+							+
DACTYLORHIZA																					
D. hatagirea	T	R		+		+	+								+						
D. kafiriana				+																	
DENDROBIUM																					
D. acinaciforme	E						+	+	+	+	+	+						+	+		+
D. aduncum	E					+	+	+								+		+	+		+
D. amoenum	E	R		+		+	+								+	+		+			
*D. azamalayanum**	E	R	+																		
D. anceps	E					+	+	+	+			+	+	+	+	+		+	+		
D. aphyllum	E		+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+
*D. aqueum**	E	R	+																		
*D. barbatulum**	E		R	+																	
D. bellatulum	E	R									+							+	+		+
D. bensonae	E	R									+	+						+	+		+
D. bicameratum	E		+	+	+	+	+			+		+			+	+		+	+		
D. brymerianum	E	R									+							+	+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Dendrobium candidm	E	R		+		+	+		+						+	+					
D. capillipes	E	R										+						+	+		+
D. cariniferum	E	Th							+	+	+	+						+	+		+
D. cathcartii	E	Th	+			+	+					+						+	+		+
D. chrysanthum	E			+		+	+		+	+	+	+			+	+		+	+	+	+
D. chryseum	E			+		+		+	+	+					+			+	+		+
D. chrysotoxum	E	R, Th					+			+	+	+						+	+		
D. crepidatum	E		+	+	+	+	+	+	+	+	+	+			+	+		+	+		+
D. cretaceum	E						+	+			+	+		+				+	+		
D. crumenatum	E	R												+			+	+	+	+	+
D. crystallinum	E	R				+												+	+		
D. cumulatum	E	R												+			+	+	+		
*D. darjeelingensis**	E	R				+															
D. densiflorum	E					+	+		+	+	+	+			+	+		+	+		−
D. denudens	E			+		+	+		+			−			+			+	+		+
D. devonianum	E						+		−	+	+	+				+		+	−		−
D. diodon	E	R	+																		
D. draconis	E	R									+							+	+		
D. eriiflorum	E			+		+	+	+	+		+			+	+	+		+	+		
D. falconeri	E						+	+	+	+	+		+		+	+		+	+		+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Dendrobium farmeri	E					+	+	+		+	+	+			+	+		+	+	+	
D. fimbriatum	E		+	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+	+
D. formosum	E		+		+	+	+	+	+		+	+		+	+			+	+		+
D. gamblei *	E	R				+															
D. gibsonii	E	Th				+	+		+			+			+	+		+	+		+
D. grande	E	En												+				+	+	+	
D. gratiosissimum	E	R									+							+	+		+
D. griffithianum	E	R						+										+	+		
*D. gammarii**	E		R											+	+						
D. haemoglossum	E		R	+														+			
*D. herbaceum**	E		R	+		+															
D. heterocarpum	E		+	+		+	+		+	+	+	+			+	+	+	+	+	+	+
*D. heyneanum**	E	R	+		+																
D. hookerianum	E					+	+	+	+	+		+			+						
D. indragiriense	E		R												+					+	+
D. infundibulum	E	R									+	+						+	+		
D. jenkinsii	E					+	+	+	+	+	+					+		+	+		+
*D. jerdonianum**	E	R	+																		
D. kentrophyllum	E	R					+	+											+	+	
*D. khasianum**	E									+											

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Dendrobium lindleyi	E					+	+	+	+	+		+			+	+		+	+		+
D. lituiflorum	E						+	+			+	+	+					+	+		+
D. longicornu	E					+	+		+	+	+	+			+	+					
D. macrostachyum	E	R	+	+			+										+				
D. mannii	E	R					+	+											+	+	
*D. microbulbon**	E	R	+		+																
*D. miserum**	E		R						+												
D. monticola	E			+		+	+								+				+		+
D. moschatum	E			+		+	+	+	+	+	+	+	+		+	+		+	+	+	
*D. nanum**	E	R	+																		
*D. nareshbahadurii**	E	R					+														
D. nathanielis	E	En						+										+	+		
D. nobile	E				+	+	+		+	+	+	+			+	+		+	+		+
*D. normale**	E	R		+																	
D. nutantiflorum	E	R	+														+				
D. ochreatum	E								+	+	+	+						+	+		+
*D. ovatum**	E	R	+																		
D. palpebrae	E	R					+											+	+		
D. panduratum	E	R	+														+				
D. parciflorum	E	R					+	+											+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Dendrobium parcum	E	R									+							+	+		+
D. parishii	E	R, Th					+			+	+	+						+	+		+
D. pauciflorum	E	R				+	+									–			+		
D. peguanum	E	R	+		+	+									+			+	+		
D. pendulum	E	R					+					+			+			+	+		+
*D. pensile**	E	R												+							
*D. perula**	E	R						+	+												
*D. plicatile**	E	R												+							
D. podagraria	E	R						+					+					+	+		
D. porphyrochilum	E			+		+	+		+		+				+	+		+	+		+
D. primulinum	E			+			+				+	+		+	+			+	+		+
D. pulchellum	E						+	+	+		+	+			+			+	+	+	
D. ramosum	E	R				+					+										
D. regium	E	R	+		+																
*D. rhodocentrum**	E	En							+												
D. ruckeri	E	R				+			+			+				+					
D. secundum	E	R												+				+	+		
D. seidenfadenii	E	R									+	+						+	+	+	
*D. shompenii**	E	R												+							
*D. spathaceum**	E	R			+	+															

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Dendrobium stuposum	E					+	+		+		+					+		+	+		+
D. sulcatum	E					+	+		+		+	+		+				+	+		
*D. tenuicaule**	E	En												+							
D. terminale	E	R				+	+	+	+			+						+	+	+	+
D. thyrsiflorum	E	R								+	+							+	+		+
D. tortile	E	En												+				+	+	+	
D. transparens	E		+	+	+	+	+	+	+	+	+	+	+		+	+					
D. wardianum	E						+			+	+					+		+	+		+
D. wattii	E	En									+							+	+		
*D. wightii**	E	R	+																		
D. williamsonii	E	R						+	+		+							+	+		+
DICKASONIA																					
D. vernicosa	E											+							+		
DIDICIEA																					
D. cunninghamii	T	R		+		+															+
DIDYMOPLEXIS																					
*D. himalaica**	T							+													
D. pallens	T		+			+	+	+	+									+	+		+
DIGLYPHOSA																					
D. latifolia	T	R					+														

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
DIPHYLAX																					
D. griffithii	T	R		+																	
D. urceolata	T			+		+	+			+					–	+	–				
DIPLOCENTRUM																					
D. congestum *	E	R	+																		
D. recurvum	E	R	+														+				
DIPLOMERIS																					
D. hirsuta	T	R, En		+		+	+								–	+					
D. josephii *	T	R					+														
D. pulchella	T	R, En					+		+						+			+			
DIPLOPRORA																					
D. championii	E		+			+	+		+					+				–			+
D. truncata	E	R					+												+		
DISPERIS																					
D. monophylla *	T		+																		
D. neilgherrense *	T	R	–																		
D. zeylanica	T	R	+														+				
DORITIS																					
D. pulcherrima	E							+	+		+							+	–		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
EPIGENEIUM																					
E. amplum	E					+	+	+	+	+	+	+	+	+	+	+		−	+		
E. chapaense	E	R					+														
E. fuscescens	E					+			+	+	+	−	−		+	+					+
E. navicularis	E						+		+						+	+		+			+
E. rotundatum	E					+	+			+					+	−		+			−
EPIPACTIS																					
E. gigantea	T	R		+		−									+	+					+
E. helleborine	T	R		+		+									−	+					+
E. persica	T	R		+																	
E. royleana	T			+		+															
E. veratrifolia	T		+	+												+					
EPIPOGIUM																					
E. africanum	S	R	+				+														
E. aphyllum	S	R		+											+	+		+			+
E. indicum *	S							+													
E. roseum	S			+	+		+	+	+	−			+			+		−		+	+
E. sessanum *	S	R					+														
E. tuberosum	S	R		+											+						

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ERIA																					
E. acervata	E					+	+		+	+	+	+			+			+	–		–
E. alba	E	R		+		–										+					
*E. albiflora**	E	R	+																		
E. amica	E			+		+	–	+	+	–		+			+	+		+	+		+
*E. andamanica**	E	R												+							
E. apertiflora	E						+	+	+									+	–		
E. bambusifolia	E		+			+	+		+		+	–						+	–		–
E. biflora	E					+	+	+	+									+	–	–	
E. bipunctata	E	R					+		+										–		
E. bractescens	E					+	+	+		+				+	+	+		+	+	+	
E. carinata	E					+	+	+	+						–	+					
*E. clausa**	E	R				+	+														
E. clavicaulis	E		+				+	+										+	+		
*E. connata**	E	R					+														
E. coronaria	E			+		+	+		+		–	+			+	+			+		+
E. corneri	E	R					+														–
*E. crassicaulis**	E	R							+												
E. cristata							+														
*E. dalzellii**	E	R	+																		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Eria excavata	E			+		+	+	+	+	+	+	+			+						
E. exilis *	E	R	+																		
E. ferruginea *	E						+		+												
E. glandulifera *	E	R							+												
E. globulifera *	E	R					+														
E. graminifolia	E			+		+	+								+	+					
E. javanica	E			+		+	+				+				+	+			+	+	
E. jenglingensis *	E	R					+														
E. lacei	E	R										+						+			
E. lasiceps	E	R				+			+									+	-		
E. lohatensis *	E	R					+														
E. macrochilos *	E	R	+																		
E. muscicola	E		+	+		+	+	-	+		+	+			+		+	+	+		-
E. mysorensis *	E	R	-																		
Eria nana *	E	R	+																		
E. obesa	E	R										+						+	-		
E. occidentalis *	E	R		+																	
E. paniculata	E					+	+	+	-	+		+			+	-	+	+			
E. pannea	E					+	+	+	+	+	+	+				+		+	+		+
E. pauciflora *	E	R	+																		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Eria polystachya *	E	R	+																		
E. pseudoclavicaulis *	E	R	+																		
E. pubescens	E			+	+	+	+		+		+	+			+	+		+	+		
E. pudica	E			+		+	+	+	+	+		+	+	+	+	+		+			+
E. pumila	E					+	+	+	+									+	+		
E. pusilla	E	R					+		+									+	+		+
E. reticosa *	E		+	+																	
E. scabrilinguis *	E	R				+															
E. sharmae *	E							+													
E. spicata	E			+		+	+	+	+	+	+	+			+			+	+		+
E. stricta	E					+	+	+	+	+					+						
E. suspensa	E	R									+										
E. tiagii *	E	R	+																		
E. tomentosa	E					+	+	+	+			+					+	+	+		
E. vittata	E					+	+				+							+			
ERIODES																					
E. barbata	E								+			+						+			+
ERYTHRODES																					
E. blumei	T						+		+								+				
E. humilis	T		+														+				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
*Erythrodes seshagiriana**	T	R					+														
ERYTHRORCHIS																					
E. achobiensis	S						+														
ESMERALDA																					
E. cahcartii	E					+	+		+						+						
E. clarkei	E					+	+		+			+			+	+		+	+		+
EULOPHIA																					
E. andamanensis		En												+				+	+	–	
E. bicallosa	T	R		+		+	+	+	+	+	+	+			+			+		+	+
E. bracteosa	T	R				+			+									+			
*E. candida**	T	R				+		+													
E. cullenii	T	R	+	+											+						
E. dabia	T		+	+	+	+	+							–	+			+	+		
*E. emilianae**	T		R	+																	
E. epidendracea	T	R	+		+												–				
E. explanata	T	R	+	+											+						
E. flava	T	R	+	+	–										+			+	+		+
E. geniculata	T	R				+													+		
E. graminea	T		+	+		+		+		+	+	+	+	+	+	+	+	+	+	+	–
E. herbacea	T		+	+	+	+		+			+	+	+	+	+						

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Eulophia hormusjii	T	R		+			+								+	+					
E. kamrupa *	T	R						+													
E. mackinnonii	T	R		+	+										+						
E. macrobulbon	T	R				+												+	-		
E. manii *	T	R						+													
E. nicobarica *	T	Rn													-						
E. nuda	T		+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+
E. obtusa	T	R		+											-						
E. ochreata *	T	R	+																		
E. pulchra	T	R	+															+			
E. ramentacea *	T	R	+																		
E. sanguinea	S	C				+	+		+								+				
E. santapaui *	TS	R							+												
E. spectabilis		R	+					+						+	-	+		-	+		+
E. uchli *	T	R		+																	
E. zollingeri	S					+	+										-				
EVRARDIANTHE																					
E. asraoa *	E								-												
FLICKINGERIA																					
F. albopurpurea	E	R					+												-		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Flickingeria bancana	E	R					+												+		
F. fimbriata	E													+					+		+
F. fugax	E			+		+	+	+		+	+	+	+		+	+		+	+		
F. hesperis *	E	R		+																	
F. macraei	E		+			+	+			+		+			+	+	+	+			
F. nodosa *	E		+																		
F. ritaeana	E						+												+		
GALEOLA																					
G. altissima	S	R					+	+										+			
G. cathcartii	S	R				+													+	+	
G. nudifolia	S	R				+	+									+		+	+	+	
GASTROCHILUS																					
G. acaulis	E	R	+		+												+				
G. acutifolius	E			+		+	+		+												
G. affinis *	E	R				+	+														
G. arunachalensis *	E	R					+														
G. bigibbus	E	R	+															+	+		
G. calceolaris	E			+		+	+	+	+	+	+	+	+		+	+			+	+	+
G. corymbosus *	E	R				+															
G. crassilabris *	E								+												

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Gastrochilus dasypogon	E		+			+	+	+							+				+		
G. distichus	E			+		+	+		+	+	+	+			+	+					
G. flabelliformis *	E	R	+																		
G. inconspicuus	E			+		+	+	+		+					+						
G. intermedius	E	R				+	+		+							+			+		
G. nilagiricus *	E	R	+																		
G. obliquus	E	R				+	+	+	+	+				+		+		+	+		
G. pseudodistichus	E	R		+		+			+	+	+	+							+		+
G. rutilans	E	R					+														
G. sessanicus *	E	R					+														
GASTRODIA																					
G. arunachalensis *	T	R					+														
G. dyeriana *	T	R				+															
G. elata	T	R				+															+
G. exilis *	T	R							+												
G. mishmensis *		R					+														
G. orobanchoides	T	R		+																	
GEODORUM																					
G. appendiculatum *	T	R					+		+	+											
G. citrinum	T	R			+													+	+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Geodorum densiflorum	T		+	+		–	–	+		+	+	–	+		–		–	+	–		
GOODYERA																					
G. alveolata	T	R				+										–					
G. biflora	T	R		+			+								+						
G. cordata	T							+	+	–					+	+			+		
G. foliosa	T			–		+	+	+	+	–		–			–	+		–	+	–	
G. fumata	T		–		+	+	+										–		–		
G. fusca	T	R		–		+	+								+	–		+			+
G. grandis *	T	R				–	–								–						
G. hemsleyana	T						–								–						
G. hispida	T				–	–	–		+										+		
G. macrantha	T	R					–														
G. prainii *	T	R								+											
G. procera	T		+	–	+	+	+	–	+	–		–	–		+	+		+	–	–	+
G. recurva *	T	R					+		–												
G. repens	T	R				–	+	+							+						
G. robusta *	T	R							–												
G. schlechtendaliana	T					+	+		–	+	–	+			+	–		+		+	–
G. secundiflora *	T								–		–										
G. thailandica	T	R	+		+														–		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Goodyera viridiflora	T			+			+	+	+	+					+	–		+	+		–
G. vittata	T					+	+														
GROSOURDYA																					
G. appendiculata	E	R												+				+	+	+	
G. muscosa	E	R												+					+	+	
GYMNADENIA																					
G. camtschatica	T	R		+															+		
G. orchidis	T		R		+		+	+								+	+			+	
HABENARIA																					
H. acuifera	T						+		–	+	–	+						+	+	+	–
H. acuminata	T	R	+														+				
H. aitchisonii	T	R		+		+									+	+					
H. andamanica *	T	R												+							
H. arcuata *	T			+																	
H. arietina *	T			+		+	+		+	+											
H. barbata	T	R	+																		
H. barnesii *	T	R	+																		
H. caranjensis *	T	R	+																		
H. cephalotes *	T	R	–																		
H. clavigera	T	R		+																	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Habenaria commelinifolia	T		+	+	+	+		+					+	+	+			+	+		
H. concinna *	T	R							+												
H. crassifolia *	T	R	+		+																
H. cubitalis	T	R							+								+	+			
H. cumminsiana *	T	R				+	+														
H. decipiens	T		+																		
H. dentata	T			+		+	+		+	+		+			+	+		+	+		
H. dichopetala	T	R	+														+				
H. digitata	T		+	+		+	+	+										+	+		
H. diphylla	T		+	+																	
H. edgeworthii	T	R		+											+						
H. elliptica *	T	R	+																		
H. elwesii *	T	R	+	+																	
H. ensifolia	T			+		+	+		+						+	+					
H. flabelliformis *	T	R	+																		
H. foetida *	T	R	+																		
H. foliosa *	T	R	+																		
H. furcifera	T		+	+	+	+		+		+	+	+	+			+	+	+	+	+	
H. gibsonii *	T	R	+		+																
H. glandifloriformis *	T	R	+																		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Habenaria griffithii *	T	R	+																		
H. heyneana *	T	R	+																		
H. hollandiana	T		+		+																
H. indica *	T	R	+																		
H. intermedia	T	R		+		+									+						
H. josephii	T	R		+		+															
H. khasiana	T	R							+		+	+							+		
H. longicorniculata *	T	R	+																		
H. longicornu *	T	R	+			+															
H. longifolia	T	R		+											+						
H. macrophyllum	T	R				+									+	+					−
H. macrostachya	T	R	+													+					
H. malintana	T	R	+		+	+				+	+							+	+		+
H. malleifera	T	R				+			+			+	+								+
H. mandersii	T							+	+	+	+										
H. marginata	T		+	+	+	+		+					+		+	+		+	+		
H. multicaudata *	T	R	+																		
H. nematocaulon	T					+															
H. oligantha *	T						+														
H. ovalifolia *	T			+																	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Habenaria pachycaulon *	T						+														
H. pallideviridis *	T			+																	
H. panchganiensis *	T	R	+																		
H. panigrahiana *	T			+		+															
H. pectinata	T			+		+	+		+						+	+					+
H. perrottetiana *	T			+																	
H. plantaginea	T		+	+		+															
H. polyodon *	T	R	+																		
H. polytricha	T					+															
H. pubescens	T			+		+									+						
H. ramayyana *	T		+																		
H. rariflora *	T			-																	
H. reflexa	T						+													+	−
H. reniformis	T	R						+	+						−				+		−
H. richardiana *	T		-																		
H. roxburghii *	T	R	+		+																
H. seshagiriana *	T	R					+														
H. stenopetala	T			+	+	+	+	+	+	−		−			−	+			+		
H. suaveolens *	T	R	+																		
H. trifurcata *	T	R						+	-												

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Habenaria virens	T	R	+														-		-		
H. viridiflora	T	R	+		+												−				
HEMIPELIA																					
H. cardifolia	T	R		+											+						
HERMINIUM																					
*H. angustelabrae**	T	R				+															
H. duthiei	T	R		+											−						
*H. haridasanii**	T	R					+														
*H. jeffreyanum**	T	R		−		−															
H. josephii	T	R		+		-	+								+	−					
*H. kalimpongensis**	T	R				+															
*H. kumaunensis**	T	R		+																	
H. lanceum	T			+	+	−		+	+	+	−	+	+				-	+	+	−	+
*H. longilobatum**	E	R					+			+											
H. mackinnonii	E	R		+											+						
H. macrophyllum	T	R		+		+									+	+					
H. monophyllum	T	R		+			+								+						
H. monorchis	T	R		+		+									+	+					+
H. orbiculare	T	R				+									+						
H. pugioniforme	T	R		+		+									+						+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Herminium quinquelobum	T	R		+		+									+						
HERPYSMA																					
H. longicaulis	T					+	+	+	+						+				+		+
HETAERIA																					
H. anomala *	T	R						+													
H. obliqua *	T	R												+							
H. oblongifolia	T	R												+							
H. ovalifolia *	T	R	+																		
H. rubens	ET					+	+	+		+								+	+		
HOLCOGLOSSUM																					
H. amesianum	E	R									+							+	+	+	
HYGROCHILUS																					
H. parishii	E	R								+	+	+						+	+		
INDIA																					
I. arunachalensis *	T	R					+														
IONE																					
I. arunachalensis *	E						+														
IPSEA																					
I. malabarica *	T	En	+																		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
JEJOSEPHIA																					
J. pusilla *	E								+												
KINGIDIUM																					
K. braceanum	E						+									+					
K. deliciosum	E		+	+		+	+	+							+	+	+	+	+		+
K. mysorense *	E		+																		
K. niveum *	E			+																	
K. taenialis	E						+		+												
LIPARIS																					
L. acuminata *	E	R							+												
L. alata	E	R	+																		
L. assamica *	E	R					+	+	+												
L. atropurpurea	T	R	+														+				
L. beddomei *	T	R	+																		
L. biloba *	E	V	+																		
L. bistriata	E					+	+		+	+	+							+	+		+
L. bootanensis	E					+	+	+	+	+	+	+				+		+	+	+	+
L. caespitosa	E		+	+		+	+	+	+	+		+				+		+	+	+	+
L. cathcartii	E	R				+	+								+	+					
L. cordifolia *	T	R		+		+	+		+			+									

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Liparis deflexa	E	R		+		+									+			+			
L. delicatula *	E	R				+	+	+	+			+									+
L. distans	E						+	+		+	+										+
L. dowatii	E	R	+															+	+		
L. elliptica	E	R	+			+	+	+	+			+			+		+		+		
L. gamblei *	E	R				+															
L. glossula	T	R		+	+	+									+	+					
L. khasiana *	E	R							+												
L. luteola	E	R					+	+	+	+								+	+		
L. lydiae *	E	R				+															
L. macrocarpa *	T	R				+			+												
L. mannii *	E	R					+	+													
L. nervosa	T		+	+		+	+		+						+	+		+	+	+	+
L. paradoxa	T	R	+	+	+	+	+	+	+	+	+	+			+			+	+		
L. perpusilla	E	R				+	+								+						
L. petiolata	T					+		+	+	+					+	+			+		
L. plantaginea	E					+	+	+	+	+	+				+	+			+		
L. platyphylla *	T	R	+																		
L. platyrachis	E			+		+									+						+
L. pygmaea *	T	R				+											+				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Liparis resupinata	E		+	+		+	+		+	+	+	–			+	+			+		
L. rostrata *	T	R		+																	
L. rupestris	T	Ex							+												
L. stricklandiana	E					+	+		+	+						–					+
L. tigerhillensis *	T	R				+															
L. torta *	E	Ex							+												
L. vestita	E	R	+			+		+			+				+		+				
L. vestita ssp. *seidenfadenii*	E	R			+																
L. viridiflora	E		+	+	+	+	+	+	+	+	+	–	+	+	+	+	+	+	+	–	+
L. walakkadensis *	T	R	+																		
L. walkeriae	T	R	+														+				
L. wightiana	T	R	+														+				
L. wrayi	T	R	+				+											+	+		
LISTERA																					
L. alternifolia *	T	R				+															
L. brevicaulis *	T	R				+															
L. dentata *	T	R		+		+															
L. divaricata *	T	R					+														
L. lindleyana	T	R		+		–									–						
L. longicaulis *	T	R		+		+															

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
*Listera micrantha**	T	R				+															
L. mucronata	T	R							+						+						+
*L. nandadeviensis**	T	R		+																	
L. ovata	T			+											+	+	+	−	+	+	+
L. pinetorum	T	R		+		+									+	+					
L. tenuis	T	R		+		+										+					
LUISIA																					
*L. abrahamii**	E	R	+																		
L. amesiana	E	R												+				+			
L. birchea	E		+														+				
L. brachystachys	E		+	+	+	+	+	+	+					+				+	+		
*L. evangelinae**	E		+																		
L. filiformis	E		+			+	+		+			+							+	+	
*L. macrantha**	E		+																		
L. macrotis	E	R						+											+		
*L. micrantha**	E		+						+												
L. microptera	E	R						+													
L. platyglossa	E	R						+						+					+		
L. primulina	E	R	+															+			
L. psyche	E						+	+	+									+			

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Luisia pulniana *	E	R	+																		
L. [illegible]	E	R												+					+		
L. trichorhiza	E		+		+	+	+	+	+									+	+		
L. [illegible] *	E	R, Th							+	+											
L. zeylanica	T, E		+	+	+	+	+	+							+	+	+				
L. zollingeri	E	R												+					+		
MACROPODANTHUS																					
M. alatus	E	R												+							
M. berkeleyi *	E	R	+											+							
MALAXIS																					
M. acuminata	T		+	+		+	+	+	+	+	+			+	+	+	+	+	+	+	+
M. andamanica *	T	R, Th												+							
M. biaurita	T	R		+					+									+	+		
M. calophylla	T	R				+			+			+						+	+	−	
M. crenulata *	T	Ex	+																		
M. cylindrostachya	T, E			+	+	+									+	+		+			
M. densiflora	T	R	+														+				
M. intermedia *	T	R	+																		
M. josephiana *	T	R, V				+	+		+		+	+			+						
M. khasiana	T	R				+	+		+	+	+	+			+				+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Malaxis latifolia	T		+	+		+	+	+	+	+	+	+	+	+	+	+	−	+	+	−	+
M. mackinnonii	T	R		+	+														+		+
M. maximowicziana *	T	R			+	+			+												
M. muscifera	T			+	+	+	+								+	−					
M. purpurea	T	R		+	+	+											+				
M. rheedei	T		+	+	+												+				
MELLEOLA																					
M. andamanica *	E	Ea												+							
M. gracilis	E			+																	
M. rosea	E			+			+														
MICROPERA																					
M. mannii *	E					+	+		+												
M. obtusa	E					+	+	+										+	+		
M. pallida	E				+			+	+	+	+		+					+	+		
M. rostrata	E						+	+	+			+							+		
MISCHOBULBON																					
M. wrayanum	T	R				−	+														
MONOMERIA																					
M. barbata	E					+	+		+						+			+	+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
MYRMECHIS																					
M. pumila	T	R				+	+								+	+		+	+		+
NEOGYNA																					
N. gardneriana	E					+	+	+	+			+			+	+		+	+		+
NEOTAINEOPSIS																					
N. barbata	E	R					+		+												
NEOTTIA																					
N. acuminata	S	R		+		+	+								−						−
N. inayatii	S	R		+																	
N. kashmiriana	S			+																	+
N. listeroides	S			+											−	−					
N. mackinnonii *	S			+																	
N. microglottis	S			+																	
NEOTTIANTHE																					
N. calcicola	T			+		+									−	−					
N. secundiflora	T			+		+	+		+		+				+						+
NEPHELAPHYLLUM																					
N. cordifolium	T	En				+		+	+	−						+					
N. nudum *	T	R				+															
N. sikkimensis	T	R				+	+									+		+	+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
NERVILIA																					
N. aragoana	E		+	+		+	+	+						+				+	+		+
*N. falcata**	T	R		+		+															
N. gammieana	T	R		+		+	+									+					
*N. gleadowii**				+																	
*N. hispida**	T	R	+																		
*N. hookeriana**	T	R				+	+		+	+											
N. infundibulifolia	T	R	+	+			+												+		
N. juliana	T		+		+		+	+									+		+		
*N. khasiana**	T								+												
*N. mackinnonii**	T	R		+																	
N. macroglossa	T	R				+	+								+	+		+			
N. plicata	T		+	+	+	+		+							+	+		+			
N. prainiana	T		+	+		+						+						+			
N. punctata	T		+	+		+								+					+		
*N. scottii**	T	R			+	+															
OBERONIA																					
O. acaulis	E			+		+	+	+	+	+	+	+				+		+			
*O. agastyamalayana**	E	R	+																		
*O. anamalayana**	E	R	+																		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Oberonia angustifolia *	E	Ex							+												
O. arnottiana	E	R	+	+													+				
O. arunachalensis *	E	R					+														
O. balakrishnanii *	E	R	+																		
O. bicornis	E	R	+					+	+		+						+				
O. brachyphylla *	E		R	+																	
O. brachystachya	E	R				+												+	+	+	
O. brunoniana *	E	R	+																		
O. caulescens	E			+		+	+		+	+					+	+					+
O. chandrasekharanii *	E	R	+																		
O. clarkei *	E	R							+						+				+		+
O. denticulata	E		+			+			+	+				+	+			+	+	+	
O. emarginata	E	R				+	+					+							+		
O. ensiformis	E		+	+		+	+	+	+		+	+			+			+	+		+
O. falcata	E					+	+		+						+	+		+	+		
O. falconeri	E		+	+	+	+	+	+											+	+	
O. jenkinsiana	E					+	+	+	+									+			+
O. josephii *	E	R	+																		
O. katakiana *	E	R					+														
O. lobulata *	E					+															

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Oberonia longibracteata	E	R	+								+						+				
O. longifolia	E	R	+																		
O. mannii	E	R							+	+											
O. maxima	E	R					+			+		+						+			
O. myosurus	E			+					+		+				+			+	+		+
*O. myriantha**	E							+	+	+	+	+									
*O. nayarii**	E	R	+																		
O. obcordata	E					+	+		+	+						+			+		
*O. orbicularis**	E					+			+												
O. pachyphylla	E	R				+													+		
O. pachyrachis	E			+		+	+	+	+	+	+		+		+	+		+	+		+
*O. pakshipadensis**	E	R	+																		
*O. platycaulon**	E	R	+																		
O. prainana	E			+		+	+								+				+	+	
*O. proudlockii**	E	R	+																		
O. pyrulifera	E			+	+	+	+	+	+		+	+				+		+	+	+	+
O. recurva	E		+			+			+							+	+		+		
*O. ritaii**	E	R				+															
O. rufilabris	E				+	+	+		+						+				+	+	
*O. santapaui**	E		+																		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Oberonia sebastiana *	E	R	+																		
O. seidenfadeniana *	E	R	+																		
O. sulcata *	E	R					+														
O. teres	E	R									+								+		
O. thwaitesii	E	R	+														+				
O. verticillata *	E		+																		
O. wightiana	E	R	+														+				
O. wynadensis *	E	R	+																		
O. zeylanica	E	En	+														+				
OREORCHIS																					
O. foliosa	T	R		+		+									+	+					
Oreorchis indica *	T		R		+																
O. micrantha	T	R		+		+	+								+	+					
ORNITHOCHILUS																					
O. difformis	E			+		+	+	+	+	+	+	+			+			+	+	+	+
OTOCHILUS																					
O. albus	E			+	+	+	+	+	+	+	+	+	+		+	+		+	+	+	
O. fuscus	E			+		+	+		+	+	+	+			+	+		+	+	+	
O. lancilabius	E			+	+	+	+		+						+	+					
O. porrectus	E			+		+	+	+	+	+	+	+			+	−		+	+	+	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
PACHYSTOMA																					
P. hirsutum *	T		+																		
P. pubescens	T		+	+		+	+	+	+		+	+		+	+		+	+	+	-	+
PANISEA																					
P. apiculata	B	R								+								+	+		
P. demissa	E					+	+	+	+	+		+			+			+			
P. tricallosa	B	R				+	+			+		+				-			+		-
P. uniflora	E	R				-						+			+	+		+	+		
PAPHIOPEDILUM																					
P. charlesworthii	T	Ex				+						+				+		+			
*P. druryi**	T	R,En	+																		
P. fairrieanum	T	En				+	+									+					
P. hirsutissimum	T	R				+			-	+	+	+									
P. insigne	T	V				+			+						+						
P. spicerianum	T	V						+			+	+									
P. venustum	T	V				+	+		-						+	+					
P. villosum	T	R										+						+	+		
P. wardii	T	En					+														
PAPILIONANTHE																					
P. biswasiana	E	R				+												-	+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Papilionanthe subulata	E		+				+										+				
P. teres	E		+		+	+	+	+	+	+	+	−	+	+	+	+		+	+		−
P. uniflora	E	R				+	+	+	+	+					+	+					
P. vandarum	E	R				+	+	+	+		+	+			−			+			
PECTEILIS																					
P. gigantea	T	R	+	+																	
P. susannae	T			+		+	+	+	+	+	+	+	+		+	+		+	+	+	+
P. triflora	T	R		−											+						
PELATANTHERIA																					
P. insectifera	E		+	+	+	+	+	+		+					+			+	+	+	
PENNILABIUM																					
P. proboscideum	E	R		+	+			+	+									−	+		
P. struthio	E	R					+												+	+	
PERISTYLUS																					
P. affinis	T	R		−		+	+		+	+					+				+		+
P. aristatus	T	R	+			+									+		+				
P. brachyphyllus *	T	R	+																		
P. constrictus	T	R	+	+	+	+			+						+	+		+	−	+	−
P. densus	T	R	+	+		+			+		+				+			+	+		+
P. duthiei *	T	R		+											+						

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Peristylus elisabethae	T	R		+											+						+
P. fallax	T	R		+		+	+								+						
P. goodyeroides	T		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
P. gracilis	T	R		+					+										+	+	
P. hamiltonianus	T	R				+		+	+						+						
P. kumaonensis *	T	R		+																	
P. lacertiferus	T	R				+			+	+	+							+	+	+	+
P. lancifolius *	T	R	+																		
*P. lawii**	T	R	+	+	+										+						
P. mannii	T				+	+			+	+	+			+				+	+		+
P. nematocaulon	T					+									+	+					
P. parishii	T	R			+	+		+						+					+	-	
P. plantagineus	T		+	+	+	+											+				
P. prainii	T					+	+	+		+								+	+		
P. pseudophrys *	T	R				+															
P. richardianus	T	R	+				–								+						
P. secundus *	T	R	-																		
*P. spiralis**	T	R	+																		
P. stocksii *	T	R	+																		
P. superanthus	T														+	+					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Peristylus tipuliferus	T	R				+					+			+				+			
PHAIUS																					
P. epihyticus	T	R							+										+		
P. flavus	T					+	+		+	+	+	+	+		+	+			+	+	+
P. longipes *	T	R				+			+										+	+	
P. luridus	T	R	+														+				
P. mishmensis	T	R				+	+	+								+		+	+		+
P. nanus *	T	R			+											+					
P. tankervilliae	T			+		+	+	+	+	+		+	+		+	+	+	+	+	+	+
PHALAENOPSIS																					
P. cornucervi	E	R						+						+				+			
P. mannii	E	Th				+	+	+	+			+			+			+	+		
P. mastersii	E	R																			
P. parishii	E	Th				+	+	+										+	+		
P. speciosa *	E	En												+							
P. tetraspis *	E	R												+							
PHOLIDOTA																					
P. articulata	E			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
P. bracteata	E						+	+	+	+	+				+	+		+	+		+
P. chinensis	E	K					+														+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Pholidota convallariae	E						+	+	+	+	+	+	+					+	+		+
P. imbricata *	E		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
P. katakiana *	E	R					+														
P. protracta	E	R				+	+			+					+	+					
P. pygmaea	E	R					+														
P. recurva	E	R				+									+	+			–		
P. rubra	E	R				+	+		+			+						+			
P. wallii *	E	R					+	+													
PHREATIA																					
P. elegans	E		+			+	+		+		+						+				
P. secunda	E	R												+							+
PLATANTHERA																					
P. arcuata	T	R		+											+	+					+
P. bakeriana	T	R				+	+								+						+
P. biermanniana	T	R				+															
P. clavigera	T					+	+								+	+					
P. dyeriana *	T	R				+	+														
P. exelliana	T	R				+									+						–
P. juncea *	T	R				+									+						
P. latilabris	T					+	+								+	+					+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Platanthera leptocaulon	T	R				+	+								−	−					
*P. sikkimensis**	T	R				+									+						
P. stenantha	T	R		−		+	+								+	−					
PLEIONE																					
P. grandiflora	E	R		+																	+
P. hookeriana	E	Th		+		+	+		+		−				+	+		−	+		+
P. humilis	E	Ep		+		+	+		+	+	+	+			+			+			
*P. lagenaria**	E	Ex							+												
P. maculata	E	Th				+	+		−		+	+			+	+		+	−		−
P. praecox	E	Th				+	+		+		+	−			−	+		+	−		+
PLOCOGLOTTIS																					
P. javanica	T	R												+					+	−	
P. lowii	T	R												−					−	+	
PODOCHILUS																					
P. cultratus	E					+	+	+			−	+	+		+			+	+		
P. khasianus	E	R				+	+		+												
P. malabaricus	E	R	+														+				
POLYSTACHYA																					
P. concreta	E		+				−						+	−					−	+	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
POMATOCALPA																					
P. andamanicum	E	R												+					+	+	
P. armigera *	E	R				+	+					+									
P. bambusarum	E	R				+									+						
P. decipiens	E	R	+		+												+				
P. mannii *	E	R				+		+													
P. ramosum	E	R			+	+												-			
P. spicata		R	+			+								+				+	+	+	
P. undulatum	E	R					+														
PONERORCHIS																					
P. chusua	T	R		+																	-
P. nana *	T	R		+		+															
P. renzii *	T	R		+																	
PORPAX																					
P. elwesii	E	R				+	+		+						-	+			+	+	
P. fibuliformis *	E	R				+			+		+	+						-	+		
P. gigantea	E	R							+		+							-	+		
P. jerdoniana *	E	R	+														-		+		
P. meirax	E	R				+			+							+		+	-	+	
P. reticulata	E		R	+																	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
PTEROCERAS																					
P. muriculatum *	E	R												+							
P. teres	E	R		+		-	+								+			−	+		
P. unguiculatum	E	R												+							
P. viridiflorum	E	R	+																		
RENANTHERA																					
R. imshootiana	E	En					+			+	−	+						-			
RHINERRHIZA																					
R. freemanii *	E	R						+													
RHOMBODA																					
R. arunachalensis *							+														
RHYNCHOSTYLIS																					
R. retusa	E		+	-	+	+	+	+		+	+	+	+		+	+		+			
RISLEYA																					
R. atropurpurea	T	R				+															
ROBIQUETIA																					
R. gracilis	E	R	+														+				
R. josephiana *	E	R	+																		
R. spathulata	E	R				+	+					+						-	+	−	+
R. succisa	E	R				-	-	+								+	+	+	+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
SACCOLABIOPSIS																					
S. pusilla	E	R	+			+	+		+									+	+		
SARCOGLYPHIS																					
S. arunachalensis *	T	R					+														
SATYRIUM																					
S. nepalense	T	Th	+	+		+	+	+	+						+	+	+	+			
SCHOENORCHIS																					
S. chrysantha	E	R	+																		
S. fragrans	E	R									+							+	+		
S. gemmata	E					+	+	+	+	+	+	+			+	+		+	+		+
S. jerdoniana *	E		+																		
S. minutiflora	E	R												+					+		
S. nivea	E	R	+																		
SEIDENFADENIELLA																					
S. chrysantha	E	R	+														+				
S. rosea *	E	R	+																		
SIRHOOKERA																					
S. lanceolata	E	R	+														+				
S. latifolia	E	R	+														+				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
SMITHSONIA																					
S. maculata *	E	R	+																		
S. straminea *	E	R	+																		
S. viridiflora *	E	R	+																		
SMITIANANDIA																					
S. helferi	E	R												+				+	+		
S. micrantha	E		+	+	+	+	+		−	+					+	+		−	+		
SPATHOGOLTIS																					
S. ixioides	T	Th				+	+		+						+	+			+	+	
S. plicata	T		+				+	+						−			+	−	+	+	
S. pubescens	T						−					+	+					−			
SPIRANTHES																					
S. sinensis	T		+	+			+	+	+	+	+	+	+		+	+	+	+	+	+	
S. spiralis	T	R		+																	
STAUROCHILUS																					
S. ramosus	E	R	+	−	+	+			+									+	+		
STEREOCHILUS																					
S. hirtus	E	R					−											+			
S. ringens *	E	R						+													

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STEREOGYNE																					
S. laskaiensis *	E											+									
STEREOSANDRA																					
S. javanica	E	R					+														
STIGMATODACTYLUS																					
S. paradoxus *	E	R					+														
S. serratus *	E	R							+												
SUNIPIA																					
S. andersonii	E	R				+	+									+		+	+		+
S. bicolor	E	R		+		+	+		+	+					+	+		+	+		+
S. candida	E	R					+		+	+						+					
S. cirrhata	E	R				+										+					
S. fusco-purpurea *	E	R					+														
S. intermedia *	E	R				+	+														
S. jainii *	E	R					+			+											
S. paleacea	E	R				+									+	+					
S. racemosa	E	R				+	+		+	+					+			+	+		
S. virens *	E	R					+														
TAENIOPHYLLUM																					
T. alwisii	E	R	+														+				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
T. andamanicum *	E	En												+							
T. arunachalensis *	E	R					+														
T. crepidiforme *	E	R				+	+														
T. filiforme	E	R												+					-	+	
T. khasianum *	E	Th							+												
T. retroapiculatum	E	R				+															
T. scaberulum *	E	R	+																		
TAINIA																					
T. bicornis	T	R	−														+				
T. cordata	T	R				+															
T. khasiana *	T	R							+												
T. latifolia	T						+	+	+	+		+				+		+	+		
T. minor	T					+	+									+					
T. viridifusca	T							+	+	+	+							+	+		+
TAPROBANEA																					
T. spathulata	E	R	+														−				
THELASIS																					
T. bifolia *	E	R							+												
T. khasiana	E	R							+										+		−
T. longifolia	E	R		+			+		+												

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Thelasia pygmaea	E	R	+			+	+		+		+			+	+			+	+	+	+
THELECOSTELE																					
T. alata	T	R							+									+	+	+	
THRIXSPERMUM																					
T. album	E	R	+											+							
T. amplexicaule	E	R												+					+	+	
T. centipeda	E	R	+				+	+	+							+		+	+		
T. complanatum	E	R	+														+				
T. hystrix	E	R							+					+				+			
T. merguense	E														+						
T. musciflorum *	E	R	+				+		+												
var. *nilagiricum* *	E		+																		
T. pulchellum	E	R	+														+				
T. pygmaeum *	E	R				+	+														
T. trichoglottis	E	R						+	+					+				+	+	+	
THUNIA																					
T. alba	T,E			+		+	+	+			+	+	+	+	+	+		+	+	+	
T. bensoniae	T				+				+												
T. bracteata	T	R	+	+														+	+		+
T. marshalliana	T	Th					+			+	+	+				+		+			

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
TIPULARIA																					
T. josephi	T					+									+	+					
TRACHOMA																					
T. coarctum *		R				+															
TRIAS																					
T. bonaccordensis *	E	R	+																		
Trias disciflora	E	R					+														
T. nasuta	E	R					+										+				
T. oblonga	E	R			+				+									+	+		
T. stocksii *	E	R	+				+														
TRICHOGLOTTIS																					
T. cirrhifera	E	R												+					+		
T. orchidea	E	R												+							
T. quadricornuta *	E	R												+							
T. tenera	E	R	+														+				
TRICHOTOSIA																					
T. dasyphylla	E	R				+	+		+	+					+			+	+		+
T. pulvinata	E	R				+	−	+	+						+			+	+	−	+
T. velutina	E	R					+														
TROPIDIA																					
T. angulosa	T		+			+	+		+									+	+		+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Tropidia curculigoides	T		+			-	−	-	+					+				+	-		+
T. pedunculata	T	R		+			-														
T. thwaitesii	T	R	+																		
TRUDELIA																					
T. alpina	E								+		+							+			
TYLOSTYLIS																					
T. discolor	E	R					-	−													
UNCIFERA																					
U. acuminata	E					+	+	-	+	+	+	-			-	+					
U. lancifolia *	E					+															
U. obtusifolia	E					+	+	+	+	−						+					
VANDA																					
V. bicolor	E					+	+	+		−						+					
V. coerulea	E	R,En					+		+	−	+	+						+	+		−
V. coerulescens	E	En					-				+							−			
V. cristata	E			+		+	-	+	-	+	+	-			+	+					-
*V. jainii**	E	R							-												
V. liouvillei	E	R									+							−	+		
V. pumila	E	R		+		+	−		+												
V. spathulata	E		+	+																	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Vanda stangeana *	E	R					+				+										
V. tessellata	E		+	+	+			+	+								+	+			
V. testacea	E		+	-		+	+	+		-		+			-				+	+	
V. tricolor	E	R									+										
V. wightii *	E	Ex	+																		
VANDOPSIS																					
V. undulata	E	R		+		+	+	+	+						-	+					
VANILLA																					
V. andamanica *	T	R											-	+							
V. aphylla	T	R	+														-				
V. pilifera	T	R						+													
V. walkeriae	T	R	+					+													
V. wightiana *	T	R	+																		
VRYDAGZYNEA																					
V. albida	E	R												+					+		
XENIKOPHYTON																					
X. smeeanum *	E	R	+																		
YOANIA																					
Y. japonica	T	R								+	+										
Y. prainii *	T	R				+				-											

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ZEUXINE																					
Z. affinis	T	R				+			+							+		+	+		
Z. andamanica *	T	R												+							
Z. clandestina	T	R	+				+											+	+		
Z. flava	T		+			+	+	+		+					+		+	+			
Zeuxine glandulosa	T	R				+										+					
Z. goodyeroides	T					+	+			+								+			
Z. gracilis	T	R	+														+				+
Z. lindleyana *	T	R			+		+														
Z. longifolia *	T	R				+															
Z. longilabris	T		+		+		+	+	+						+	+	+				+
Z. nervosa	T					+	+	+							+	+			+		+
Z. pulchra *	T	En				+			+												
Z. reflexa *	T	R				+															
Z. rolfeana *	T	R																			
Z. seidenfadenii *	T	R		+																	
Z. strateumatica	T		+	+			+	+	+	+	+	+	+		+	+		+	+	+	

* = Endemic; E = Epiphyte; En = Endangered; Ex = Extinct; R = Rare; S = Saprophyte; T = Terrestrial; Th = Threatened; V = Vulnerable

Satish Kumar and Manilal (1994), while cataloguing orchids of India, divided the whole country into 3 regions, i.e. (i) the Peninsular region, (ii) the Himalayan tract including extra peninsular area, and (iii) Andaman & Nicobar Islands. However, in the present study the Himalayan region is further divided into eastern Himalayan region and western Himalayan region, as both the regions were considered important and botanically distinct by many phytogeographers (Clarke, 1898; Hooker, 1906), although to some extent they are similar in species composition. Accordingly, India has been divided into four regions in order to understand the species diversity of orchids. They are (i) Eastern Himalayan region, (ii) Western Himalayan region, (iii) Peninsular region, and, (iv) Andaman & Nicobar Islands. For each region, largest genera, genera represented by number of species and other interesting features are taken into consideration while discussing the orchid diversity.

Eastern Himalayan region

The Eastern Himalayan region here includes the Darjeeling district of West Bengal and other North-eastern states, i.e. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. Phytogeographically, the eastern Himalaya is a distinct botanical region with high floristic diversity, and family Orchidaceae is not an exception. Topographically, these areas have comparatively lower altitude than the western Himalaya. Climate of the region is relatively warmer with high humidity and heavier precipitation.

The orchid flora of the eastern Himalaya comprises *ca* 870 species belonging to 159 genera. This constitutes 72.8 per cent of total Indian orchid species. The largest genus in the region is *Bulbophyllum*, which is represented by 84 species. Other dominant genera are *Dendrobium* (77 spp.), *Eria* (41 spp.), *Liparis* (33 spp.), *Habenaria* (32 spp.), *Coelogyne* (31 spp.), *Oberonia* (31 spp.), *Cymbidium* (25 spp.), *Calanthe* (24 spp.), *Goodyera* (19 spp.), etc. An analysis of species diversity in eastern Himalayan region leads to the following categorisation :

Genera with	1 species	67
Genera with	2 species	24
Genera with	3-5 species	40
Genera with	6-10 species	8

Genera with	11-15 species	8
Genera with	16-25 species	5
Genera with	26-35 species	4
Genera with	36-50 species	1
Genera with	51-100 species	2

It is observed from the above data that the majority of the genera of this region belong to 1, 2 and 3-5 species categories. The diversity becomes more significant due to presence of about 56 genera, which are confined only to this region. Some of them are *Acriopsis*, *Acrochaene*, *India*, *Rhomboda*, *Risleya*, etc. A state wise analysis shows that Arunachal Pradesh has the highest number of orchids and is represented by 552 species. It is followed by Sikkim, including Darjeeling district of West Bengal, with 543 species and Meghalaya with 389 species. Other states of the region, *viz*. Assam accounts for 257 species, Nagaland for 246 species, Mizoram for 234 species, Manipur for 215 species and Tripura for 57 species.

Western Himalayan region

The region starts from the Kumaon to Chitral and spreads over India and Pakistan. The states of Jammu & Kashmir, Himachal Pradesh, and Uttaranchal come under the western Himalaya.

The western Himalayan region differs greatly from its eastern counter part in the greater size, higher altitude, cooler-drier climate and the greater breadth of the mountain mass. Gregarious coniferous forests of pine, deodar, fir, etc. dominate the region. The orchid flora of the region has a very little difference as compared to other regions and is a continuation of the eastern region. The frequency of occurrence of species diminishes towards west on account of less rainfall. In all *ca* 288 species under 75 genera are known to occur in the region, which form 24.1 per cent of total Indian orchids. Of these, *ca* 222 species are common with eastern Himalayan region and 94 species with Peninsular India. Considering the species diversity at generic level, it is found that genus *Habenaria* is the largest and represented by 20 species. It is followed by *Bulbophyllum* (19 spp.), *Dendrobium* (18 spp.), *Eria* (12 spp.), *Eulophia* (12 spp.), *Herminium* (11 spp.), *Peristylus* (11 spp.), *Liparis* (10 spp.), *Cymbidium* (10 spp.), etc. Besides, there are 31 genera which are represented by a single species each. It is followed by 15 genera with 2 species each; 11 genera with 3-5 species categories etc. Maximum species diversity occurs in the genera represented by 11-15 and 16-25 species categories. Three genera, viz. *Archineottia, Coeloglossum, Hemipilia* are exclusively known from this region only.

Peninsular region

The Peninsular region comprises Madhya Pradesh, parts of Orissa, Andhra Pradesh, Gujrat, extra peninsular regions of central India and Gangetic plains along with Eastern and Western Ghats. Western Ghats has dense forests with high humidity and rainfall. These forests consist of scrub jungles, moist and dry deciduous forests, tropical evergreen forests and montane grasslands. Orchids are abundant in these forests along the border of Kerala. However, in the 'Shola' forests amidst grasslands of Nilgiris at an elevations of 1700 m and above, the orchid diversity is comparatively poor. Unlike Western Ghats, Eastern Ghats do not have high ranges of mountains and consist of broken hills. Orchid wealth of Eastern Ghats is poor as compared to Western Ghats.

About 379 species belonging to 89 genera are known from the Peninsular region. Like western Himalayan region, genus *Habenaria* is the largest with 42 species. It is followed by *Oberonia* (29 spp.), *Bulbophyllum* and *Dendrobium* (28 spp. each), *Liparis* (18 spp.), *Eria* (15 spp.), *Eulophia* (14 spp.), *Peristylus* (14 spp.), *Luisea* (11 spp.), *Malaxis* (11 spp.), etc. The orchids of Peninsular India represent *ca* 31.72 per cent of the total Indian orchid flora and about 157 species of this region are common with that of eastern Himalaya. A species analysis of this region leads to the following categorisation.

Genera with	1 species	36
Genera with	2 species	14
Genera with	3-5 species	20
Genera with	6-10 species	5
Genera with	11-15 species	3
Genera with	16-25 species	2
Genera with	26-35 species	3
Genera with	36-50 species	1

It is evident here also that majority of the genera belong to 1, 2 and 3-5 species categories. The genera *Aenhenrya, Diplocentrum, Disperis, Ipsea, Seidenfadeniella, Sirhookera, Smithsonia, Taprobanea* and *Xenikophyton* are confined only to Peninsular India.

Andaman & Nicobar Islands region

The Andaman & Nicobar islands are a group of about 319 islands and islets in the Bay of Bengal. The South-east monsoon governs the climate of these islands. Due to heavy mist over the forests during morning hours, high rainfall from May to November and constant sea currents keep the forests moist through out the year. These factors provide congenial habitats for luxuriant growth of unique orchid flora in the area.

A total of 115 species belonging to 53 genera are recorded from this region. About 40 species of this region are common to Peninsular India, especially western Ghats, and 54 species to eastern Himalaya. Genera *Grosourdya, Plocoglottis* and *Vrydagzynea* are confined only to this region. An analysis of species diversity shows that about 29 genera are represented by single species each and 12 genera by two species each. Similarly, *Dendrobium* is the largest genus represented by 19 species, followed by *Eulophia* (6 spp.), *Bulbophyllum* (5 spp.), *Luisea* (5 spp.), *Thrixspermum* (5 spp.), etc. Some other dominant genera of the region are *Peristylus*, represented by 4 species and *Aerides, Cleisostoma, Eria, Malaxis, Phalaenopsis, Trichoglottis* by 3 species each.

The orchid diversity in India is further supplemented by the presence of many monotypic genera. About 18 genera of Indian orchids are identified as monotypic. *Arundina graminifolia* distributed throughout the country, is one of the most common monotypic orchid. *Acrochaene, Aenhenrya, Anthogonium, Bulleya, Cephalantheropsis, Dickasonia, Eriodes, Herpysma, Hygrochilus, India, Jejosephia, Neogyna, Ornithochilus, Risleya,* and *Stereosandra* are some other monotypic genera found in eastern Himalaya. Genus *Didicea* is found both in eastern and western Himalaya. Truly endemic to peninsular India, the recent monotypic genus *Xenikophyton* is found in Kerala, Karnataka and Tamilnadu.

Diversity in some ornamental genera

Numerous orchid genera have great potential in horticulture and often used in hybridisation. Today there are about 1,00,000 registered hybrids

(Nagrare, 2001) of inter specific as well as inter generic nature that have been produced world over. Some of the ornamental orchid genera occurring in India are *Aerides, Arundina, Anoectochilus, Calanthe, Coelogyne, Cymbidium, Cypripedium, Dendrobium, Gastrochilus, Paphiopedilum, Phaius, Phalaenopsis, Pleione, Renanthera, Thunia, Vanda*, etc. The diversity in some of them is discussed below.

Anoectochilus: These orchids are tender with creeping stems and are popularly known as 'Jewel Orchid' They are famous for their variously decorated beautiful leaves and hence are suitable as indoor plants. The genus is represented by 17 species, which prefer cool, humid conditions and diffused light.

Coelogyne: In India, the genus is represented by 38 species which are mostly distributed in North-eastern states. Eastern Himalaya has 31 species, followed by western Himalaya with 6 species, Peninsular India with 5 species and Andaman & Nicobar with 1 species only. All species are epiphytic and produce pseudobulbs usually with two leaves. Flowers are quite attractive and their colour varies from pure white to yellowish or brownish. The ornamentation on the lip shows range of variation and is characteristic of each species. *Coelogyne cristata* has pure white flowers with beautiful undulate perianth, whereas flowers of *C. schultesii* are yellowish to deep brownish. *C. corymbosa* is sweet scented and certain plants produce peloric flowers in which two petals also become lip like. On the other hand *C. barbata* bears erect spikes having white, musk scented flowers with contrasting fimbriate maroon coloured lip at the center. The species of the genus are worthy of cultivation in the gardens.

Cymbidium: The genus is also of great importance in horticulture due to large, showy and long lasting flowers, which are used in cut flower trade. Numerous popular *Cymbidium* hybrids have been evolved world over. The genus is represented by 25 species in India that are distributed in tropical, subtropical and temperate areas. The eastern Himalaya harbours all 25 species, followed by western Himalaya (10 spp.) and Peninsular India (2 spp.). Cymbidiums are of various habit bearing short, stout pseudobulbs enclosed by the linear leaves joined to the base. Most of the species grow epiphytically. Species, like *C. munronianum* and *C. macrorhizon* are terrestrial. Of these, *C. macrorhizon* is a saprophyte. Inflorescences are variable and may be erect, semi-erect or pendulous bearing large, showy, variously coloured flowers. Flowers in *C. devonianum* are purplish brown with green lines and lip also purplish brown with eye like spots near the base. *C. elegans* is easily recognised by its pendulous, densely flowered, lemon yellow-flushed pink or brown, partly open flowers. Flowers in *C. iridioides* are ochraceous yellow to pink purplish brown with 2 keels running from base to apex, whereas *C. munronianum* has sweet scented, straw-coloured flowers with purple streaks or light green flowers with central purple streak. Similarly, other species also bear beautiful attractive flowers and are extensively used in hybridization.

Dendrobium: This genus is well known among hobbyists for their variously coloured, beautiful flowers and diverse morphological features. It is the second largest genus in the country being represented by 103 species. Eastern Himalaya shows maximum diversity with 77 species, followed by Peninsular India (28 spp.), Andaman & Nicobar (19 spp.) and western Himalaya (18 spp.). The genus is essentially epiphytic or lithophytic. The vegetative structure of *Dendrobium* species varies considerably. The stem (pseudobulbs) may be dwarf or elongated with jointed stems like cane. They may be cylindrical, angled, clavate or any other shaped. *D. moschatum* has erect cane type stem and attractive slipper shaped lip, whereas *D. chrysanthum* and *D. falconeri* have pendulous stems. The long pendulous stems of *D. aphyllum* become leafless at the time of flowering and produce pale rose flowers with yellow pubescent lip, *D. chrysanthum* has golden yellow flowers which are produced in fascicles of 2-4 at nodes on short peduncles. The lip is sub-fimbriate, yellow with two brownish purple spots. Similarly, flowers of *D. chrysotoxum* are deep yellow and stem is clavate. *D. densiflorum*, is popularly known as 'Pine apple orchid' due to their golden yellow flowers produced densely on decurved axis giving an appearance of a ripe pine apple fruit. *D. devonianum* is unique in having slender pseudobulbs, white flowers with purple apex and lip margin fimbriate with two orange-yellow bloches and purple apex. Similarly almost all other species of *Dendrobium* have unique flower colours and thus are in great demand in hybrid programmes.

Paphlopedilum: The species of this group of orchids are precious and popularly known as 'lady's slipper' orchid. They are in great demand in horticulture because of their easy culture and long lasting flowers, both on the plants and as cut flower. Paphiopedilums are known by 9 species in India. Out of which 2 species, *viz. P. wardii*, from Arunachal Pradesh and *P. charlesworthii* from Mizoram, reported earlier (Pradhan, 1976) could not be recollected. However, remaining 7 species are well distributed in

India. It is also significant that out of 7 species (Kataki, 1984), 6 species, viz. *P. villosum, P. hirsutissimum, P. spicerianum, P. fairrieanum, P. insigne* and *P. venustum* occur in North east India. The remaining species, *P. druryi* is endemic to South India. The species are usually terrestrial in habit, but some times grow as epiphytes also. Flowers are curiously shaped in that lip is pouch like. Dorsal sepal is hood like and variously coloured. Similarly, lateral petals are also variously coloured and shaped.

Leaves of *P. venustum* are tessellated where as in other species they are green throughout. *P. druryi* bears a prominent medium black band in their sepals. The dorsal sepal in *P. venustum* is whitish with dark green lines while in *P. fairrieanum* it is greenish-white with dark purple vein. In other species, like *P. insigne* the dorsal sepal is partly white in upper part and greenish-white with purple spots or blotches in lower part. Petals in *P. hirsutissimum* are hirsute, violet-purple with crisped margins, where as *P. spicerianum* has reddish spotted yellowish-green petals with wavy margins. Similarly, size and shape of lip or pouch also vary from species to species and give attractive nature to flowers.

Phaius: It is another group of terrestrial orchids with distinct rhizomes bearing several leaves. The genus is known by 7 species in India and is of considerable importance in horticulture. Many inter-specific and generic hybrids have been produced in recent past. *P. flavus* is famous both for foliage and flowers, which are yellow in colour. *P. mishmensis* bears rose coloured flowers. Flowers of *P. tankervilliae* are fragrant, buff coloured with a hue of brown white towards the margin and the trumpet shaped lip in white with orange yellow base streaked with red. Eastern Himalaya has maximum number of 5 species, followed by Andaman & Nicobar (2 spp.) and western Himalaya with a single species.

Vanda: It is most popular genus among commercial growers in warmer parts of the world. In India, it is represented by 13 species, out of which 10 species belong to the eastern Himalaya, 5 to western Himalaya and 4 to Peninsular India. The monopodial habit, strap shaped leaves and long lasting flowers in racemes or panicles are some of the remarkable features of the plant. Flowers are usually large, varying in colour from white-yellow-brown-blue to pink. *V. coerulea*, popularly known as 'blue vanda' bears blue flowers with deep blue tessellated perianth and deep blue lip. This species is extensively cultivated and several hybrids have been developed from it. *V. cristata* bears yellowish perianth with deep brown markings on the lip. Other species (*V. bicolor*, *V. spathulata*, *V. tessellata*) have perianth which is white on outer and variously coloured and tessellated on inner sides. Vandas can easily be multiplied through tissue culture techniques.

ENDEMISM

The taxa confined to narrow phytogeographical ranges because of their isolation by geographical (spatial), ecological genetic or adaptive barriers are known as endemics. The diverse climatic and habitat conditions in our country provide favourable conditions for speciation. The barrier of high mountains in the North, separation of southern region of the country by large water bodies of Arabian Sea, Bay of Bengal and Indian Ocean, extremely arid conditions in the West and humid tropical conditions of Western Ghats and North eastern region are some of the important factors that contribute to the high endemism in Indian flora.

About 5,725 species of flowering plants are estimated to be endemic to India (Nayar, 1996). Kumar and Manilal (1994) estimated about 347 species of orchids as endemic to India. In the present state of our knowledge, about 384 species of orchids are found to be endemic to Indian flora, that constitute about 31.8 per cent of total Indian orchids. A large number of endemic species occur in moist tropical and subtropical forests and have restricted distribution in a particular floristic region. However, certain species show extended distribution and grow in more than one region, therefore increasing the number of endemic species in a particular floristic region. A region wise distribution of endemic taxa is listed in Table II.

Table II
Region wise distribution of endemic orchids in India

Floristic region	Number of species	Number of endemic species	Percentage
Eastern Himalayan region	870	200	22.99
Western Himalayan Region	288	33	11.46
Peninsular India	379	149	39.31
Andaman and Nicobar Islands	115	21	18.26

Thus, from the above data it is observed that the maximum endemism occurs in Peninsular India, followed by eastern Himalaya and Andaman & Nicobar Islands. Western Himalayan region has the lowest percentage of endemic species. Peninsular Indian region can be considered as rich site of orchid endemism although the species diversity is much less than the eastern Himalaya. Poor endemism in eastern Himalaya may be due to the fact that the region is the meeting place of different elements from neighbouring countries. Genera showing high degree of endemism according to their number of species on all India basis are *Bulbophyllum* (37 spp.), *Habeneria* (37 spp.), *Oberonia* (26 spp.), *Dendrobium* (24 spp.), *Eria* (21 spp.), *Liparis* (17 spp.), *Coelogyne* (10 spp.), *Eulophia* (9 spp.), *Peristylus* (9 spp.), *Anoectochilus* (8 spp.) and *Calanthe* (8 spp.), and so on.

The endemic species are of great potential for breeding, hybridisation and are most vulnerable because of their narrow geographical distribution. There is a great need to multiply these taxa using both conventional as well as modern technologies.

PHYTOGEOGRAPHY

The orchid flora of India shows close affinities with the flora of adjacent and distant regions. The orchids of Himalaya show similarities with the flora of South Asian countries by virtue of occurrence of species common to both regions.

The species common with Nepal, Bhutan: *Acampe ochracea, A. papillosa, Anoectochilus crispus, Aorchis roborovskii, A. spathulata, Bulbophyllum affine, B. careyanum, B. leopardinum, Coelogyne fimbriata, Dendrobium aphyllum, D. heterocarpum, Oberonia caulescens, Pecteilis susannae*, etc.

Species common with Myanmar, Thailand, Malaya: *Aerides multiflora, A. odorata, Ascocentrum ampullaceum, Brachycorythis obcordata, Bulbophyllum careyanum, B. leopardinum, B. wallichii, Cheirostylis griffithii, Cleisostoma aspersum, Dendrobium bicameratum, D. chrysanthum, D. moschatum*, etc.

Species common with Sri Lanka: *Ascocentrum ampullaceum, Bulbophyllum guttulatum, B. leopardinum, Calanthe triplicata, Cymbidium aloifolium, C. bicolor, Dendrobium macrostachyum, Epipogium roseum, Eria muscicola, Peristylus plantagenieus*, etc.

Species common with China: *Aerides rosea, Aorchis spathulata, Arundina graminifolia, Ascocentrum ampullaceum, Brachycorythis galeandra, Bulbophyllum repens, B. secundum, B. umbellatum, Coelogyne cristata, C. ovalis, Dendrobium chrysanthum, D. denudans, Oberobnia caulescens, O. pachyrachis,* etc.

Similarly, the flora of Andaman & Nicobar, though poorly studied also shows close affinities with the flora of South Asian countries, like Myanmar, Thailand and Malaysia. The species, like *Eulophia andamanensis, Flickingeria fimbriata, Plocoglottis javanica, P. lowii, Pomatocalpa andamanicum, Taeniophyllum filiforme,* found only in Andamans, are also distributed in Malaya, Thailand, Myanmar, etc. Certain species, like *Listera ovata* which occurs in western Himalaya has its wide distribution up to United Kingdom.

On the other hand the orchid flora of Peninsular India shows close resemblance with that of Sri Lanka. The species, like *Acampe congesta, Acanthephippium bicolor, Aerides ringens, Anoectochilus regalis, Bulbophyllum elegans, B. macraei, Calanthe purpurea, Cheirostylis parviflora, Chiloschista pusilla, Chrysoglossum maculatum, Cleisostoma tenuifolium, Coelogyne breviscapa, C. odoratissima, Diplocentrum recurvum, Eulophia epidendraea, Seidenfadeniella chrysantha, Taprobanea spathulata,* etc. are common to both Peninsular India and Sri Lanka.

ECONOMIC IMPORTANCE

The economic importance of orchids lie mainly in their ornamental value, but many species are used in traditional system of medicine, as a remedy for a number of ailments. They are rich in alkaloids, flavonoids, glycosides, carbohydrates and other phytochemicals.

The use of orchids as medicine is known from various parts of the world since time immemorial. In India, orchids were first used as medicine during vedic period. The leaves of *Vanda tessellata* (Vandika in Sanskrit) were used to cure rheumatism in Ayurvedic system of Indian medicine. The dried tubers and pseudobulbs are kept as 'Salep' and used in Unani and Ayurvedic system of medicine. Substantial information is available in the scientific literature about the folklore therapeutic uses and phyto-constituents of orchids, but biological evaluation of these plants or their derived products has not been undertaken so far. Some such orchid species with their medicinal values used by various communities in many parts of India have been enumerated below (Table III)

Besides medicinal use, orchids are also associated with the culture and religions belief of different communities. In Kameng district of Arunachal Pradesh such orchids, as *Dendrobium hookerianum, D. nobile, D. gibsonii* are grown in Buddhist temples, symbolizing the sanctity of the place. The Monpas consider the flowers of *Cymbidium hookerianum* important in the holy worship.

In Assam, the beautiful inflorescences of *Rhynchostylis retusa* and *Aerides odorata*, popularly known as 'Kapouphul' and 'Bhatouphul' are invariably adorned by women during 'Bihu' festival for ornamentation of their heads. It is believed to symbolise youthfulness.

Table – III
Ethnobotanical uses of some orchids
(Source: Chowdhery, 1998; Jana *et al*, 1997; Paul & Hegde, 1998)

Name of species	Parts used	Therapeutic use
Acampe papillosa	Roots	Rheumatism
Acampe praemorsa	Roots	Rheumatism
Anthogonium gracile	Roots	As gummy substance in medicine
Aerides odorata	Whole plant	Anti tuberculosis
Aorchis roborovskii	Bulbs	Rheumatism
Arundina graminifolia	Whole plant	Fodder
Calanthe triplicata	Root extract	Diarrhoea and tooth cavities
Cleisostoma williamsonii	Leaves and stems	Bone fracture
Coelogyne assamica	Pseudobulbs	Chutney
Coelogyne corymbosa	Pseudobulbs	Burn and pain killer
Coelogyne ovalis	Whole plant	Aphrodisiac
Coelogyne punctulata	Pseudobulbs	Burn injury and wounds
Cymbidium aloifolium	Whole plant and pod	Emetic

Name of species	Parts used	Therapeutic use
Cymbidium ensifolium	Root and flowers	Gonorrhoea and sore eye
Cymbidium longifolium	Bulb	Salep and emetic
Cypripedium elegans	Whole plant	Nervous disorder
Dactylorrhiza hatagirea	Tubers	Aphrodisiac, expectorant. astringent
Dendrobium hookerianum	Flower	Dye
Dendrobium nobile	Seeds	Wounds and nervous disorder
Dendrobium ovatum	Whole plant	Stomachache, bile secretion, laxative
Epipactis latifolia	Whole plant	Nervous disorder
Eria pannea	Roots and leaves	boneache
Eria spicata	Shoot	Headache
Eulophia nuda	Tubers	Blood purifier
Eulophia dabia	Whole plant	Blood purifier
Eulophia epidendraea	Tubers	Vermifuge
Flickingeria macraei	Pseudobulbs	Aphrodisiac
Geodorum densiflorum	Roots	Insecticide
Geodorum oblongifolia	Entire plant	Gout
Goodyera pubescens	Roots	Antidote
Goodyera repens	Whole plant	Eye disorder, snake bite
Gymnadaenia orchidis	Tubers	Diarrhoea, dysentery, fever
Habenaria clavigera	Whole plant	Anti AIDS
Habenaria edgewwrthii	Whole plant	Ingredient in chyavanprash
Habenaria crinifera	Whole plant	Headache
Habenaria commenlinifolia	Roots and tubers	As salep
Habenaria intermedia	Roots and tubers	Rejuvenating drug
Habenaria longicorniculata	Whole plant	Pain and swelling
Luisia tenuifolia	Whole plant	Emollient, boils and tumour
Luisia trichorrhiza	Tubers	Muscle pain

Name of species	Parts used	Therapeutic use
Malaxis acuminata	Pseudobulbs	Tonic
Nervilia aragoana	Whole plant	Cooling material
Oberonia caulescens	Tubers	Liver ailment
Pecteilis sssannae	Tubers	Boil
Peristylus stocksii	Whole plant	Tonic
Phaius tankervilliae	Pseudobulbs, Root and leaf	Boil and wound
Phaius imbricata	Pseudobulbs	Abdomen pain, rheumatism
Pholidota pallida	Pseudobulbs	Rheumatism
Platanthera latilabris	Roots and tubers	Blood purifier and rejuvenating drug
Platanthera sikkimensis	Whole plant	Salep
Pleione maculata	Rhizomes	Liver disorder and stomachache
Rhynchostylis retusa	Whole plant	Emollient
Satyrium nepalense	Tubers	Anti malarial, dysentery
Spiranthes sinensis	Shoot	Sores
Tropidia curculigoides	Roots	Diarrhoea
Vanda testacea	Leaves and flowers	Rheumatism
Zeuxine strateumatica	Stems	Salep

ORCHID TRADE

Orchids with their bewildering range of flowers, are an immense source of aesthetic beauty, and are quite popular among professionals and amateur orchid lovers almost throughout the world. Orchid growing, which started as a hobby at first, slowly transformed into a commercial enterprise worldwide. Today, orchid trade is a multi million-dollar business with production centers concentrated in Europe (The Netherlands), America (California), Japan, and South East Asian countries (Thailand, Bangkok, Singapore). At present, orchids share about 8 per cent of the international flower market. *Cymbidium* ranks among the top ten floriculturally important plants in international market and accounts for 2.7 per cent of the total cut flower production (Nagrare, 2001).

Although India possesses rich orchid genetic resources and the suitable agro-climatic conditions for commercial growing of orchids, the orchid industry is still in its infancy. This was primarily due to lack of awareness about the commercial significance of national orchid heritage and different national priorities in the recent past. But the scenario is now changing gradually and our national policy also started encouraging and favouring orchid based floriculture industry. Subsequently, some entrepreneurs have started orchid cultivation at Bangalore, Chandigarh, Gangtok, Mumbai, Chingelpet (near Chennai), Cochin, Ernakulum, Quilon, Kalimpong, Pune and Thiruvananthapuram, with a view to meet the domestic requirements. Breeding work has also been initiated at Orchid Research and Development Centre (ORDC), Tipi, Arunachal Pradesh; Tropical Botanic Garden and Research Institute (TBGRI), Thiruvananthapuram, Kerala; Indian Institute of Horticultural Research (IIHR), Bangalore, Karnataka and in some Indian universities.

Orchid trade may be broadly classified into following categories (i) plants, (ii) species, (iii) hybrids, and (iv) cut flowers. Depending upon the quality of the flowers and rarity of occurrence, the orchid plants are sold at a rate ranging from rupees five to thousands of rupees. India has large variety of good quality tropical orchids, like members of *Aerides, Anoectochilus, Arachnis, Ascocentrum, Bulbophyllum, Calanthe, Coelogyne, Cymbidium, Cypripedium, Dendrobium, Diplomeris, Hygrochilus, Kingidium, Paphiopedilum, Papilionanthe, Phaius, Phalaenopsis, Pleione, Renanthera, Rhynchostylis, Spathoglottis, Thunia, Vanda,* etc. Some of these even out-shine the hybrids and command a high demand in international market. North-eastern part of India has got tremendous potential of orchid cut flower trade, which may serve as booming industry in South East Asia, Australia and Hawaii. Most of the species important for breeding and raising new hybrids are available locally in North-eastern region. But due to lack of large-scale production and infrastructural facilities it is yet to acquire an industrial status.

There are several constraints which hamper the development of a meaningful orchid based floriculture industry in the country. These include the lack of proper material and protocols for commercial cultivation, post harvest technology, market information and appropriate policies and incentives, etc. Therefore, proper handling of problems by both the government and the scientific community of the country will be helpful for orchid trade in India to emerge as major industrial sector in days to come.

RARE AND THREATENED TAXA

The taxa with small world populations that are not at present endangered or vulnerable but are at risk are called rare species. International Union for Conservation of Nature and Natural Resources (IUCN) has already defined various categories of threat. Due to over exploitation and habitat destruction many species of orchids have fallen under Red categories. As a result species of *Dendrobium, Paphiopedilum, Vanda*, etc. have become rare in nature.

Our concern about the threats to the Indian plants became apparent in the 11th Technical meeting of the IUCN, held at New Delhi in 1969. Subsequently leading institutions, like Botanical Survey of India started listing of rare plants from various parts of India. Besides, about 64 species of Indian orchids are placed in various threat categories in the three volumes of Red Data Books on Indian plants published by Botanical Survey of India so far.

In recent year, several species have been rediscovered after a long gap of many years though they are rare in nature. Some of these are *Paphiopedilum druryi* from Agastyamala hill in Thiruvananthpuram district. *Pholidota wattii*, which had its locality only in Assam, has been recollected from Dibang valley in Arunachal Pradesh and North Cachar Hills in Assam. Similarly *Bulbophyllum rothschildianum* was rediscovered from Nagaland and *B. obrienianum* from Arunachal Pradesh. *Cymbidium gammieanum*, originally known from Sikkim, has been found in Darjeeling and Arunachal Pradesh. *Hetaeria ovalifolia*, an extremely rare species, was found restricted to three localities in South India. *Phaius luridus*, probably extinct in its original home in Sri Lanka, has been rediscovered from Agastyamala hills in South India. *Calanthe pachystalyx* a rare orchid from Garhwal Himalaya and Nepal has been found in Arunachal Pradesh.

Besides, some species are known by single collection only. Some such species are *Anoectochilus clarkei, Aphyllorchis gollani, Bulbophyllum nodosum, Coelogyne treutleri, Chrysoglossum hallbergii, Habenaria flabelliformis, Malaxis crenulata, Paphiopedilum wardii, Pleione lagenaria, Vanda wightii*, etc. A species earlier known by very scanty collections and referred by different names in the literature, like *Odontochilus rotundifolius* or *Anoectochilus rotundifolius* was rediscovered from Kerala and Tamil Nadu. It was transferred to the monotypic genus *Aenhenrya* (Satish Kumar & Rasmussen, 1997). Now concerted efforts are required to search these rare, threatened and presumably extinct taxa in their type localities for correct assessment of their status.

MAJOR THREATS

As already mentioned, the demand of orchids is due to their long lasting, fascinating flowers. They are also used as a progenitor for the production of some of the hybrids in European and other countries. Hence, their demand has attracted the attention of collectors continuously. Two main human activities, *viz.* extraction of wild plants for trade and habitat alteration or destruction for alternate land use, are primarily responsible for the threat to the natural orchid population. However, all orchid taxa are not threatened by these factors. According to an estimate 147 orchid species are under threat of extinction worldwide (Anonymous, 1996). Some 35 species in Indian region, which include India, Nepal, Bhutan, Bangladesh, Sri Lanka and Pakistan are considered extinct or on the verge of extinction and over 100 species are threatened (Pradhan, 1996).

The collection of orchids from Indian jungles started long back. During the British colonial period when commercialisation of orchids was in its infancy, orchids were exploited and exported to European destinations. The commercial orchid growing in India is yet to be properly organized and the trade is virtually in the hands of some dealers who collect the orchids from wild to meet their foreign and local demands. The trade in species collected from wild has increased to such an extent that a number of species have almost been collected to extinction, while others have fallen in rare and threatened categories. However, the greatest threat to orchid population is the loss of habitat. It may be mentioned that thousands of hectares of habitat are lost annually to agriculture, mining and urban development throughout the country. Besides these, natural calamities, like seasonal floods, forest fires, landslides and erosion; biotic activities, like shifting cultivation, monoculture and military movements are also responsible for the destruction of orchid habitats. By these actions many species of popular genera, like *Cymbidium, Dendrobium, Paphiopedilum, Pleione, Vanda,* etc. have become threatened or fallen into red data categories. The oak trees are favourite abode of the orchid species and during deforestation they are the first to be axed for their valuable wood. thereby reducing the population of many epiphytic species. Similarly over-exploitation of species, like *Paphiopedilum*, *Cypripedium*, etc. on account of attractive flowers has resulted in the deptetion of their natural populations in their native places. Habitat of one of the very rare species of orchids *Paphiopedilum fairrieanum*, is greatly affected by the military establishments of Tenga valley in Arunachal Pradesh.

In India, particularly North-eastern region, the shifting cultivation practiced by tribal communities has also resulted into the depletion of orchid habitats. Some of the ornamental species, like *Renanthera imschootiana, Vanda coerulea, Paphiopedilum fairrieanum, P. Spicerianum, P. insigne, P. villosum*, etc. have become extremely rare in the wild. Intensive efforts to relocate some of the presumably lost species, like *Aphyllorchis montana, A. parviflora, Bulbophyllum obrienianum, B. rothschildianum, Eulophia mannii, Galeola falconeri, Gastrochilus distichus, Gastrodia orobanchoides, Paphiopedilum druryi, Pomatocalpa ramosum, Malaxis latifolia and Habenaria andamanica* are also going on and have been quite successful.

Selective logging of valuable timber species in forests modifies light intensity, humidity, and other monoclimatic factors affecting the survival of many epiphytic species and disturb the mycorrhizal relationship of terrestrial species. Botanical collections by various educational institutions and the economic conditions of rural people are also responsible for reduction of orchid population. In many North-eastern states, particularly in Manipur and Meghalaya, rural poor collect orchids from the wild and sell them in the market at very cheap rate for their livelihood.

CONSERVATION

Conservation and management of orchids require a proper understanding of their reproductive biology and concerted efforts to preserve their habitats (Vij, 1998). They live delicately in balanced equilibrium with their ecosystem and are highly vulnerable in disturbed environmental conditions. The Species Survival Commission (SSC) of International Union for Conservation of Nature and Natural Resources (IUCN) has already formulated a strategic action plan to document the diversity and suggest conservation strategies for orchids in general. More efforts are required to be taken up in the near future by the Orchid Specialist Group (OSG) of IUCN at micro level for the conservation and preservation of orchids. The Convention on International Trade in Endangered Species of Wild Fauna and flora (CITES) prohibits the trade of orchid species by placing certain species in Appendix I and the remaining species of the family in Appendix II. The species included in the Appendix I of CITES are *Vanda coerulea, Renanthera imschootiana* and all species of *Paphiopedilum*, which cannot be traded for commercial purpose . However, species included in Appendix II can be traded only with the export permit from the competent authority of the country of origin.

Protection of natural habitats by establishing sanctuaries and forest reserves, salvation of plants from damaged and threatened habitats and their multiplication in orchidaria, botanic gardens and other rescue centers, propagation of threatened plants and their reintroduction in well protected habitats are some of the measures that could be adopted for *in situ* and *ex situ* conservation of orchids in India. Conservation of seeds and genetic variations of all the species by setting up of seed/gene banks is another most efficient means of genetic conservation as well as artificial propagation through breeding. The Botanical Survey of India has brought a large number of rare and threatened species under cultivation in its three National Orchidaria at Howrah, Shillong and Yercaud. The prime objectives of these orchidaria are to bring representative collections of all Indian species of orchids and to undertake taxonomic, phenological, nutritional requirement and other behavioural studies. Such efforts are also being made at orchidaria/ botanic gardens attached to some universities and research institutes of the country. More efforts are required to be taken for preparation of a national inventory of orchids, inventories from protected areas, identification of rare and threatened taxa to formulate effective conservation strategies.

Government of India has already taken up steps to protect orchid rich habitats by establishing protected areas in floristically rich areas of the country. Orchid sanctuaries have also been established by some state governments such as Tipi and Sessa in Arunachal Pradesh; Lolegaon and Takdah in West Bengal; Deorali and Singtam in Sikkim; Ngopa and Sairep in Mizoram; Kyrdamkulai in Meghalaya, etc. However, more such orchid rich areas in other parts of the country are required to be brought under protection to save the precious orchid wealth.

Finally, the orchids of India require a well-defined policy so that it can emerge as a revenue-generating sector of our country. It is obvious that as long as orchids enjoy an economic status and demand, their exploitation from nature will continue. To reduce this pressure, mass propagation by using conventional as well as tissue culture techniques, like meristem culture, seed culture, embryo culture, etc. would be, an important strategy. Besides, massive R & D activities are required to develop suitable planting material from among the indigenously available germplasm. Production of quality planting material through desired matings and by inducing somaclonal variations etc. can be taken up to meet the international demands. Academic institutions of the country can introduce vocational training course on floriculture (orchid culture), thereby opening the doors for self-employment. For all these aspects, a suitable infrastructure, integrated planning and sufficient finance is required. It is thus necessary that financial institutions should come forward with suitable schemes to harness the tremendous economic potential of orchids.

Public awareness is the foremost requirement in any conservation programme. Therefore, it is required to educate general public about the need for preservation and conservation of orchids through exhibitions, seminars, symposia and programmes that illustrate the importance of biodiversity.

Today orchidology is not only an important and fascinating branch of plant science but also represents royality and aristocracy in floriculture. The decline of orchid species is an indicator of ecosystem degradation. Implementation of all international and national laws governing the trade and protection of orchids is the utmost requirement of the hour to conserve orchids and their habitats otherwise most of our wonderful species of orchids may vanish forever.

REFERENCES

Abraham, A. and P. Vatsala 1981. *Introduction to orchids*. Tropical botanic garden & Research Institute. Trivandrum.

Anonymous 1996. *Status Survey and Conservation Action Plan: Orchids.* IUCN, Gland, Switzerland.

Blatter, E. and C. McCann 1931-32. Revision of the flora of the Bombay Presidency. Orchidaceae (Parts 6-19). *J. Bombay Nat. Hist.* Soc. **35**: 254-275; 484-495; 722-736 & **36**: 13-28.

Bose, J.K. and S.K. Bhattacharjee 1980. *Orchids of India*. Calcutta.

Chowdhery, H.J. 1998. *Orchid flora of Arunachal Pradesh*. Bishen Singh Mahendra Pal Singh, Dehradun.

Clarke, C. B. 1898. On the Botanical Sub areas of British India. *J. Linn. Soc. Bot.* **34**: 1-146.

Deva, S. and H.B. Naithani 1986. *The Orchid Flora of North West Himalaya*. Print & Media Associate, New Delhi.

Dressler, R. L. 1993. *Phylogeny and classification of the Orchid family*. Cambridge University Press, Cambridge.

Duthie, J.F. 1906. The orchids of the north-western Himalaya. *Ann. Roy. Bot. Gard.* Calcutta **9**: 81-211.

Fischer, C.E.C. 1928. Orchidaceae In Gamble, J.S., *Flora of the Presidency of Madras* **8**: 1399-1478.

Gentry, A. H. and C. H. Dodson 1987. Diversity and biogeography of Neotropical vascular epiphytes. *Ann. Miss. Bot. Gard.* **74**: 205-233.

Hegde, S.N. 1984. *Orchids of Arunachal Pradesh*. Itanagar.

Hooker, J. D. 1888-1890. Orchidaceae In: *Flora of British India* **5**: 667-858 & **6**: 1-198. Ashford, Kent.

Hooker, J. D. 1892-1894. *Icones Plantarum* 4. s. 2. London.

Hooker, J. D. 1895. A century of Indian orchids. *Ann. Roy. Bot. Gard.* 5. Calcutta.

Hooker, J. D. 1906. *A brief sketch of the Flora of British India.* London.

Hynniewta, T. M. S.K. Kalaki and B.M. Wadhwa 2000. *Orchids of Nagaland.* BSI. Calcutta.

Jain, S. K. and A. Melhotra 1984. *A Preliminary Inventory of Orchidaceae in India.* BSI, Howrah.

Jana, S. K., G. P. Sinha and A. S. Chauhan 1997. Ethnobotannical aspects of orchids in Sikkim. *J. Orchid Soc. India* **11**(1-2): 79-84.

Kataki, S. K. 1984. *Lady's slipper orchids of India.* POSSCEF, BSI, Howrah.

Kataki, S. K. 1986. *Orchids of Meghalaya.* Meghalaya Forest Department, Shillong.

Kataki, S. K., S. K. Jain and A. R. K. Sastry 1984. *Stereogyne lushaiensis* Summerh. *Pl. Cons. Bull.* **5**: 31.

King, G. and R. Pantling 1895. On some new orchids from Sikkim. *Journ. As. Soc. Bengal* **64**: 329-344.

Lindley, J. 1857. Contributions to the Orchidology of India- 1. *J. Linn. Soc.* **1**: 170-190.

Mabberley, D. J. 1990. *The plant book.* Cambridge University Press, Cambridge.

Nagrare, V. S. 2001. World of Orchids. *Emp. News.* **XXVI** (16):1-2.

Nayar, M. P. 1996. *'Hot Spots' of Endemic Plants of India. Nepal and Bhutan.* TBGRI, Thiruvananthapuram.

Paul, S. and Hegde, S. N. 1998. Some orchids of ethno botanical interest. In: Hegde, S.N. (ed.) *Articles and Abstracts Int. Fes. Orch. Work* & Orch. pp. 28-31. SFRI, Itanagar.

Pradhan, U. C. 1976. *Indian orchids, Guide to identification and culture.* 1 Kalimpong & Faridabad.

Pradhan, U.C. 1979. *Indian Orchids. Guide to Identification and Culture* 2. Faridabad.

Pradhan, U. C. 1996. India. In: Hagsater, E. and Vinciane Dumont (eds.) *Status Survey and Conservation Action Plan: Orchids* IUCN, Gland, Switzerland.

Raizada, M. B., H. B. Naithani and H. O. Saxena 1981. *Orchids of Mussoorie.* Dehradun.

Roxburgh, W. 1832. *Flora Indica* (ed. W. Caray) **3**: 450-488. Serrampore.

Santapau, H. and Z. Kapadia 1996. *The orchids of Bombay.* Delhi.

Sathish Kumar, C. and K. S. Manilal 1994. *A catalogue of Indian orchids.* Bishen Singh Mahendra Pal Singh, Dehradun.

Seidenfaden, G. and C. M. Arora 1982. An enumeration of orchids of North Western Himalaya. *Nord. J. Bot.* **2**: 7-27.

Sharma, J. R., V. Mudgal and Hajra, P. K. 1997. Floristic diversity-review, scope and perspectives. In: Mudgal, V. and P. K. Hajra (eds.). *Floristic Diversity and Conservation Strategies In India.* **I**: 1-45. BSI, Dehra Dun.

Singh, D.K., B.M. Wadhwa and K.P. Singh 1990. A conspectus of Orchids of Mizorum: their status and conservation. *J. Orchid Soc. India* **4**: 51-64.

Van Rheede, H.A. 1678-1693. *Hortus Malabaricus.* 12 volumes. Amsterdam.

Vij, S. P. 1998. Orchidology in India. In: Hegde, S. N. (ed.) Articles and Abstracts, *Int. Fes. Orch. Work. & Orch. Show.* SFRI, Itanagar.

Acampe ochracea

Agrostophyllum callosum

Bulbophyllum leopardinum

Coelogyne fuscescens

Coelogyne fuliginosa

Coelogyne holochila

Dendrobium farmeri

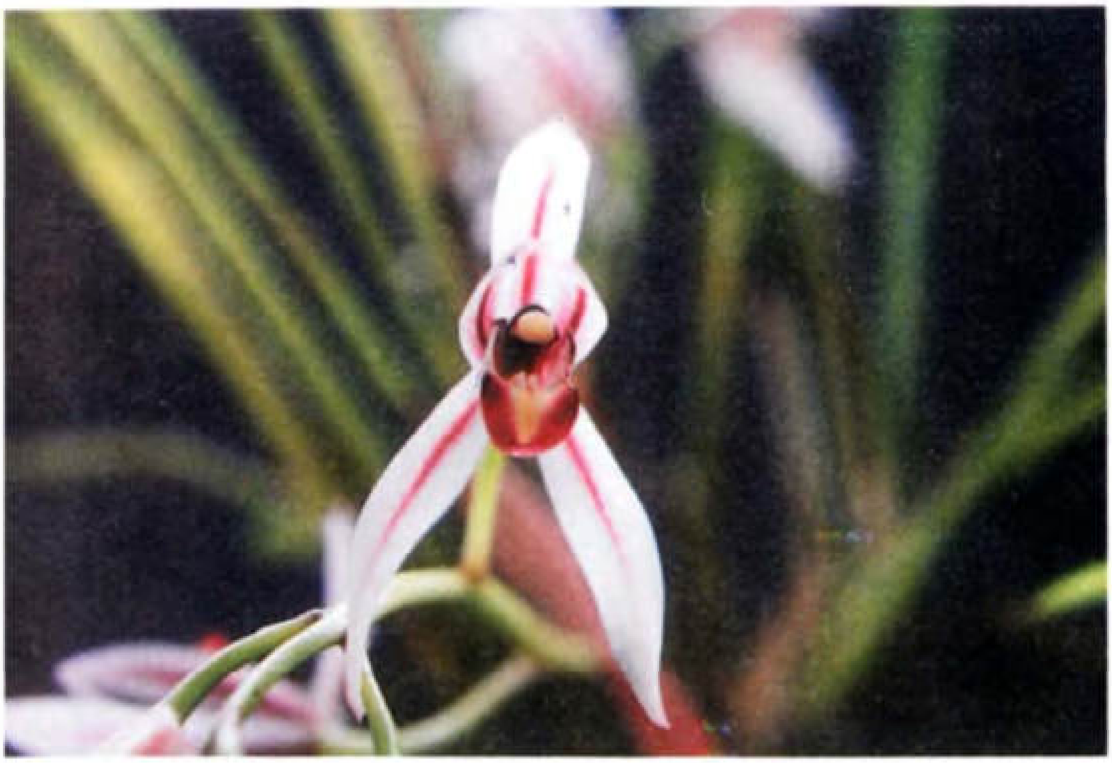
Dendrobium brymerianum

Dendrobium moschatum

Dendrobium nobile - State flower of Sikkim

Dendrobium falconeri

Hygrochilus parishii



Cymbidium dayanum

Cymbidium tracyanum

Cymbidium lowianum

Cymbidium mastersii

Esmeralda clarkei

Panisea uniflora

Cleisostoma appendiculatum

Eria sutepensis

Liparis viridiflora

Eria carinata

Pholidota imbricata

Neogyna gardneriana

Paphiopedilum hirsutissimum

Thunia marshalliana

LEGUMINOSAE

M. Sanjappa

Legumes are a fascinating group of flowering plants and are next to cereals in their economic importance. Among the flowering plants they are unique in two respects: (i) ability to enrich soil nitrogen through symbiotic nitrogen fixation in association with the root and stem nodule bacteria - *Rhizobium* and its allies, and (ii) protein-rich seeds which form the major source of vegetable protein consumed by man and his domesticated animals. Because of these biological properties, legume crops are used in low-input agriculture. The family yields wide range of industrial products, like drugs, dyes, resins, tannins, gums and a variety of timber products. Some of the legumes are the world's best known ornamentals. Much of the beauty and aesthetics of urban landscape owes to legume trees which bear elegant foliage and praise-worthy blooms in a range of colours. Ecologically, the family is as versatile as grasses and infact, in most ecosystems they coexist (for example grassland ecosystem). Some of the legumes are bottom up control species in ecosystem, whereas others act as keystone species. With about 17,000 species belonging to 700 genera *Leguminosae* is the third largest family of flowering plants (after *Compositae* with 21,000 species and *Orchidaceae* with 20000 species). Legumes are significant components of nearly all terrestrial biomes and are found throughout the world but the maximum diversity is met in tropics and subtropics. The chief centres of distribution of the family are Africa, Madagascar and South America. The family includes a myriad of life forms - from tiny herbs to gigantic trees. The family is subdivided into three subfamilies viz., Caesalpinioideae, Mimosoideae and Papilionoideae. These sub families are further classified into 41 tribes and 28 subtribes. A synopsis of the tribes and subtribes within each sub family alongwith the number of genera and species hitherto known from the whole world is presented in Table I. All legumes bear pods, a character by which most of them can be easily recognised. The pods may be round or flat, winged, long or short, thin or thick, papery or leathery, woody or fleshy. Some are as small as pin head to the size of a cricket ball, others can be more than one meter long. Usually the pods split lengthwise along one or both margins to expose and release 1-several dozen seeds that they contain. Owing to their economic and ecological value to mankind, the legumes received much attention from scientists all over the world. This is evident by the series of National, Regional and International workshops on legumes held during the last decade and the global initiative for an all purpose data base on world legumes.

Table-I
An analysis of the diversity in different tribes within each subfamily of Leguminosae in world.

Subfamily	Tribe	Number of		Remarks
		Genera	Species	
Caesalpinioideae	Caesalpineae	47	36	
	Cassieae	20	598	With 2 subtribe
	Cercidae	5	263	With 4 subtribe
	Detarieae	58	468	
	Macrolobieae	23	240	
Mimosoideae	Parkieae	2	42	
	Mimozygantheae	1	1	
	Mimoseae	37	766	
	Acacieae	2	1201	
	Ingeae	17	981	
Papilionoideae	Swartzeae	11	184	
	Sophoreae	48	382	
	Dipteryxeae	3	21	
	Dalbergieae	19	330	
	Abreae	1	17	
	Tephroseae	50	873	
	Robinieae	21	164	
	Indigofereae	7	720	
	Desmodieae	27	567	With 4 subtribe
	Phaseoleae	84	1485	With 8 subtribe
	Psoraleeae	6	136	
	Amphoreae	8	238	
	Aeschynomeneae	25	473	
	Adesmieae	1	230	

Subfamily	Tribe	Number of		Remarks
		Genera	Species	
	Galegeae	20	2589	With 4 subtribe
	Carmichaelieae	5	46	
	Hedysareae	7	263	With 6 subtribe
	Loteae	4	127	
	Coronilleae	6	54	
	Viciae	5	298	
	Cicereae	1	40	
	Trifolieae	7	477	
	Brongnierteae	2	76	
	Mirbelieae	23	455	
	Bossiaeae	10	75	
	Podalyrieae	3	47	
	Liparieae	5	50	
	Crotalarieae	3	1112	
	Euchresteae	1	5	
	Thermopsideae	6	48	
	Genisteae	20	478	

DIVERSITY

First systematic study of Indian legumes was made as early as 1678 by a Dutch botanist Van Rheede from Malabar region of South India. He described and enumerated 63 species belonging to 33 genera (Nicolson *et al.*, 1988). Based on this work and other collection from India, Linnaeus (1753, 1754) described about 72 species of legumes belonging to 20 genera in his *Species Plantarum* and *Genera Plantarum*. Subsequently, Burmann (1768), Lamark (1785), Willdenow (1802), Candolle (1825), Taubert (1894), Roxburgh (1795, 1832), Wallich (1820), Wight and Arnott (1834) described a number of Indian legume genera and species from time to time. The first comprehensive study was made by J.G. Baker (1876-78) for J. D. Hooker's "The Flora of British India" wherein he recognised 833 species belonging to 132 genera. Of these only 548 species in 120 genera were distributed within the present political boundaries of India. Since then a number of regional floras were written, taxonomic revisionary study of some genera at national, regional and global level were made.

nomenclatural concepts underwent tremendous changes, more areas were explored intensively and extensively, all of which led to the description of new taxa, new distributional records, spliting or merging of genera and transfer of species from one genus to the other, etc. Besides a considerable number of legumes were introduced for cultivation, many of which are now naturalised, but no attempt was made to assess the diversity of the family even after a century of their first comprehensive study by Baker *l.c.*). This is probably because there were only two taxonomists who worked on legumes, David Prain in pre-independent period and K. Thothathri in the post-Independent period. As a first step to assess the legume diversity in India, Sanjappa (1992) published a checklist of all the known Indian legumes based on literature and specimens available in various herbaria. This checklist not only gives the magnitude of legume diversity in India but also provides baseline data for taxonomic revisions, floristic accounts and monographs. Infact the entire checklist information as such formed the nucleus for South-Asian legume database, a part of the global initiative of International Legume Database and Information Service (ILDIS). There are about 1252 species belonging to 199 genera in India today (table II, III). Some genera like, *Astragalus, Crotalaria, Indigofera* show explosive adaptive radiation with species ranging from 60 to 100 and occupy a wide range of ecological niches across altitudinal and latitudinal gradients. Some species like *Vigna marina, Sophora tomentosa, Canavalia maritima* (now called *Canavalia rosea*) occur at sea level along the coasts, while others, like *Trifolium repens* at about 7000 m in the Himalaya. The diversity of legumes is highest in Peninsular India which hosts about 550 species, followed by Himalaya (*ca* 500 species) and North-eastern India (*ca* 400 species).

Table II
Legume Diversity in India

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
LEGUMINOSAE (*Nom.alt.* Fabaceae)	*ca* 700	*ca* 199	*ca* 17000	***ca*1250**
Caesalpinioideae	160	35	1936	**175**
Caesalpinieae	47	11	365	**42**
Gymnocladus			05	**03**
Gleditsia			14	**05**

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
Acrocarpus			02	01
**Colvillea*			01	01
**Delonix*			10	02
Peltophorum			09	05
**Schizolobium*			02	01
Caesalpinia			150	20
**Haematoxylum*			03	01
**Parkinsonia*			15	01
Pterolobium			11	02
Cassieae	20	05	598	59
**Ceratonia*			02	01
Dialium			40	02
Cassia			30	09
Chamaecrista			250	11
Senna			240	36
Cercideae	05	01	263	31
Bauhinia			250	31
Detarieae	58	18	460	43
Cynometra			70	07
Maniltoa			25	01
**Schotia*			05	01
**Afzelia*			13	02
Intsia			03	02
**Lysidice*			01	01
Saraca			10	05
**Hymenaea*			15	02
Crudia			55	02
Hardwickia			01	01
Kingiodendron			06	01
**Baikiaea*			04	01
**Copaifera*			30	02
**Sindora*			20	01
**Brownea*			30	06

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
**Amherstia*			01	01
Humboldtia			06	06
**Tamarindus*			01	01
MIMOSOIDEAE	70	23	2991	173
Parkieae	02	01	42	06
Parkia			40	06
Mimoseae	37	13	766	33
Adenanthera			08	02
**Desmanthus*			25	01
Dichrostachys			12	02
Entada			32	02
Indopiptadenia			01	01
**Leucaena*			40	02
**Elephantorrhiza*			09	01
Mimosa			500	10
Neptunia			12	03
*Parapiptadenia'			04	01
Prosopis			44	05
Xylia			13	02
* Tetrapleura			02	01
Acacieae	02	02	1201	94
Acacia			1200	93
**Faidherbia*			01	01
Ingeae	20	07	981	40
Albizia			150	20
Archidendron			100	06
Calliandra			200	09
Zapotecha			2	01
Cathormion			01	01

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
**Enterolobiuim*			05	02
**Pithecellobium*			25	02
PAPILIONOIDEAE (FABOIDEA)	470	140	12000	894
Swartzieae	11	01	184	01
** Swartzia*			135	01
Sophoreae	48	09	382	21
**Myroxylon*			03	01
**Castanospermum*			01	01
Ormosia			100	05
**Baphia*			60	02
Dalhousiea			03	02
**Bolusanthus*			01	01
Calpurnea			08	01
Sophora			50	07
Cladastris			06	01
Dalbergieae	19	04	330	42
**Andira*			20	03
Dalbergia			100	33
**Centrolobium*			06	01
Pterocarpus			20	05
Abreae	01	01	17	03
Abrus			17	03
Tephrosieae	50	10	873	71
Aganope			06	02
Derris			60	22
Kunstleria			10	01
**Lonchocarpus*			100	02
Millettia			100	13

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
Mundulea			15	01
**Piscidia*			08	01
Pongamia			01	01
Tephrosia			400	27
**Wisteria*			06	01
Robinieae	21	03	164	12
**Gliricidia*			04	01
**Robinia*			05	01
Sesbania			50	10
Indigofereae	07	03	750	62
Indigofera			60	60
Indigastrum			05	01
Cyamopsis			03	01
Desmodieae	27	8	567	102
**Brya*			04	01
Tadehagi			03	01
Phylodium			01	01
Dendrolobium			02	02
Desmodium			300	40
Dicerma			01	01
Codariocalyx			02	02
Pseudarthria			06	01
Pycnospora			01	01
Mecopus			01	01
Uraria			20	08
Christia			10	02
Alysicarpus			35	18
Leptodesmia			06	01
Kumerovia			02	01
Eleiotis			02	02

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
Campylotropis			65	10
Lespedeza			40	09
Phaseoleae	84	42	1485	
Erythrina			110	20
Strongylodon			20	01
Mucuna			100	09
Butea			02	02
Meizotropis			02	02
Spatholobus			15	06
Apios			10	01
Cochlianthus			01	01
Dioclea			30	01
Canavalia			50	07
Pachynrhizus			06	01
Galactia			50	02
**Psophocarpus*			09	01
Sphenostylis			07	01
Lablab			01	01
Dolichos			60	03
Macrotyloma			24	03
Vigna			150	24
Macroptilium			20	02
**Phaseolus*			50	05
Çajanus			37	16
Calopogonum			08	01
Pueraria			20	13
Nogra			03	03
**Glycine*			09	01
Teramnus			08	05
Mastersia			02	01
Neonotonia			01	01
Shuteria			05	04

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
Dumasia			08	02
Amphicarpa			03	01
Ophrestia			13	01
**Kennedia*			15	02
**Hardenbergia*			02	01
**Centrosema*			45	02
Clitoria			70	05
Dysolobium			04	04
Dunbaria			15	07
Flemingia			30	20
Rhynchosia			200	27
Eriosema			130	02
Paracalyx			06	01
Psoraleeae	6	3	136	07
**Psoralea*			20	03
Cullen			35	03
**Bituminaria*			02	01
Amorpheae	8	01	238	01
**Amorpha*			15	01
Aeschynomeneae	25	07	473	32
Aeschynomene			150	03
Ormocarpum			20	02
Smithia			30	18
Geissapsis			03	02
Zornia			80	03
Stylosanthes			25	03
**Arachis*			22	01
Galegeae	20	09	2589	125
**Clianthus*			02	02
Colutea			28	02

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
Caragana			80	12
Chesneya			20	02
Astragalus			2000	85
Oxytropis			300	16
Gueldenstaedtia			10	03
Alhagi			03	02
**Glycyrrhiza*			20	01
Hedysareae	07	05	263	12
Hedysarum			100	07
Taverniera			10	01
Stracheya			01	01
Onobrychis			130	02
Ebenus			20	01
Loteae	04	01	127	02
Lotus			100	02
Coronilleae	06	01	54	01
**Ornithopus*			06	01
Viceae	05	04	298	29
Vicia			140	15
Lathyrus			150	10
**Lens*			05	02
**Pisum*			02	02
Cicereae	01	01	40	03
Cicer			40	03
Trifolieae	07	06	477	39
Ononis			75	02
Parochetus			01	01
Melilotus			20	04
Trigonella			80	12

Name of the taxon	No. of genera		No. of species	
	World	India	World	India
Medicago			50	08
Trifolium			250	12
Mirbelieae	23	03	455	03
**Brachysema*			.15	01
**Oxylobium*			25	01
**Chorizema*			18	01
Bossiaeeae	10	01	75	01
**Lamprolobium*			01	01
Podalyrieae	03	01	47	01
**Virgilia*			02	01
Crotalarieae	16	02	1112	98
Crotalaria			600	97
Rothia			02	01
Euchresteae	01	01	05	01
Euchresta			05	01
Thermopsideae	06	02	48	03
Piptanthus			03	01
Thermopsis			23	02
Genisteae	20	08	478	15
**Lupinus*			200	02
Argyrolobium			70	03
**Laburnum*			02	01
**Chamecytisus*			30	02
**Cytisus*			38	04
*Spartium			01	01
Genista			87	01
Ulex			20	01

* Exclusively cultivated in India.

Table-III
Diversity of Leguminosae in India

Subfamily	No. of Genera	No. of Species	No. of Subspecies	No. of varieties
Caesalpinioideae	32 (2)	175 (25)	03	06 (2)
Mimosoideae	23	175 (18)	09	11 (5)
Papilionoideae	144	902 (189)	11 (3)	92 (46)
Total	199 (2)	1252	23	109

Crotalaria with 97 species is the largest genus of Legumes in India followed by *Astragalus* with 85 species. A perusal of Table II reveals that 83 genera of Indian Leguminosae are represented in India by just a single species, while there are only 12 genera which have more than 20 species in the country (Table IV).

Table IV
Comparative size of genera with respect to number of species recorded in India

Subfamily	Number of genera with			
	1 species	2-10 species	11-20 species	≻ 20 species
Caesalpinioideae	17	13	02	02
Mimosoideae	13	09	01	01
Papilionoideae	53	66	13	09
Total	83	88	16	12

ENDEMIC AND RARE SPECIES

About 21 per cent of Indian legumes, including two genera *Hardwickia* and *Moullava*, are endemic and bulk of them belong to the genera *Crotalaria, Indigofera, Desmodium, Astragalus, Smithia,* *Alysicarpus, Dalbergia, Rhynchosia, Humboldtia,* etc. Only two monotypic genera, viz. *Hardwickia* and *Moullava* are endemic to India. Another genus which is essentially endemic to South Western Ghats of India is *Humboldtia* with 6 species.One of its species, which was collected only once in the last century from Tirunelveli Ghats, extends to Sri Lanka where it is common. Several of these endemics have highly restricted distribution and are represented by a few populations. Some of the critically endangered endemic tree species, like *Pterocarpus santalinus, Kingiodendron pinnatum, Humboldtia unijuga, H. bourdilloni, H. decurrens, Cynometra bourdilloni, C. beddomei, C. travancorica, Dialium travancoricum, Ormosia travancorica. Inga cyanometroides, Gleditsia assamica* and *Gymnocladus assamicus* are highly exploited for timber. Besides, all these tree species are very slow growing and it takes more than 30 years to harvest them for timber. Through intensive field surveys, it was possible to relocate species, like *Humboldtia unijuga, H. bourdilloni, Gleditsia assamica, Gymnocladus assamicus, Cynometra bourdilloni, C. beddomei, Dialium travancoricum* and *Inga cynometroides,* which were collected only once during the last century. Many of the shrubby and herbaceous endemics are rare but not endangered at present. About 40 rare and endemic legume species are introduced and established in experimental gardens of Botanical Survey of India for conservation , multiplication and reintroduction into their natural habitats. The endemic taxa in different subfamilies of Leguminosae are presented in Table V-VII, whereas Table VIII and IX shows some rare and highly localised Indian legumes.

Table V
Distribution of endemic taxa of the subfamily Caesalpinioideae

Name of the Taxon	Life form	Distribution
Bauhinia foveolata	S/T	Gujarat, Karnataka and Maharashtra
Bauhinia khasiana	S	Arunachal Pradesh, Manipur, Meghalaya and Mizoram
Bauhinia nicobarica	C	Andaman and Nicobar Islands
Bauhinia phoenicea	S/T	Karnataka, Kerala, Maharashtra and Tamil Nadu
Cassia roxburghii	T	Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Pondichery and Tamil Nadu

Name of the Taxon	Life form	Distribution
Chamaecrista kolabensis	H	Maharashtra
Chamaecrista montana	S	Andhra Pradesh, Gujarat, Karnataka and Tamil Nadu
Chamaecrista nilgirica	H	Andhra Pradesh and Tamil Nadu
Senna davidsonii	H	Uttaranchal (Kumaon)
Senna floribunda var. *pubescens*	H	Tamil Nadu (Nilgiri hills)
Senna intermedia	H/S	Kerala, Orissa and Tamil Nadu
Senna sophera var. *purpurea*	S	Coromandel Coast (Andhra Pradesh, Orissa, Tamil Nadu) Assam, Bihar, Delhi, Gujarat, Punjab, Sikkim, Uttar Pradesh and West Bengal
Cynometra beddomei	T	Kerala (Wynaad)
Cynometra bourdillonii	T	Karnataka, Kerala and Tamil Nadu
Cynometra travancorica	T	Karnataka, Kerala and Tamil Nadu
Dialium travancoricum	T	Kerala (Ponmudi)
Gleditsia assamica	T	Arunachal Pradesh and Nagaland
Gymnocladus assamicus	T	Meghalaya (Mawphlong)
Hardwickia binata	T	Peninsular and central India, Bihar, Delhi, Rajasthan and Uttar Pradesh
Humboldtia bourdilloni	T	Kerala
Humboldtia brunonis	S/T	Karnataka, Kerala and Tamil Nadu
Humboldtia decurrens	T	Kerala and Tamil Nadu
Humboldtia unijuga var. *unijuga*	T	Kerala and Tamil Nadu
Humboldtia unijuga var. *trijuga*	T	Kerala (Kovitherimalai)
Humboldtia vahliana	T	Kerala and Tamil Nadu
Kingiodendron pinnatum	T	Karnataka (S. Canara) to Tamil Nadu (Kanniyakumari)
Moullava spicata	C	Karnataka, Kerala and Maharashtra

H = Herb, S = Shrub, T = Tree.

Table VI
Distribution of endemic taxa of subfamily Mimosoideae

Name of the Taxon	Life form	Distribution
Acacia bolei	T	Tamil Nadu
Acacia campbellii	T	Andhra Pradesh and Tamil Nadu
Acacia diadenia	C/S	Assam
Acacia donaldi	T	Madhya Pradesh, Orissa and West Bengal
Acacia hohenackeri	S/T	South Western Ghats
Acacia pennata var. *canescens*	C/S	Bihar and Sikkim
Acacia pennata var. *heyneana*	S	Southern Peninsula and Orissa
Acacia pseudoeburnea	T	North western India, Bihar and Uttar Pradesh
Albizia arunachalensis	T	Arunachal Pradesh
Albizia kalkora	T	Madhya Pradesh and Nagaland
Albizia lathamii	T	Tamil Nadu
Albizia orissensis	T	Orissa
Albizia sikharamensis	T	Andhra Pradesh
Albizia thompsonii var. *thompsonii*	T	Orissa and Tamil Nadu
Albizia thomsonii var. *galbana*	T	Bihar and Orissa
Archidendron monadelphum var. *gracile*	S/T	Karnataka, Kerala andTamil Nadu
Inga cynometroides	S/T	Kerala (Rosemala hills)
Dichrostachys cinerea	S/T	Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh
Dichrostachys santapaui	S/T	Tamil Nadu
Mimosa angustifolia	S	Eastern and South Western Ghats
Mimosa barberi	H	Andhra Pradesh, North-eastern and central India
Mimosa prainiana	S	Andhra Pradesh and Gujarat

Table VII
Distribution of endemic taxa of subfamily Papilionoideae

Name of the Taxon	Life form	Distribution
Abrus fruticulosus	C/S	Karnataka, Meghalaya, Rajasthan, Tamil Nadu and Uttar Pradesh
Alysicarpus beddomei	H	Tamil Nadu (Nilgiri Hills)
Alysicarpubelgaumensis	H	Goa, Gujarat, Karnataka and Maharashtra
Alysicarpu bupleurifolius var. *gracilis*	H	Andhra Pradesh, Bihar, Madhya Pradesh, Rajasthan, Tamil Nadu and Uttar Pradesh
Alysicarpu bupleurifolius var. *hybridus*	H	Bihar, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal
Alysicarpu gamblei	H	Andhra Pradesh, Karnataka, Madhya Pradesh. and Orissa
Alysicarpu hamosus	H	Peninsula, Bihar, Delhi, Punjab, Rajasthan, Uttar Pradesh and West Bengal
Alysicarpu heyneanus var. *meeboldii*	H	Jammu & Kashmir, Madhya Pradesh and Uttar Pradesh
Alysicarpu mehabubnagarensis	H	Andhra Pradesh
Alysicarpu luteovexillatus	H	Maharashtra
Alysicarpu pubescens var. *pubescens*	H	Peninsula, Bihar and West Bengal
Alysicarpu pubescens var. *vasavadae*	H	Karnataka, Madhya Pradesh and Maharashtra
Alysicarpu racemosus	H	Gujarat, Karnataka, Maharashtra and Tamil Nadu
pubescens roxburghianus	H	Peninsula, Bihar, Rajasthan and Uttar Pradesh
Alysicarpu scariosus var. *pilifer*	H	Southern India
Alysicarpu vaginalis var. *stocksii*	H	Gujarat and Maharashtra

Name of the Taxon	Life form	Distribution
Alysicarpu vaginalis var. *venosa*	H	Arunachal Pradesh, Rajasthan, Tamil Nadu and West Bengal
Argyrolobium album	H	Punjab
Astragalus aegacanthoides	H	Uttaranchal (Kumaon)
Astragalus bakeri	H	Jammu & Kashmir (Temperate areas)
Astragalus cashmirensis var. *cashmirensis*	H	Jammu & Kashmir (between 3000 and 3500 m)
Astragalus cashmirensis var. *falconeri*	H	Kashmir
Astragalus gilgitensis	H	Jammu & Kashmir.
Astragalus hoffmeisteri var. *pilosa*	H	Jammu & Kashmir.
Astragalus kashmirensis	H	Himachal Pradesh, Jammu & Kashmir and Uttaranchal.
Astragalus khasianus	H	Meghalaya (Khasi Hills, upto 2035 m)
Astragalus maxwellii	H	Temperate W. Himalaya 2000 - 4400 m
Astragalus zemuensis	H	Sikkim
Cajanus cajanifolius	H	Andhra Pradesh, Bihar, Madhya Pradesh, Meghalaya, Orissa and Tamil Nadu
Cajanus sericeus	S	Peninsula and Rajasthan
Cajanus villosus	H/S	Sikkim and West Bengal
Calpurnia indica	S	Karnataka and Tamil Nadu
Campylotropis thomsonii	H	Assam and Meghalaya
Clitoria uniflora	H	Daman, Goa, Gujarat, Madhya Pradesh, Maharashtra and Rajasthan
Crotalaria barbata	S	Tamil Nadu and Kerala
Crotalaria beddomeana	H	Kerala and Tamil Nadu
Crotalaria bidiei	H	Kerala and Tamil Nadu
Crotalaria candicans	H	Tamil Nadu
Crotalaria clarkei	H	Andhra Pradesh, Karnataka, Kerala, Orissa and Tamil Nadu

Name of the Taxon	Lifeform	Distribution
Crotalaria decasperma	H	Maharashtra
Crotalaria digitata	H/S	Karnataka and Tamil Nadu
Crotalaria epunctata	H	Andhra Pradesh, Karnataka, Maharashtra, Orissa and Tamil Nadu
Crotalaria filipes var. *filipes*	H	Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Rajasthan
Crotalaria filipes var. *trichophora*	H	Bihar, Maharashtra and West Bengal
Crotalaria formosa	H	Tamil Nadu
Crotalaria fysoni	H	Kerala and Tamil Nadu
Crotalaria globosa	H	Andhra Pradesh, Bihar, Karnataka and Tamil Nadu
Crotalaria grahamiana	H	Kerala and Tamil Nadu
Crotalaria heyneana	H	Karnataka, Kerala and Tamil Nadu
Crotalaria leptostachya	H	Gujarat, Karnataka and Maharashtra
Crotalaria longipes	H	Andhra Pradesh and Tamil Nadu
Crotalaria lutescens	H	Karnataka and Maharashtra
Crotalaria madurensis var. *madurensis*	H	Karnataka and Tamil Nadu
Crotalaria madurensis var. *kurnoolica*	H/S	Andhra Pradesh
Crotalaria meeboldii	H	Nagaland
Crotalaria naikiana	H/S	Maharashtra
Crotalaria notonii	S	Gujarat, Karnataka and Tamil Nadu
Crotalaria noveoides	H	Meghalaya (Khasi Hills)
Crotalaria obtecta	H	Kerala and Tamil Nadu
Crotalaria obtecta var. *glabrescens*	H	Karnataka, Kerala and Tamil Nadu
Crotalaria paniculata var. *nagarjunakondensis*	H	Andhra Pradesh
Crotalaria peduncularis	H/S	Tamil Nadu (Nilgiris)
Crotalaria priestleyoides	H	Tamil Nadu

Name of the Taxon	Life form	Distribution
Crotalaria pulchra	H/S	Karnataka and Tamil Nadu
Crotalaria. pusilla	H	Western Peninsula and Bihar
Crotalaria ramosissima	H/S	Western Peninsula and Orissa
Crotalaria rigida	H/S	Andhra Pradesh. Karnataka and Tamil Nadu
Crotalaria rubiginosa	H/S	Tamil Nadu
Crotalaria salicifolia	H/S	Karnataka, Kerala and Tamil Nadu
Crotalaria sandoorensis	H/S	Karnataka (Bellary)
Crotalaria scabra	H/S	Tamil Nadu
Crotalaria sessiliflora var. *sessiliflora* f. *garhwalensis*	H	Uttaranchal
Crotalaria sessiliflora var. *anthylloides* f. *anthylloides*	H	Himachal Pradesh, Meghalaya and West Bengal
Crotalaria sessiliflora var. *anthylloides* f. *leneariformis*	H	Madhya Pradesh and Uttar Pradesh
Crotalaria speciosa	S	Andhra Pradesh and Tamil Nadu
Crotalaria tecta	S	Maharashtra and Tamil Nadu
Crotalaria topouensis	H	South India and Bihar
Crotalaria vestita	H/S	Gujarat, Karnataka and Maharashtra
Crotalaria willdenowiana subsp. *willdenowiana*	H	Andhra Pradesh and Tamil Nadu
Crotalaria willdenowiana subsp. *glabrifoliolata*	H	Tamil Nadu (Coimbatore)
Dalbergia beddomei	S/T	Kerala (Silent valley)
Dalbergia clarkei	C/S	Arunachal Pradesh, Assam and Meghalaya
Dalbergia congesta	C/S	Tamil Nadu (Nilgiri hills)
Dalbergia coromandeliana	S	Tamil Nadu

Name of the Taxon	Life form	Distribution
Dalbergia duarensis	T	West Bengal
Dalbergia gerardiana	C/S	Tamil Nadu (Nilgiri hills)
Dalbergia horrida	C/S	Karnataka, Kerala, Maharashtra and Tamil Nadu
Dalbergia horrida var. *concanensis*	C/S	Maharashtra (Konkan)
Dalbergia horrida var. *glabrescens*	C/S	Karnataka and Tamil Nadu
Dalbergia malabarica	CS/T	Karnataka, Kerala, Maharashtra and Tamil Nadu
Dalbergia millettii var. *oldhami*	CS/T	Meghalaya
Dalbergia pinnata var. *acaciaefolia*	CS/T	Karnataka and Tamil Nadu
Dalbergia rimosa var. *griffithii*	CS/T	Meghalaya
Dalbergia thomsonii	CS	Assam and Meghalaya
Dalbergia tinnevelliensis	CS	Tamil Nadu
Dalbergia travancorica	S	Kerala
Dalbergia wattii	T	Manipur
Dalhousiea paucisperma	CS	Assam
Derris andamanica	CS	Andaman and Nicobar Islands
Derris benthamii var. *wightii*	CS	Tamil Nadu
Derris brevipes var. *brevipes*	CS	Karnataka, Kerala, Maharashtra and Tamil Nadu
Derris brevipes var. *coriacea*	CS	Karnataka, Kerala and Tamil Nadu
Derris brevipes var. *travancoriensis*	CS	Kerala
Derris cuneifolia var. *cuneifolia* f. *assamica*	CS	Assam
Derris elegans var. *elegans* f. *andamanensis*	CS	Andaman Islands
Derris heyneana	CS	Goa, Gujarat, Karnataka and Maharashtra

Name of the Taxon	Life form	Distribution
Derris lushaiensis	CS	Mizoram
Derris macrocarpa	CS	Uttar Pradesh (Pilibhit)
Derris ovalifolia	CS	South India
Derris pseudorobusta	CS	Arunachal Pradesh and Meghalaya
Derris scancens var. *saharanpurensis*	CS	Uttar Pradesh
Derris secunda	CS	Arunachal Pradesh, Assam
Derris thothathrii	CS	Karnataka, Maharashtra and Tamil Nadu
Desmodium barbatum subsp. *saulierei*	S	Tamil Nadu
Desmodium benthamii	S	Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal
Desmodium dioicum	S	Arunachal Pradesh
Desmodium dolabriforme	H/S	Kerala and Tamil Nadu
Desmodium ferrugineum ssp. *wynadense*	S	Kerala and Tamil Nadu
Desmodium kulhaitense	S	Sikkim and West Bengal
Desmodium likabalium	H	Arunachal Pradesh
Desmodium ritchiei	H	Gujarat, Karnataka, Kerala, Maharashtra, Rajasthan and Tamil Nadu
Dumasia cordifolia	CH	Manipur and Meghalaya
Dunbaria debilis	CH	Manipur, Meghalaya and Sikkim
Dysolobium tetragonum	CH/CS	Assam and West Bengal
Erythrina blakei	H	Uttar Pradesh (cultivated in Gardens) origin unknown
Erythrina resupinata	H	Bihar, Orissa, Uttar Pradesh and West Bengal
Flemingia gracilis	H	Karnataka and Maharashtra
Flemingia nilgheriensis	H	Goa, Karnataka, Maharashtra, Orissa and Tamil Nadu
Flemingia praecox var. *robusta*	H	Gujarat and Maharashtra

Name of the Taxon	Life form	Distribution
Flemingia rollae	H	Maharashtra
Flemingia tuberosa	S	Goa, Gujarat, Karnataka and Maharashtra
Galactia longifolia	CH	Peninsular India and West Bengal
Geissapsis tenella var. *tenella*	H	Karnataka, Kerala, Maharashtra and Tamil Nadu
Geissapsis tenella var. *malabarica*	H	Kerala
Hedysarum astragaloides	H	Himachal Pradesh and Jammu & Kashmir
Hedysarum falconeri var. *cachemirianum*	H	Jammu & Kashmir
Hedysarum microcalyx	H	Himachal Pradesh, Jammu & Kashmir and Uttaranchal
Hedysarum pseudomicrocalyx	H	Himachal Pradesh, Jammu & Kashmir and Uttaranchal
Indigofera angulosa	S	Gujarat, Madhya Pradesh, Maharashtra, Rajasthan and Uttaranchal
Indigofera barberi	H/S	Andhra Pradesh and Tamil Nadu
Indigofera bracteata var. *khasiana*	H	Meghalaya
Indigofera cedrorum	S	Hamachal Pradesh and Uttaranchal
Indigofera cerulea var. *monosperma*	S	Gujarat, (Kutch) and Rajasthan
Indigofera dalzellii	H	Goa, Karnataka and Maharashtra
Indigofera deccanensis	S	Maharashtra
Indigofera dosua var. *simlensis*	S	Himachal Pradesh and Uttar Pradesh
Indigofera gangetica	S	Himachal Pradesh and Uttar Pradesh
Indigofera glandulosa var. *sykesii*	H	Madhya Pradesh and Maharashtra
Indigofera hamiltonii	S	Bihar, Himachal Pradesh, Madhya Pradesh, Orissa and Uttar Pradesh

Name of the Taxon	Life form	Distribution
Indigofera himalayensis	S	Himachal Pradesh, Jammu & Kashmir and Punjab
Indigofera karuppiana	H	Karnataka, Kerala and Tamil Nadu
Indigofera mysorensis	S	Andhra Pradesh, Karnataka, Tamil Nadu and West Bengal
Indigofera prostrata	H	Andhra Pradesh, Goa, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Pondichery, Punjab and Tamil Nadu
Indigofera santapaui	H	Maharashtra
Indigofera sesquipedalis	S	Arunachal Pradesh, Meghalaya and Nagaland
Indigofera thothathrii	H/S	Uttar Pradesh
Indigofera tirunelvelica	H	Tamil Nadu
Indigofera trifoliata var. *duthiei*	H	Maharashtra
Indigofera trita var. *marginulata*	S	Tamil Nadu
Indigofera trita var. *purandharensis*	S	Maharashtra
Indigofera uniflora	H	Karnataka, Kerala, Maharashtra and Tamil Nadu
Kunstleria keralensis	CS	Kerala and Karnataka
Lablab purpureus subsp. *purpureus* var. *lignosus*	CS	Tamil Nadu (cultivated)
Lablab purpurens subsp. *bengalensis*	CS	Cultivated throughout India
Lespedeza elliptica	S	Meghalaya
Lespedeza speciosa	S	Himachal Pradesh and Uttaranchal
Macrotyloma uniflorum	CH	Cultivated throughout India
Millettia rubiginosa·	CS	Kerala and Tamil Nadu
Millettia splendens	CS	Tamil Nadu
Neonotonia wightii var. *coimbatorensis*	CH	Kerala and Tamil Nadu

Name of the Taxon	Life form	Distribution
Nogra dalzellii	CH	Karnataka and Maharashtra
Ophrestia pentaphylla	CS	Karnataka, Maharashtra and Meghalaya
Ormosia assamica	T	Assam
Ormosia travancorica	T	Karnataka, Kerala and Tamil Nadu
Oxytropis shivai	H	Jammu & Kashmir
Pterocarpus dalbergioides	T	Andaman & Nicobar Islands
Pterocarpus marsupium var. *acuminata*	T	Bihar, Gujarat, Karnataka, Maharashtra and Rajasthan
Pterocarpus santalinus	T	Andhra Pradesh and Tamil Nadu
Pachyrrhizus stracheyi	CS	Uttar Pradesh
Rhynchosia beddomei	H	Andhra Pradesh and Karnataka
Rhynchosia courtallensis	H	Southern India
Rhynchosia filipes	S	Tamil Nadu
Rhynchosia fischeri	S	Tamil Nadu
Rhynchosia hainesiana	S	Orissa
Rhynchosia heynei	H/S	Andhra Pradesh, Karnataka and Tamil Nadu
Rhynchosia jacobii	H	Tamil Nadu
Rhynchosia meeboldii	CS	Nagaland
Sesbania procumbens	H	Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Tamil Nadu
Shuteria hirsuta var. *bracteosa*	CS	Meghalaya and Sikkim
Smithia agharkarii	H	Maharashtra
Smithia capitata	H	Goa, Karnataka, Maharashtra, Rajasthan and Tamil Nadu
Smithia gracilis	H	Karnataka, Kerala and Tamil Nadu
Smithia grandis	H	Assam, Meghalaya, Sikkim and West Bengal
Smithia hirsuta	H	Karnataka, Maharashtra, Meghalaya and Tamil Nadu

Name of the Taxon	Life form	Distribution
Smithia oligantha	H	Maharashtra
Smithia purpurea	H	Karnataka and Maharashtra
Smithia pycnantha	H	Karnataka, Maharashtra, Rajasthan and Tamil Nadu
Smithia setulosa	H	Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu
Smithia venkobarowii	H	Kerala (Peermade)
Spatholobus purpureus	CS	Goa, Karnataka, Kerala, Maharastra and Tamil Nadu
Sophora bakeri	S	Bihar
Sophora interrupta	S	Andhra Pradesh, Karnataka, Madhya Pradesh, Orissa and Tamil Nadu
Sphenostylis bracteata	C	Maharashtra
Tephrosia barberi	H	Tamil Nadu
Tephrosia calophylla	S	Andhra Pradesh, Karnataka and Tamil Nadu
Tephrosia canarensis	S	Karnataka, Kerala and Tamil Nadu
Tephrosia coccinea	H/S	Gujarat, Maharashtra and Rajasthan
Tephrosia collina var. *collina*	H	Gujarat, Maharashtra and Rajasthan
Tephrosia collina var. *lanuginocarpa*	H	Rajasthan
Tephrosia jamnagarensis	S	Gujarat
Tephrosia purpurea var. *maritima*	H	Orissa
Tephrosia roxburghiana	H	Andhra Pradesh, Karnataka and Orissa
Tephrosia wynaadensis	S	Kerala and Tamil Nadu
Teramnus hookerianus	CH	West Bengal
Trigonella podperae	H	Jammu & Kashmir
Vigna bourneae	CH	Karnataka and Tamil Nadu

Name of the Taxon	Life form	Distribution
Vigna clarkei	CH	Arunachal Pradesh, Assam, Sikkim and West Bengal
Vigna hainiana	CH	Assam, Bihar, Madhya Pradesh, Orissa, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal
Vigna khandalensis	H	Gujarat, Karnataka, Maharashtra and Tamil Nadu
Vigna trilobata var. *pusilla*	CH	Maharashtra
Vigna vexillata var. *sepiaria*	CH	Karnataka, Kerala, Maharashtra and Tamil Nadu
Vigna vexillata var. *stocksii*	CH	Andhra Pradesh, Bihar, Karnataka, Kerala, Maharashtra, Maharashtra, Orissa and Tamil Nadu
Vigna vexillata var. *wightii*	CH	Karnataka, Kerala and Tamil Nadu
Zornia quilonensis	H	Karnataka, Kerala, Tamil Nadu and West Bengal

Table VIII
Legume species known only by a few collections in herbaria but rare or common in adjoining countries

Name of the taxon	Distribution
Caesalpinioideae	
Acrocarpus fraxinifolius	North-eastern India, Western Ghats
Bauhinia ovalifolia	Arunachal Pradesh
Cassia holosericea	Gujarat
Cynometra malaccensis	Assam
Gleditsia delavayi	Arunachal Pradesh
Gymnocladus chinensis	Aruanachal Pradesh
Gymnocladus burmanicus	Arunachal Pradesh
Hamboldtia laurifolia	Tamil Nadu - Kerala border
Maniltoa polyandra	Assam, Meghalaya, Mizoram

Name of the taxon	Distribution
Mimosoideae	
Acacia hydaspica	Punjab
Acacia pennata subsp. *hainanensis*	Meghalaya
Adenanthera microsperma	Great Nicobar Island (South bay)
Albizia sherriffii	Arunachal Pradesh
Indopeptadenia oudhensis	Uttar Pradesh (Gonda)
Papilionoideae	
Campylotropis parviflora	Meghalaya
Chesnea depressa	Jammu & Kashmir
Cochlianthus gracilis	Meghalaya (Khasi hills)
Crotalaria kurzii	Mizoram
Dalbergia oliveri	Arunachal Pradesh
Dalbergia reniformis	Assam
Dalbergia velutina	Meghalaya (Khasi hills)
Derris hainesiana	Bihar
Desmodium willamsii	Arunachal Pradesh (Lohit Dist.)
Dunbaria podocarpa	Mizoram
Euchresta horsfieldii	Meghalaya (Khasi hills)
Indigofera lacei	Nagaland (Tuensong)
Indigofera vicioides	Tamil Nadu (Tirunelveli)
Leptodesmia congesta	Tamil Nadu (Nilgiri hills)
Mecopus nidulans	West Bengal (Unspecified)
Meizotropis pellita	Uttaranchal (near Nainital)
Nogra filicaulis	Madhya Pradesh (Bilaspur)
Pterocarpus macrocarpus	Tripura
Pueraria bella	Arunachal Pradesh
Pueraria yunnanensis	Assam
Rhychosia acutissima	Kerala (Thiruvanantapuram)

Name of the taxon	Distribution
Rhynchosia velutina	Tamil Nadu
Sophora mollis subsp. *griffithii*	Punjab
Spatholobus acuminatus	Andaman & Nicobar Islands (South Andaman)
Spatholobus crassifolius	Meghalaya (Khasi hills)
Strongylodon lucidus	Andaman & Nicobar Islands (South Andaman)
Teramnus repens subsp. *gracilis*	Maharashtra
Uraria hispida	Nagaland

Table IX
Highly localised endemic legume species known only from 1 or 2 localities and by 1 - 5 collections

Name of the taxon	Distribution
Caesalpinioideae	
Cynometra beddomei	Kerala (Wynaad)
Cynometra bourdilloni	Karnataka (Hassan), Kerala (Wynaad)
Dialium travancoricum	Kerala (Ponmudi)
Gleditsia assamica	Arunachal Pradesh (Pasi Ghat)
Gymnocladus assamicus	Meghalaya (Mawphlong)
Humboldtia bourdilloni	Kerala (Peermade Ghats)
Humboldtia unijuga var. *unijuga*	Kerala - Tamil Nadu border (Near Agastyamalai)
Hamboldtia unijuga var. *trijuga*	Kerala (Kovitherimalai)
Mimosoideae	
Acacia bolei	Tamil Nadu
Acacia didenia	Assam

Name of the taxon	Distribution
Albizia arunachalensis	Arunachal Pradesh
Albizia lathami	Tamil Nadu
Albizia sikharamensis	Andhra Pradesh
Inga cynometroides	Kerala (Rosemala hills)
Papilionoideae	
Dalbergia beddomei	Kerala (Silent valley)
Dalbergia duarensis	West Bengal (Alipur Duar)
Dalbergia tinnivelliensis	Tamil Nadu (Tirunelveli)
Dalbergia travancorica	Kerala (Thiruvanantapuram)
Dalbergia wattii	Manipur (Mayung, Meitaphum)
Dalhousiea paucisperma	Assam (unknown locality)
Derris brevipes var. *travancorensis*	Kerala
Derris lushaiensis	Mizoram
Derris macrocarpa	Uttar Pradesh (Pilibhit)
Desmodium barbatum subsp. *saulierei*	Tamil Nadu (Pulney hills)
Millettia splendens	Kerala (Idduki district)
Ormosia assamica	Assam (Cachar)
Pachyrrhizus stracheyi	Uttar Pradesh (Kumaon)
Sphenostylis bracteata	Maharashtra (Konkan)
Tephrosia barberi	Tamil Nadu

ECONOMIC USES

Food

a. Human food

CAESALPINIOIDEAE

Bauhinia malabarica (leaf), *B.vahlii* (seed); *Cassia floribunda* (pod); *Chamaecrista absus* (leaf); *Senna alata* (tender pod); *S. auriculata* (leaf); *S. hirsuta* (leaf); *S. obtusifolia* (leaf, pod, seed); *S. occidentalis* (leaf, seed); *S. sophera* (leaf); *Tamarindus indica* (tender shoot, leaf, and pod , pulp, seed).

MIMOSOIDEAE

Acacia nilotica subsp. *indica* (gum); *A. senegal* (gum); *A. sinuata* (tender leaf, seed); *Neptunia oleracia* (tender shoot, pod); *Parkia timoriana* (pod, seed); *Prosopis cineraria* (bark, shoot, pod, gum).

PAPILIONOIDEAE

Abrus precatorius (leaf); *Aeschynomene aspera* (leaf), *A. indica* (whole plant); *Alhagi maurorum* (whole plant); *Alysicarpus longifolius* (whole plant); *Canavalia cathartica* (tender pod, seed); *C. gladiata* (tender pod, leaf, flower, seed); *Clitoria annua* (tender pod); *Crotalaria juncea* (flower); *Cyamopsis tetragonoloba* (tender pod, gum); *Dendrolobium triangular* (leaf); *Flemingia macrophylla* (pod); *F. tuberosa* (tuber); *Indigofera cordifolia* (seed); *I. glandulosa* (seed); *I. linifolia* (seed); *I. cassioides* (flower); *I. dosua* (flower); *I. heterantha* (flower); *Lablab purpureus* (tender pod, seed); *Lathyrus sativus* (tender shoots, leaf, seed); *Macrotyloma uniflorum* (seed); *Mucuna gigantea* (seed); *M. nigricans* (seed); *M. monosperma* (seed); *M. pruriens* (tender pod), *M. pruriens* var. *utilis* (seed); *Cullen corylifolia*(seed); *Pachyrrhizus erosus* (tuber); *Pisum sativum* (seed); *Pueraria tuberosa* (tender twigs, leaves, tuber); *Rothia indica* (leaf, pod); *Sesbania bispinosa* (seed); *S. grandflora* (leaf, flower, tender pod); *S. procumbens* (seed); *Smithia conferta* (leaf); *S. sensitiba* (leaf); *Spatholobus parviflorus* (seed); *Trigonella foenum-graceum* (leaf, seed); *Vigna aconitifolium* (tender pod, seed); *V. dalzelliana* (tender pod, seed); *V. marina* (tender pod, seed); *V. mungo* (tender pod, seed); *V. pilosa* (seed); *V. grahamiana* (tender pod, seed); *V. khandalensis* (tender pod, seed); *V. sinensis* (tender pod, seed); *V. umbellata* (tender pod, seed); *V. wightii* (tender pod, seed); *V. radiata* (tender pod, seed); *V. trilobata* (seed); V. *unguiculata* (pod, seed tender shoot); *V. vexillata* (seed).

b. Animal food:

CAESALPINIOIDEAE

Caesalpinia bonduc (leaf); *Parkinsonia aculeata* (pod); *Senna occidentalis* (tender plant); *S. sophera* (leaf).

MIMOSOIDEAE

Mimosa hamata (shoot); *M. pudica* (shoot).

PAPILIONOIDEAE

Aeschynomene indica (whole plant); *Alhagi maurorum* (whole plant); *Alysicarpus longifolius* (whole plant); *A. monilifer* (whole plant); *A. pubescens* (whole plant); *A. scariosus* (whole plant); *A. vaginalis* (whole plant); *Butea manosperma* (leaf); *B. superba* (leaf); *Canavalia cathartica* (whole plant); *Cicer arietinum* (whole plant); *Clitoria ternatea* (leaf); *Codariocalyx motorius* (leaf); *Crotolaria ferruginea* (leaf); *C. juncea* (leaf); *C. medicaginea* (seed); *Cyamopsis tatragonoloba* (whole plant); *Desmodium triflorum* (shoot); *Flemingia strobilifera* (whole plant); *Indigofera linifolia* (whole plant); *I. nummulariifolia* (whole plant); *I. oblongifolia* (shoot); *Medicago sativa* (whole plant); *M. lupulina* (whole plant); *M. polymorpha* (whole plant); *Melilotus alba* (whole plant); *M. indica* (whole plant); *Millettia extensa* (leaf); *M. racimosa* (leaf); *Cullen corylifolia* (whole plant); *Lathyrus sativus* (whole plant); *Phyllodium pulchellum* (whole plant); *Pueraria tuberosa* (leaf); *Rhynchosia cana* (whole plant); *R. capitata* (whole plant); *R. rufescens* (whole plant); *Sesbania bispinosa* (whole plant); *S. grandiflora* (shoot, leaf, flower); *S. procombens* (whole plant); *Smithia blanda* var. *racemosa* (whole plant); *S. conferta* (whole plant); *S. hirsuta* (whole plant); *S. sensitiva* (whole plant); *Stylosanthes fruticosa* (whole plant); *Tephrosia candida* (whole plant); *T. tinctoria* (whole plant); *Teramanus labialis* (whole plant); *Trifolium alexandrium* (whole plant); *T. fragiferum* (whole plant); *T. resupinatum* (whole plant); *T. rapens* (whole plant); *Trigonella carniculata* (whole plant); *T. foenum-graceum* (whole plant); *T. occulta* (whole plant); *Vigna mungo* (whole plant); *V. pilosa* (whole plant); *V. aconitifoiia* (whole plant); *V. radiata* (whole plant); *V. trilobata* (whole plant); *V. unguiculata* (whole plant); *Zornia diphylla* (whole plant).

Medicine

CAESALPINIOIDEAE

Bauhinia acuminata (pod, bark), *B. malabarica* (bark), *B. purpurea* (bark, stem, leaf, flower), *B. phonicia* (root), *B. racemosa* (bark, stem, leaf, pod), *B. roxburghiana* (bark), *B. vahlii* (bark, leaf, flower, seed), *B. variegata* (root, leaf, bark, flower), *B. wallichii* (whole plant); *Caesalpinia bonduc* (root, bark, seed, seed oil), *C. crista* (root, bark, leaf, seed), *C. cucullata* (seed), *C. decapetala* (all parts), *C. digyna* (root), *C. mimosoides* (root, stem), *C. pulcherrima* (stem, leaf, flower, seed), *C. sappan* (wood); *Cassia fistula* (all parts), *C. floribunda* (leaf, bark, pod); *Ceratonia siliqua* (pod, seed); *Chamaechrista absus* (leaf, seed), *C. mimosoides* (all parts); *Cynometra cauliflora* (seed), *C. iripa* (root, leaf, seed); *Delonix elata* (leaf); *Haematoxylum camphechianum* (wood); *Humboldtia vahliana* (stem); *Hymaenea verrucosa* (stem); *Kingiodendron pinnatum* (stem); *Moullava spicata* (root, stem, pod); *Senna auriculata* (all parts); *S. didimobotrya* (leaf, root), *S. hirsuta* (leaf, seed), *S. italica* (leaf, pod, seed); *S. obtusifolia* (root, leaf, seed), *S. occidentalis* (root, leaf, seed), *S. obovata* (leaf), *S. pumila* (all parts), *S. sophera* (root, leaf, bark, seed), *S. surattensis* (stem, leaf), *S. tora* (root, stem, leaf, seed); *Saraca asoca* (bark, flower, seed); *Tamarindus indica* (bark, leaf, pod, seed).

MIMOSOIDEAE

Adenanthera pavonina (wood, seed); *Acacia caesia* (root, bark); *A. catechu* (wood, bark, gum), *A. dealbata* (gum), *A. decurrens* (bark), *A. farnesiana* (all parts), *A. feruginea* (bark, wood), *A. gageana* (bark), *A. jaquemontii* (gum), *A. leucophloea* (root, bark, wood, pod), *A. modesta* (gum), *A. nilotica* subsp. *indica* (all parts), *A. pennata* (root, bark, leaf), *A. pseudoeburnea* (bark, leaf), *A. torta* (bark), *A. senegal* (root, gum), *A. sinuata* (bark, stem, leaf, pod), *Albizia amara* (leaf, flower, seed, gum), *A. chinensis* (bark), *A. julibrissin* (all parts), *A. lebbeck* (all parts), *A. myriophylla* (all parts), *A. odoratissima* (bark, leaf), *A. procera* (bark, leaf, seed), *Archidendron clypearia* (leaf), *A. monoadelphum* (leaf, seed), *Dichrostachys cineraria* (root, stem, leaf, pod), *Entada rheedii* (bark, stem, wood, leaf, seed), *Leucaenea leucocephala* (bark), *Mimosa hamata* (leaf, seed), *M. himalayana* (root, leaf, whole plant), *M. pudica* (root, stem, leaf), *Neptunia oleracea* (all parts), *N. triquetra* (root, leaf), *Pithecellobium dulce* (bark), *Prosopis cineraria* (all parts), *Xylia xylocarpa* (bark).

PAPILIONOIDEAE

Abrus fruticulosus (root, leaf, seed), *A. precatorius* (root, stem, leaf, seed), *A. pulchelus* (seed); *Aeschynomene indica* (whole plant); *Alhagi maurorum* (whole plant); *Alysicarpus bupleurifolium* (whole plant), *A. longifolium* (root), *A. monolifer* (whole plant), *A. rugosus* (seed), *A. vaginalis* (root, leaf, seed); *Andira inermis* (wood, seed); *Arachis hypogea* (pod); *Astragalus aegacanthoides* (root), *A. candolleanus* (root), *A. gummifer* (gum), *A. hamosus* (whole plant), *A. himalayanus* (seed), *A. multiceps* (seed), *A. tribuloides* (seed); *Butea monosperma* (root, bark, leaf, flower, seed, gum), *B. superba* (all parts, gum); *Cajanus cajan* (leaf, seed), *C. goensis* (root), *C. liniata* (leaf), *C. mollis* (whole plant), *C. platycarpa* (seed), *C. scarabeoides* (whole plant), *C. volubile* (root); *Canavalia gladiata* (root, pod), *C. cathartica* (seed); *Caragana gerardianum* (wood); *Cicer arietinum* (whole plant), *C. microphyllum* (root, seed); *Clitoria ternatea* (root, leaf, seed); *Colutea nepalensis* (leaf); *Codoryocalyx motorius* (whole plant), *C. gyroides* (root); *Crotalaria albida* (root), *C. bialata* (whole plant), *C. burhia* (root), *C. laburnifolia* (whole plant), *C. medicagenia* (whole plant), *C. prostata* (whole plant), *C. retusa* (whole plant), *C. calycina* (whole plant), *C. saltiana* (leaf), *C. spectabilis* (whole plant), *C. trifoliastrum* (root), *C. verrucosa* (leaf); *Cullen corylifolia* (pod, seed); *Cyamopsis tetragonoloba* (pod, seed); *Cytisus scoparius* (stem); *Dalbergia horrida* (stem, leaf), *D. lanceolaria* (bark, stem, seed), *D. latifolia* (stem), *D. paniculata* (bark, leaf), *D. sisso* (stem, leaf), *D. spinosa* (root), *D. volubilis* (root, leaf), *Derris trifoliata* (bark, stem, seed); *Desmodium dichotomum* (whole plant), *D. elegans* (root), *D. gangeticum* (whole plant), *D. hetèrocarpon* var. *strigossum* (whole plant), *D. heterophyllum* (whole plant), *D. laxiflorum* (root), *D. microphylum* (root), *D. triflorum* (leaf), *D. velutinum* (whole plant), *D. umbellatum* (leaf, pod); *Dendrolobium triangulare* (root, leaf); *Dolichos trilobos* (root, seed); *Erythrina arborescens* (bark, wood, leaf), *E. resupinata* (tuber), *E. stricta* (bark, wood, leaf, flower), *E. suberosa* (bark, leaf), *E. variegata* (bark, wood, leaf, seed); *Flemingia chappar* (root, seed), *F. macrophylla* (root, whole plant), *F. nana* (root), *F. procumbens* (root, pod), *F. strobilifera* (root, leaf, whole plant), *F. tuborosa* (root, tuber); *Glycine max* (stem);

Glycirrhiza glabra (root, leaf); *Indigofera aspalathoides* (root, leaf, tender shoot, flower), *I. astragalina* (leaf), *I. cassioides* (root, leaf, flower, pod), *I. cerulea* (root, leaf, seed), *I. cordifolia* (root), *I. glandulosa* (seed), *I. hirsuta* (whole plant), *I. heteroantha* (root), *I. linifolia* (whole plant), *I. linnaei* (whole plant), *I. oblongifolia* (root, whole plant), *I. prostrata* (seed), *I. suffruticosa* (whole plant), *I. trifoliata* (seed), *I. tinctoria* (all parts), *I. trita* (seed); *Lablab purpureus* (root, leaf, pod, seed); *Lathyrus aphaca* (leaf, seed), *L. sativus* (seed); *Lens culinaris* (seed); *Lupinus albus* (whole plant); *Macrotyloma uniflorum* (all parts); *Meizotropis buteformis* (seed); *Melilotus indica* (whole plant), *M. officinalis* (whole plant); *Millettia caudata* (leaf); *M. extensa* (root, bark); *Mucuna bracteata* (stem, pod, seed, whole plant); *M. gigantia* (bark), *M. monosperma* (whole plant, seed), *M. nigricans* (stem, seed), *M. pruriens* (root, pod, seed); *Mundulea sericea* (bark); *Ormocarpum cohinchinensis* (root); *Ougenia oojeinensis* (stem, bark, leaf); *Oxytropis mullis* (whole plant), *O. tatarica* (whole plant); *Paracalyx scariosus* (root); *Parochetus communis* (leaf); *Phaseolus lunatus* (seed), *P. vulgaris* (whole plant); *Phyllodium pulchellum* (root, bark, flower); *Pongamia pinnata* (all parts); *Pseudarthria viscida* (whole plant); *Pterocarpus indicus* (wood, gum, seed), *P. marsupium* (wood, leaf, flower), *P. santalinus* (wood, pod); *Peuraria tuberosa* (root, tuber, shoot, seed); *Rhynchosia minima* (leaf); *Rothia indica* (whole plant); *Sesbania bispinosa* (whole plant, seed), *S.grandiflora* (root, bark, leaf, flower), *S. sesban* (leaf, flower, seed); *Smithia conferta* (whole plant), *S. sensitiva* (whole plant); *Sophora mollis* (seed), *S. tomentosa* (root, seed), *S. wightii* (root); *Spatholobus parviflorus* (root, stem, bark, leaf, seed); *Stylosanthes fruticosa* (whole plant); *Taverniera cuneifolia* (leaf); *Tephrosia candida* (leaf, seed), *T. purpurea* (leaf, root, whole plant), *T. spinosa* (root, bark), *T. tinctoria* (seed), *T. uniflora* subsp. *petrosa* (leaf), *T. villosa* (root, leaf, whole plant); *Teramnus labialis* (whole plant); *Trigonella foenum-graceum* (leaf, seed), *T. hamosa* subsp. *uncata* (seed), *T. occulta* (seed); *Trifolium corniculata* (pod), *T. pratense* (flower); *Uraria alopecuroides* (leaf), *U. crinita* (root, leaf, flower), *U. hamosa* subsp. *uncata* (whole plant), *U. lagopidioides* (root, leaf, pod, whole plant), *U. picta* (leaf, root, whole plant); *U. rufescens* (leaf); *Vicia faba* (stem); *Vigna aconitifolia* (root, seed), *V. adenantha* (whole plant), *V. grahamiana* (root), *V. mungo* (seed), *V. radiata* (root, seed), *V. trilobata* (leaf), *V. umbellata* (leaf), *V. unguiculata* subsp. *cylindrica* (seed); *Zornia diphylla* (root, whole plant)

Timber

CAESALPINIODEAE

Bauhinia malabarica, B. purpurea, B. racemosa, B. semla, B. tomentosa, B. variegata; Caesalpinia coriaria: Cassia fistula, C. montana, C. roxburghii; Senna siamea, S. surattensis, S. timorensis; Delonix elata, D. regia; Hardwickia binata; Parkinsonia aculeata; Peltophorum pterocarpum; Saraca asoca; Tamarindus indica.

MIMOSOIDEAE

Acacia auriculiformis, A. catechu, A. dealbata, A. eburnea, A. farnesiana, A. ferruginea; A. lenticularis, A. leucophloea, A. modesta, A. pennata, A. planifrons, A. tomentosa; Adenanthera pavonina; Albizia amara; A. chinensis; A. lebbeck; A. odoratissima; A. procera, A. thompsoni; Dichrostachys cinerea; Leucaena leucocephala; Parkia biglandulosa; Pithecellobium dulce; Prosopis chilensis, P. cineraria; P. glandulosa; Samanea saman; Xylia xylocarpa.

PAPILIONOIDEAE

Butea monosperma; Dalbergia congesta, D. lanceolaria, D. latifolia, D. paniculata, D. rubiginosa, D. sissoo, D. volubilis; Erythrina fusca, E. stricta, E. suberosa, E. subumbrans; E. variegata; Ougeinia oojeinsis; Pongamia pinnata; Pterocarpus marsupium, P. santalinus; Sesbania grandiflora, S. sesban.

Miscellaneous

CAESALPINIOIDEAE

Acrocarpus fraxinifolius (pulp), ***Bauhinia malabarica*** (fibre), ***B. tomentosa*** (dye), ***B. varigata*** (dye), ***Caesalpinia coriaria*** (dye, tannin), ***C. decapetala*** (tannin), ***C. pulcherrima*** (dye), ***C. sappan*** (dye), ***Casia fistula*** (dye), ***Delonix regia*** (dye), ***Hematoxylum camphechianum*** (dye), ***Peltophorum pterocarpum*** (dye), ***Senna alata*** (tannin), ***S. auriculata*** (tannin, dye), ***S. didymobotrya*** (tannin), ***S. obtusifolia*** (dye), ***S. pumila*** (gum), ***S. occidentalis*** (dye), ***S. tora*** (dye), ***Tamarindus indica*** (dye).

MIMOSOIDEAE

Acacia auriculiformis (tannin), *A. caesia* (tannin), *A. catechu* (dye, tannin, gum), *A. chundra* (dye, tannin, gum), *A. dealbata* (tannin, gum), *A. decurrens* (tannin), *A. farnesiana* (dye, gum), *A. leucopholoea* (dye), *A. nilotica* subsp. *indica* (dye, gum), *A. pennata* (dye, tannin), *A. planifrons* (tannin), *A. sinuata* (dye, tannin), *A. pycanantha* (tannin, gum), *A. senegal* (fibre), *A. suma* (tannin), *A. tortilis* (gum), *A. lenticularis* (gum), *A. mearnsii* (tannin, gum), *A. melanoxylon* (tannin), *Adenanthara pavonina* (dye), *Albizia amara* (gum), *A. lebbeck* (dye, gum), *A. odoratissima* (dye), *Pithecellobium dulce* (dye).

PAPILIONOIDEAE:

Abrus precatorius (fibres), *Aeschynomene aspera* (fibres, wood, seed oil), *A. indica* (stem), *Alhagi maurorum* (tannin), *Alysicarpus vaginalis* (seed gum), *Butea monosperma* (bark, fibre, gum, dye), *B. superba* (bark, fibre, gum, dye), *Clitoria ternatea* (dye), *Crotolaria juncea* (fibre), *C. mucronata* (dye), *C. spectabilis* (fibre), *Cyamopsis tetragonoloba* (dye, gum), *Derris scandens* (fibre), *D. trifoliata* (fibres), *Desmodium gangeticum* (fibre), *Flemingia grahamiana* (dye), *F. macrophylla* (dye), *Indigofera arrecta* (dye), *I. Aspalathoides* (dye), *I. caerulea* (dye), *I. dosua* (dye), *I. hirsuta* (dye), *I. longiracemosa* (dye), *I. tinctoria* (dye), *Indigastrum parviflorum* (dye), *Lablab purpureus* (dye), *Lotus corniculatus* (dye), *Millettia extensa* (fibres), *Pterocarpus indicus* (dye), *P. santalinus* (dye), *Sesbania bispinosa* (dye, fibre), *Sophora japonica* (dye), *Spatholobus parviflorus* (fibre, gum, oil), *Tephrosia maxima* (dye), *T. perpurea* (dye), *T. tinctoria* (dye), *Vigna unguiculata* (dye).

Environmental

CAESALPINIOIDEAE

Caesalpinia decapetala (hedge, lac host plant), *C. pulcherrima* (ornamental, hedge); *Cassia floribunda* (soil binder, shade tree); *Senna alata* (ornamental, green manure), *S. auriculata* (ornamental, forage, green manure, soil binder, revegetation), *S. didymobotrya* (shade plant), *S. hirsuta* (cover crop, green manure), *S. obtusifolia* (cover crop), *S.*

occidentalis (green manure, revegetation, shade plant), *S. pumila* (soil binder, green manure), *S. sophera* green manure); *Chaemecrista mimosoides* (cover crop).

MIMOSOIDEAE

Acacia auriculaeformis (sand binder), *A. decurrens* (green manure, wind breaker); *Albizia amara* (green manure), *A. stipulata* (green manure); *Mimosa hamata* (hedge, green maure), *M. pudica* (green manure).

PAPILIONOIDEAE

Aeschynomene americana, A. indica (green manure); *Alysicarpus monilifer* (drought resistant), *A. vaginalis* (soil improver, soil binder); *Canavalia gladiata* (green manure); *Crotalaria juncea* (green manure), *C. semperflorens* (green manure, soil binder), *Desmodium gangeticum* (green manure), *D. velutinum* (green manure, cover crop), *D. heterophyllum* (green manure, cover crop); *Dendrolobium triangulare* (green manure, cover crop); *Flemingia lineata* (green manure, host for lac insect); *Indigofera oblongifolia* (green manure), *I. tinctoria* (green manure, cover plant); *Lotus corniculatus* (soil binder, forage), *Mundulea sericea* (revegetation); *Cullen corylifolia* (green manure); *Rhynchosia cana* (green manure), *R. capitata* (green manure), *R. rufescens* (green manure); *Sesbania bispinosa* (cover crop, green manure), *S. grandiflora* (support plant); *Spatholobus parviflorous* (lac host plant); *Tephrosia candida* (green manure, wind breaker, shade plant), *T. hookeriana* (green manure, cover crop), *T. purpurea* (green manure), *T. tinctoria* (cover crop, green manure), *T. villosa* (green manure); *Teramnus labialis* (cover crop, green manure); *Uraria picta* (ornamental); *Vigna unguiculata* (cover crop, green manure); *Ulex europeus* (ornamental, hedge); *Zornia diphylla* (cover crop, green manure).

Fuel

PAPILIONOIDEAE

Aeschynomene aspera, A.indica, Butea monosperma, B.superba.

Poison

CAESALPINIOIDEAE

Senna alata (whole plant: livestock and fish poison), *S. didymobotrya* (shoots: livestock and fish poison).

PAPILIONOIDEAE

Abrus precatorius (seed); *Derris scandens* (seed); *Millettia extensa* (root, seed), *M. pachycarpa* (root), *M. racemosa* (root, seed); *Ormocarpum cochinchinensis* (whole plant); *Ougenia oojeinensis* (bark: fish poison); *Rhynchosia minima* (whole plant: fish poison); *Tephrosia candida* (whole plant : fish poison).

Social uses

CAESALPINIOIDEAE

Bahinia scandens (serpent repellent), *B. vahli* (leaf); *Caesalpinia bonduc* (seed), *C. pulcherrima* (flower).

MIMOSOIDEAE

Leucaena leucocephala (seed); *Prosopis cineraria* (whole plant).

PAPILIONOIDEAE

Abrus precatorius (seed); *Aeschynomene aspera* (pith); *Clitoria ternatea* (flower); *Crotalaria juncea* (fibre); *Uraria lagopodioides* (whole plant); *Vigna mungo* (seed), *V. radiata* (seed); *Dalbergia latifolia* (wood, twigs), *D. pinnata* (bark).

REFERENCES

Baker, J.G. 1876-78. Leguminosae. In: J.D. Hooker, *Flora of British India* **2:** 56 306. Reeve & Co., London.

Burman, N. L. 1768. *Flora Indica.* Lugd. Batav.

Candole, A. P. de 1825-27. *Memoires sur la Famille des Legumineuses.*

Candolle, A. P. de 1825. Leguminosae. Prodromus systematis naturalis. *Regni Vegetabilis.* **2:** 93-524.

Lamarck, J.B. A.P.M. de 1785. *Encyclopedie methodique Botanique,* I. Paris.

Linnaeus, C. 1753. *Species Plantarum.* Stockholm.

Linnaeus, C. 1754. *Genera Plantarum.* Stockholm.

Nicolson, D.H., C.R.Suresh and K.S. Manilal, 1988. An Interpretation of Van Rheed's Hortus Malabaricus. *Regnum Vegetabile* Vol. 119. Germany.

Roxburgh, W. 1795. *Plants of the Coast of Coromandel.* Vol. I (Pt. I & II).

Roxburgh, W. 1832. *Flora India.* ed. 2. Calcutta.

Sanjappa, M. 1992. *Legumes of India.* Dehra Dun.

Taubert, P. 1894. Leguminosae. In: A. Engler & K. Prantl, *Die Naturlichen Pflanzenfamilien.* ed. 1, 3, **3:** 259. Berlin.

Wallich, N. 1820. Description of some rare Indian plants. *Asiat. Res.* **13:** 369-415.

Wight, R. and G.A.W. Arnott 1834. Characters of three genera of Indian plants. *N. Philos. J.* **16**: 314-316.

Willdenow, C.L. 1802. Leguminosae. In: *Species Plantarum* **3**(2): 1171-1220. Berlin.

Acrocarpus fraxinifolius

N. Sashidharan

Kingiodendron pinnatum


N. Sashidharan

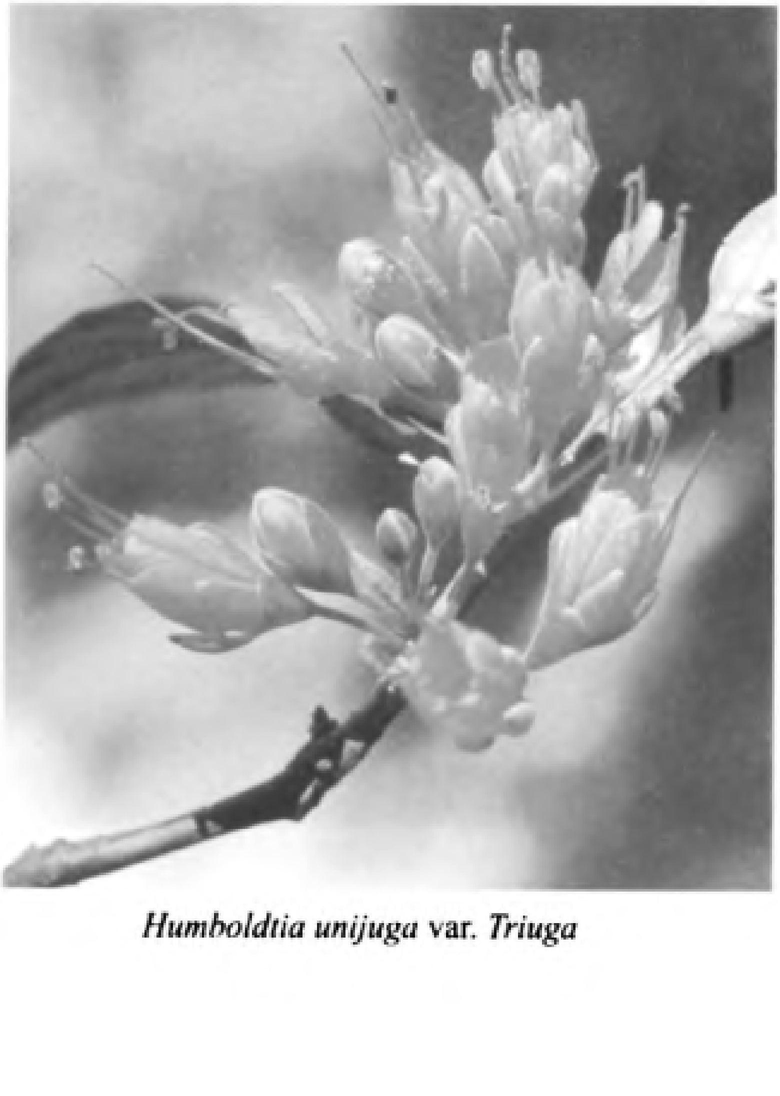
Cynometra beddomei (beddomei)

Hymenia verrucosa

Humboldtia laurifolia

Moullava spicata

Humboldtia unijuga var. *unijuga*



Humboldtia unijuga var. *Triuga*

Humboldtia brunonis

Mucuna pruriens

N. Sashidharan

Albizia lathamii

Archidendron clyperia

Calliandra cynometroides

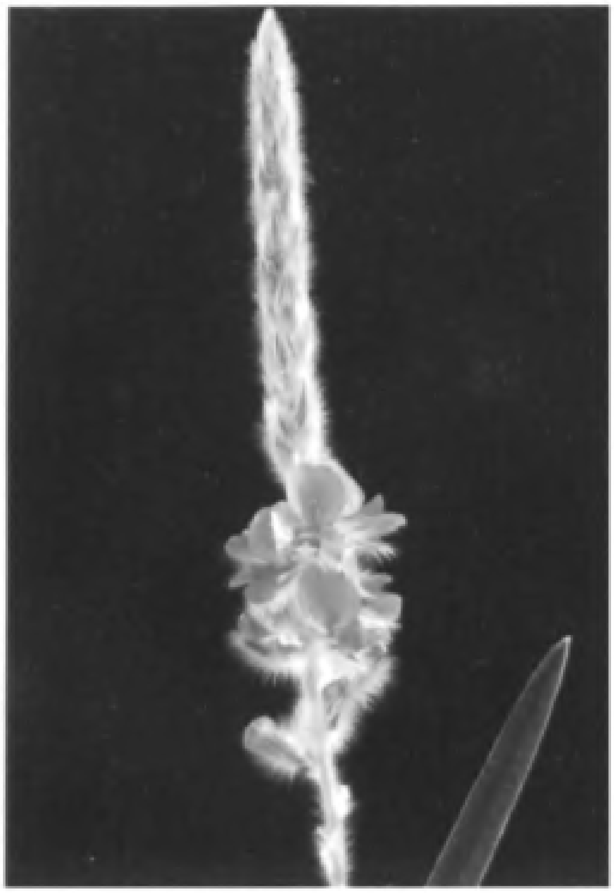
Neptunea oleracea

Crotalaria filipes

Ulex europeus

Indigofera dalzellii

Sesbania sesban



S.R. Yadav

Alysicarpus pubescens

Smithia purpurea - a population

S.R. Yadav

Smithia purpurea (close up)

Cajanus sericeus

Meizotropis buteiformis

Vigna khandalensis

1902

Flemingia nilgheriensis

ASTERACEAE

D.K. Singh
Reshma Mathur

Asteraceae or the 'Sunflower family', comprising about 25,000 species under 1,100 genera, is the largest flowering plant family in world (Heywood, 1993). Mabberley (1998), however, puts the global diversity figure of the family at about 22,750 species spreading over to 1,528 genera. The family includes evergreen shrubs or undershrubs, annual to perennial, rhizomatous, tap-rooted or tuberous rooted herbs and a few trees and climbers. The family Asteraceae is a natural assemblage of closely related taxa which are characterised by the inflorescence bearing involucrate heads or capitula with two distinct type of florets, i.e. *Ray Florets* and *Disc Florets*. Ray florets are female, ligulate, while the disc florets are bsiexual and tubular. Capitula having both ray and disc florets are called 'Radiate' type but if only disc florets are present, it is known as 'Discoid', or if only ray florets are present then the capitula is known as 'Ligulate'. Other significant morphological feature of the family are the 5-lobed, gamopetalous corolla, the presence of pappus of simple hairs, scales or awn instead of usual calyx, the inferior, bicarpellate, uniloculate ovary with a simple basal ovule, and the characteristic fruit types namely cypsela or achenes and nonendospermous seeds. On account of the prsecne of composite flowering heads, the family is also known by the alternative name 'Compositae'.

The range of variation in the leaves of this family is worth mentioning because they are very artistically made by the nature in various sizes, shapes, texture and ofcourse the beautifully cut margins, colours, different shades of pubescence and tomentum. Texture wise they are either membranous or coriaceous. Venation is another interesting character of the family. Some of the species exhibit beautiful, prominent, reticulate venation which gives an ornamentation to the plants, viz. *Senecio grahami, Synotis rufinervis*, etc.

The family is truly cosmopolitan, showing worldwide distribution except the continental Antarctica, with the principal loci of their speciation and proliferation being the central and South America, Africa, the Mediterranean and Australia. While the Asteraceous elements are also abundant in arctic, alpine and temperate regions of the world, they have rather poor representation in tropical rain florets.

The first record of Indian Asteraceae comes through Van Rheede's (1690) *Hortus Malabaricus* (vol. 10) wherein 14 species were documented. Subsequently, Linnaeus' (1953) in his two volumes of *Species Plantarum*, described 72 species from the country while, Burman (1786) recorded 56 species of Asteraceae from India. However, the first important contribution on the family was made by Don (1825) and Candolle (1838). Although Wallich (1831) catalogued about 400 species of the family from the Indian region, a number of which were named for the first time, a majority of them were treated as synonyms by different subsequent workers. Roxburgh (1832) recorded 89 species of Asteraceae from East India, while Royle (1839) described 12 species from Jammu & Kashmir. Around the same time, Wight (1834) made a significant contribution towards the Asteraceae in peninsular India, wherein he (Wight, *l.c.*) described 126 species. Major contribution on Asteraceae of Indian region, however, was made by Clarke (1876, 1881) who described 608 species in 128 genera from the erstwhile 'British India'. This was followed by a number of provincial treatments, which also dealt with the Asteraceae of the respective regions (Collett, 1902; Prain, 1903; Cooke, 1906; Fyson, 1914, 1932; Rao, 1914; Gamble, 1921; Fischer, 1938; Duthie, 1903-1926; Kanjilal *et al.*, 1939 etc.). Thus, subsequent to the publications by Clarke (*l.c.*) and Hooker (*l.c.*) more than 450 species have been added to the Asteraceae of flora of India (Calder *et al.*, 1926; Razi, 1959; Nayar & Ramamurthy, 1973; Ghosh & Dutta, 1976, 1979; Nayar & Karthikeyan 1981, Naithani, 1990).

DIVERSITY AND DISTRIBUTION

Recently, Rao *et al.*, (1988) enumerated 1052 taxa of Asteraceae from within the present political boundaries of India. Subsequently, Hajra *et al.*, (1995a, 1995b) published a detailed, revised taxonomic account of the family in India comprising 892 species, 37 subspecies, 123 varieties and 13 forma in 167 genera, 12 tribes and 17 subtribes (Table I, II). They (Hajra *et al.*, 1995a, 1995b) also listed 41 species of Asteraceae, belonging to 10 genera, which are widely cultivated in different parts of the country as ornamentals. Asteraceae thus represents fourth largest flowering plant family in India after Poaceae

(1291), Orchidaceae (1229) and Fabaceae (1192) (Karthikeyan, 2000). The chief centre of diversity of the family in India is the western Himalaya which hosts over 550 species followed by the eastern Himalaya (including the N.E. region) with over 350 species and Western Ghats with about 250 species. Whereas the Andaman & Nicobar Islands, with just 25 species hitherto recorded, represent the other extreme (Vasudeva Rao, 1986; Lakshminarasimhan & Rao, 1996). It is rather interesting to note that while all the Indian species in genera *Tanacetum, Taraxacum* and *Waldheimia* are confined to the Himalayan region alone, 60 out of 61 species of *Saussurea* are also confined to this region alone. A comparative account of distribution of different Tribes of the family in India *vis-a-vis* world is given in Table-I.

Table I
Distribution of Asteraceae in India and the World
(after Bremer *et al.*, 1992; Rao & Datt, 1996)
(excluding widely cultivated taxa)

Tribe	No of genera/ species in India	Distribution	
		India	World
Anthemidieae	12/66	Himalaya, Western Ghats, N.E. India	Old world, mainly Mediterranean and South Africa
Astereae	18/83	Mostly in Himalaya, also in Western Ghats and N.E. region	Cosmopolitan in temperate region
Calenduleae	1/2	Western Himalaya	Mediterranean and South Africa
Cardueae	21/119	Mostly Himalaya, N.E. region; a few also in northern, N.W. plains and southern plataeu	Chiefly in old world in the northern Hemisphere; few extending to new World
Cichroieae	22/184	Mostly in Himalaya, a few in plains as well.	Cold temperate regions

Tribe	No of genera/ species in India	Distribution	
		India	World
Eupatorieae	5/15	Most part of the country, ascending, up to 1800 m in Himalaya	Chiefly America
Heliantheae	27/56	Almost throughout	Tropical to temperate regions
Inuleae	25/147	Himalaya, N.E. region and Western Ghats	Cosmopolitan, chiefly in Australia and South Africa
Mutisieae	9/15	Himalaya	Chiefly South America
Senecioneae	16/133	Mostly in Himalaya	Cosmopolitan
Tageteae	2/4	Throughout	Tropical North - west America
Vernonieae	8/68	Chiefly in Western Ghats; also in tropical and subtropical Himalaya	Pantropical

State wise, Jammu & Kashmir, with about 481 species (Singh *et al.*, 1999) has the largest representation of the family in India, followed by Himachal Pradesh (328 spp.), Uttar Pradesh (325 spp), Sikkim (280 spp.), Tamil nadu (240 spp), etc. (Mudgal & Hajra, 1999a, 1999b). Other states of the Indian Union, having 100 or above species, are Arunachal Pradesh (186), Karnataka (177), Bihar (152), Punjab (142), West Bengal (139) Kerala (138); Assam (127), Rajasthan (125), Orissa (117), Gujarat and Madhya Pradesh (106 each), and Nagaland (101) Mudgal & Hajra, *l.c.;* K.K. Khanna, *pers. com.*).

Table II

A conspectus of genera and species of Asteraceae in India

Name of Genera	Number of				
	Species	Sub-species	Variety	Forma	Remarks
Acanthospermusm	1	–	–	–	–
Achillea	4	–	–	–	Wild/ Cultivated
Acroptilon	1	–	–	–	–
Adenocaulon	1	–	–	–	–
Adenoon	1	–	–	–	–
Adenostemma	1		8	–	–
Ageratum	2	–	–	–	Wild/ Cultivated
Ainsliaea	3	–	–	–	–
Amberboa	2	–	–	–	–
Ambrosia	1	–	–	–	–
Anaphalis	31	–	6	–	–
Anisopappus	1	–	–	–	–
Anthemis	1	–	–	–	–
Arctium	1	–	–	–	–
Arnica	1	–	–	–	Cultivated
Artemisia	34	–	25	6	Wild/ Cultivated
Aster	23	5	7	1	–
Athroisma	1	–	–	–	–
Bellis	1	–	–	–	Wild/ Cultivated
Bidens	10	–	3	–	–
Blainvillea	1	–	–	–	–
Blepharispermum	2	–	–	–	–
Blumea	29	–	8	–	–
Blumeopsis	1	–	–	–	–
Brachyactis	3	–	–	–	–
Brachycome	1	–	–	–	–
Braea	1	–	–	–	–

Name of Genera	Number of				Remarks
	Species	Sub-species	Variety	Forma	
Cacalia	5	–	–	–	–
Caesulia	1	–	–	–	–
Calendula	2	–	–	–	–
Calotis	1	–	–	–	Cultivated
Carduus	4	–	–	–	–
Carpesium	3	–	7	–	–
Carthamus	3	–	–	–	Wild/ Cultivated
Catamixis	1	–	–	–	–
Cavea	1	–	–	–	–
Cenia	1	–	–	–	–
Centaurea	4	–	–	–	Wild/ Cultivated
Centipeda	1	–	–	–	–
Centratherum	1	–	–	–	–
Chondrilla	2	–	–	–	–
Chrysanthellum	1	–	–	–	–
Chrysanthemum	16	–	–	–	Wild/ Cultivated
Cicerbita	6	3	–	–	–
Cichorium	2	–	–	–	–
Cirsium	7	–	–	–	–
Cissampelopsis	7	–	–	–	–
Conyza	10	–	2	–	–
Coreopsis	2	–	–	–	Cultivated
Cosmos	1	–	–	–	Cultivated
Cotula	5	–	–	–	Wild/ Cultivated
Cousinia	5	–	–	–	–
Crassocephalum	1	–	–	–	–
Cremanthodium	14	3	–	2	–
Crepis	9	4	–	–	–
Crupina	1	–	–	–	–
Cyathocline	1	–	3	–	–

Name of Genera	Number of				Remarks
	Species	Sub-species	Variety	Forma	
Dahlia	2	2	–	–	–
Dichrocephala	2	–	–	–	–
Dicoma	1	–	–	–	–
Dimorphotheca	1	–	–	–	–
Doronicum	3	–	2	–	–
Dubyaea	2	2	–	–	–
Echinops	3	–	–	–	–
Eclipta	1	–	–	–	–
Elephantopus	1	–	–	–	–
Eleutheranthera	1	–	–	–	–
Emilia	8	–	5	–	–
Enhydra	1	–	–	–	–
Epaltes	2	–	–	–	–
Erechtites	2	–	–	–	–
Erigeron	14	–	3	–	Wild/ Cultivated
Ethulia	1	–	–	–	–
Eupatorium	12	–	1	1	Wild/ Cultivated
Filago	3	–	–	–	–
Flaveria	2	–	–	–	–
Gaillardia	2	–	–	–	Cultivated
Galinsoga	2	–	–	–	–
Garhadiolus	1	–	–	–	–
Gerbera	3	–	–	–	–
Glossocardia	2	–	–	–	–
Glossogyne	1	–	–	–	–
Gnaphalium	10	2	1	–	–
Goniocaulon	1	–	–	–	–
Grangea	1	–	–	–	–
Guizotia	1	–	–	–	Wild/ Cultivated
Gynura	8	2	–	–	Wild/ Cultivated

Name of Genera	Number of Species	Number of Sub-species	Number of Variety	Number of Forma	Remarks
Helianthus	5	–	–	–	Cultivated
Helichrysum	5	–	4	–	–
Hemistepta	1	–	–	–	–
Heteropappus	3	–	–	–	–
Hieracium	6	–	2	–	–
Hochstetteria	1	–	–	–	–
Hypochoeris	2	–	–	–	–
Ifloga	1	–	–	–	–
Inula	20	–	–	–	–
Ixeris	3	–	2	–	–
Jurinea	2	–	–	–	–
Kalimeris	1	–	–	–	–
Kleinia	4	–	2	–	–
Koelpinia	1	–	–	–	–
Lactuca	24	–	3	–	–
Lagascea	1	–	–	–	–
Lagenifera	1	–	–	–	–
Laggera	3	–	–	–	–
Lamprachaenium	1	–	–	–	–
Lapsana	1	–	–	–	–
Launaea	9	–	–	–	–
Leibnitzia	2	–	–	–	–
Leontopodium	8	–	2	–	–
Leucanthemum	1	–	–	–	–
Leucomeris	2	–	–	–	–
Ligularia	11	2	–	2	Wild/ Cultivated
Logfia	1	–	–	–	Wild/ Cultivated
Matricaria	2	–	–	–	–
Microglossa	1	–	–	–	–
Mikania	1	–	–	–	–
Montonoa	1	–	–	–	–

Name of Genera	Number of				Remarks
	Species	Sub-species	Variety	Forma	
Moonia	2	–	–	–	–
Myriactis	5	–	2	–	–
Nannoglottis	1	–	–	–	–
Nanothamnus	1	–	–	–	–
Olgaea	1	–	–	–	–
Onopordum	1	–	–	–	–
Parthenium	1	–	–	–	–
Pascalia	1	–	–	–	–
Pegolettia	1	–	–	–	–
Pentanema	3	–	–	–	–
Petasites	1	–	–	–	–
Phagnolon	3	–	–	–	–
Phyllocephalum	9	–	–	–	–
Picris	1	–	–	–	–
Piloselloides	1	3	–	–	–
Pluchea	6	–	–	–	–
Prenanthes	6	–	–	–	–
Pseudelephantopus	1	–	–	–	–
Pseudojacoboea	1	–	–	–	–
Psiadia	1	–	2	–	–
Psychrogeton	1	–	3	–	–
Pterocaulon	1	–	–	–	–
Pulicaria	11	–	–	–	–
Reichardia	1	–	–	–	–
Rhynchospermum	1	–	–	–	–
Saussurea	61	–	9	–	–
Sclerocarpus	1	–	–	–	–
Scorzonera	2	–	–	–	–
Senecio	44	–	6	–	Wild/ Cultivated
Serratula	1	–	–	–	–
Siegesbeckia	1	–	–	–	–
Silybum	1	–	–	–	–

Name of Genera	Number of				Remarks
	Species	Sub-species	Variety	Forma	
Solidago	4	–	–	1	Wild/ Cultivated
Soliva	1	–	–	–	–
Sonchus	5	2	–	–	–
Soroseris	5	4	–	–	–
Sphaeranthus	4	–	–	–	–
Sphaeromorphaea	1	–	–	–	–
Spilanthes	6	–	–	–	–
Stevia	1	–	–	–	–
Struchium	1	–	–	–	–
Synedrella	2	–	–	–	–
Synotis	19	–	–	–	–
Tagetes	3	–	–	–	Wild/ Cultivated
Tanacetum	12	–	–	–	–
Taraxacum	82	1	2	1	–
Thespis	1	–	–	–	–
Tithonia	2	–	–	–	–
Tragopogon	5	–	–	–	–
Tricholepis	10	–	–	–	–
Tridax	1	–	–	–	–
Tussilago	1	–	–	–	–
Uechtritzia	1	–	–	–	–
Verbesina	1	–	–	–	–
Vernonia	53	–	17	–	Wild/ Cultivated
Vittadinia	1	–	–	–	Cultivated
Waldheimia	5	–	–	–	–
Wedelia	5	–	1	–	–
Xanthium	3	–	–	–	–
Youngia	13	–	2	–	–
Zinnia	2	–	–	–	Cultivated
Zoegia	1	–	–	–	–

An analysis of the taxa of Indian Asteraceae (Table II) shows that out of 177 genera (including cultivated ones) 80 are represented in the country by just a single species. This includes 19 monotypic genera (Uniyal & Mathur, 1994; Mabberley, 1998) as well (Table III). On the other end of the spectrum *Taraxacum* with 82 species is the largest genus of Asteraceae in India, followed by *Saussurea* (61) and *Vernonia* (53). The ten dominant genera of the family are shown in Table IV. There are 58 genera having 2-5 species each, 21 genera having 6-10 species each; 7 genera with 11-15 species; only two genera having 16-20 species each; while there are three genera each in the 21-30, 31-50 and 51-100 species bracket respectively.

Table III
Monotypic genera of Asteraceae in India and their distribution

Name of the Genera	Distribution
Acroptilon	Jammu & Kashmir, Pakistan, Iran, CIS, North America
Adenoon	Tamil Nadu, Karnataka, Maharashtra, Gao. Endemic.
Blumeopsis	West and eastern Hiamlaya, Bihar, Karnataka, Andaman & Nicobar Islands, Bangladesh, Malaya, Sumatra
Caesulia	Uttar Pradesh, Madhya Pradesh, Rajasthan, Punjab, West Bengal, Bihar, Orissa, Andhra Pradesh, Karnataka, Maharashtra, Goa, Bangladesh, Nepal, Myanmar.
Catamixis	Uttaranchal, Uttar Pradesh, Haryana, Nepal.
Cavea	Eastern Himalaya, Endemic.
Chrysanthellum	Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh, Gujarat, Andhra Pradesh, Madagascar, Tropical Africa.

Name of the Genera	Distribution
Eleutheranthera	West Bengal, America.
Goniocaulon	Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal
Hemistepta	Arunachal Pradesh, Assam, Manipur, Uttaranchal, West Bengal, Bihar, Nepal, Myanmar, Bangladesh, China, Japan, eastern Australia.
Hochstetteria	Jammu & Kashmir, Pakistan, Arabia, Tropical Africa.
Lamprachaenium	Western Ghats. Endemic
Nanothamnus	Karnataka, Maharashtra. Endemic.
Pseudojacoboea	Rajasthan, Kerala, Tamil Nadu. Endemic.
Rhynchospermum	Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Meghalaya, Nagaland, Myanmar, Japan, Malaya, Java.
Silybum	Jammu & Kashmir, Himachal Pradesh, Tamil Nadu, Pakistan, North Africa, Europe.
Struchium	Kerala, Andaman & Nicobar Islands, Mexico, West Indies, America, Africa.
Sphaeromorphaea	Western peninsula, China.
Tussilago	Jammu & Kashmir, Himachal Pradesh, Uttaranchal, North West Asia, North Africa, Europe.

Table IV
Dominant Genera of Asteraceae

Genera	No. of Species
Taraxacum	81
Saussurea	61
Vernonia	53
Senecio	43
Artemisia	34
Anaphalis	31
Blumea	29
Lactuca	24
Aster	23
Inula	20

PHYTOGEOGRAPHICAL AFFINITIES

Because of phytoglographically strategic location of the country at the confluence of three major global biogeographic realms, viz. the Afro-tropical, Eurasian and Indo-Malayan, the flora of India shows remarkable admixture of the floristic elements of these regions. The territorial contignity of the country with the Middle East, Central Asia, China and eastern Asiatic region has resulted into a closer affinity between the Asteraceous elements of our country and that of several countries of the above regions. While the members of the family in the West Himalaya are more akin to the elements from the Central Asia, Mediterranean and Europe, those in the eastern Himalaya and the North-eastern regiòn are characterised by the presence of Indo-Malayan and Indo-Chiniese elements. On the other hand, Indian Asteraceae also represent some floristic elements from such distant places as Africa, America, Australia, Japan and New Zealand, and, therefore, exhibit disjunct distribution (Table V). Such discoutinuous distribution of a particular species or vicariads in countries now widely separated by vast oceanic barriers is of considerable phytogeographical significance as it provides some suggestive insight into different episodes in the climatic and geological history of the earth that might have influenced the evolution, migration and even survival of floras (Steere & Inoue, 1972).

Table V
Some disjunct species of Asteraceae

Name of the species	Distribution
Acanthospermum hispidum	India (WH, EH, Rajasthan), Africa, South America, Nepal
Achillea alpina	India (Meghalaya), Europe, CIS
Achillea millefolium	India (WH, Tamil Nadu), Central Asia, Europe, America
Ainsliaea aptera	India (WH, EH), Pakistan, Bhutan, China
Ambrosia artemisiifolia	India (Meghalaya), America, China
Anaphalis margaritacea	India (WH, EH, NE), South-East Asia, North America
Arctium lappa	India (WH), China, Tibet, West Asia, Eruope
Artemisia dracunculus	India (WH), Central Asia, Tibet, China
Artemisia nilagirica	India (WH, EH, WG), Central Asia, Africa, Nepal, Sri Lanka, Java
Bidens biternata	India, Africa, Sri Lanka, Australia
Bidens sulphurea	India, Africa, Central and South America
Blainvillea acmella	India (GP, WH), Africa, America, Australia, Sri Lanka
Cousinia vulgaris	India (J&K, Gujarat), Europe
Elephantopus scaber	India, Africa, Australia

Name of the species	Distribution
Eleutheranthera ruderalis	India (W.B.), America
Emilia sonchifolia	India, China, Africa, Central Asia, Australia
Erechtites valerianaefolia	India (U.P., M.P., Tamil Nadu), Sri Lanka, Central and South America, China, Japan, Australia
Erigeron karvinskianus	India (WH, NE), Europe, America, Australia, Nepal, Bhutan, Myanmar, Japan, Mexico
Ethulia megacephala	India (WH, EH, NE), Europe, China
Eupatorium nodiflorum	India (J&K, NE) Central Asia, Europe
Filago hurdwarica	India (WH), West Asia, Tibet, Europe
Gnaphalium polycaulon	India, Australia, Myanmar, China, Japan, Senegal
Hemistepta lyrata	India (WH, EH, NE), Nepal, Myanmar, China, Australia
Leontopodium brachyactis	India (WH, EH), Central Asia
Picris hieracioides	India (WH), Europe, Australia, New Zealand
Senecio vulgaris	India (J&K, Gujarat, Tamil Nadu), North Africa, Europe
Siegesbeckia orientalis	India (Hills), Africa, Myanmar, China
Silybum marianum	India (WH, Tamil Nadu), Europe, Africa
Soliva anthemifolia	India (UP), South America, Australia
Struchium sparganophorum	India (WG, A & N), Africa, Central and South America

Name of the species	Distribution
Syndrella vialis	India (Maharashtra), America
Taraxacum baltistanicum	India (WH), Central Asia. Australia
Taraxacum ceratophorum	India (J&K), Europe, America
Taraxacum duplidens	India (H.P.), France, Germany
Tussilago farfara	Idnia (WH), Europe, Africa, America
Vittadinia australis	Idnia (EH), Africa, New Zealand, Australia, Sri Lanka
Wedelia biflora	India (W.B., Maharashtra), Africa, Indo-China, Japan, Australia
Zoegea purpurea	India (J&K), Central Asia

GP=Gangetic Plain; EH=Eastern Himalaya, WH=Western Himalaya; WG=Western Ghats; NE = North-eastern region; A&N=Andaman & Nicobar Islands.

Recently, Rao and Datt (1996) recognised following floristic groups in Indian Asteraceae, based on their phytogeographical affinities :

Widespread : *Ambrosia* spp., *Bidens* spp., *Conyza* spp., *Cotula* spp., *Chrysanthellum* sp., *Eclipta* sp., *Enhydra* sp., *Gnaphalium* spp., *Pluchea* spp., *Erigeron* spp., *Wedelia* spp., *Xanthium* spp., etc.

Pantropical : *Adensotemma* sp., *Blainvillea* sp., *Eupatorium* spp., *Spilanthes* spp., *Siegesbeckia* spp., *Pterocaulon* sp., *Veronia* spp., etc.

Mediterranean : *Amberboa* sp., *Carduus* spp., *Ifloga* sp., *Matricaria* spp., *Pentanema* sp., *Reichardia* sp., *Scorzonera* spp., etc.

Palaeotropical : *Crepis* spp., *Dicoma* sp., *Dimorphotheca* spp., *Crassocephalum* sp., *Gerbera* spp., *Guizotzia* sp., *Helichrysum* spp., *Kleinia* spp., *Laggera* spp., *Pegolettia* spp., *Psiadia* Sp., etc.

Eurasian : *Chondrilla* spp., *Doronicum* spp., *Lactuca* spp., *Lapsana* sp., *Picris* sp., *Pulicaria* spp., *Sonchus* spp., *Tragopogon* spp., *Tussilago* sp., etc.

North Temperate : *Adenocaulon* sp., *Achillea* spp., *Artemisia* spp., *Aster* spp., *Chrysanthemum* spp., *Cicerbita* spp., *Cirsium* spp., *Tanacetum* spp., *Taraxacum* spp., etc.

Australian : *Brachycome* sp., *Erechtites* spp., etc.

Neotropical : *Acanthospermum* sp., *Galinsoga* spp., *Lagascea* sp., *Montonoa* sp., *Sclerocarpus* sp., *Tithonia* spp., *Tridax* sp., etc.

North American : *Flaveria* spp., *Prenanthes* spp., *Solidago* sp., etc.

Western and Central Asiatic : *Acroptilon* sp., *Brachyactis* spp., *Cousinia* spp., *Garhadiolus* sp., *Jurinea* spp., *Olgaea* sp., *Phagnolon* spp., *Psychrogeton* sp., etc.

African-Asiatic-Australian : *Blepharispermum* spp., *Blumea* spp., *Grangea* sp., *Gynura* spp., *Koelpinia* spp., *Echinops* spp., *Myriactis* spp., *Sphaeranthus* spp., etc.

Indo-Malesian : *Adenoon* sp., *Centipeda* sp., *Goniocaulon* sp., *Moonia* spp. etc.

Euro-Siberian : *Anaphalis* spp., *Anthemis* sp., *Centaurea* spp., *Cichorium* spp., *Inula* spp., *Leontopodium* spp., *Serratula* sp., etc.

Sino-Japanese : *Soroseris* spp., *Thepsis* sp., etc.

Indian : *Caesulia* sp., *Catamixis* sp., *Cyathocline* sp., *Lamprachaenium* sp., *Leucomeris* spp., *Nanothamnus* sp., etc.

Indian wides : *Cremanthodium* spp., *Blumeopsis* sp., *Dubyaea* spp., *Rhynchospermum* sp., *Tricholepis* spp., *Youngia* spp., etc.

ENDEMISM

Endemism is a phytogeographically significant phenomenon which provides an insight into the centres of diversity, vicariance and the adaptive evolution of the floristic elements of a particular country or the region and highlights the indigenous nature of its plant diversity. About 242 taxa, including four genera, representing approximately 23 per cent of the total Asteraceae element in the Indian flora, are endemic to the country (Ahmedhullah & Nayar, 1987; Nayar, 1995; Rao & Datt, 1996). Out of the endemic genera *Cavea* is confined to the eastern Himalaya, *Lamprachaenuim* and *Nanothamnus* to the western Ghats, whereas *Glossocardia* is widely distributed throughout the plains of the country (Ahmedullah, 2000). The Himalayan region, with about 116 taxa and the Western Ghats with 100 taxa, constitute two major centres of endemicity of the family in India. Table VI presents some endemic tax of Asteraceae in India. The genera showing high endemism in India are *Taraxacum* (44 out of 82 species), *Vernonia* (27 out of 53 species), *Senecio* (21 out of 44 species), *Phyllocephalum* (8 out of 9 species), *Anaphalis* (11 out of 31 species), etc.

Table VI
Some endemic taxa of family Asteraceae in India

Name of the species	Distribution
Aster laka	N.W. Himalaya
Aster molliusculus var. *minor*	N.W. Himalaya (Himachal Pradesh)
Aster platylepis	Eastern Himalaya (Sikkim)
Aster trinervius var. *wattii*	N.E. India (Nagaland, Manipur)
Acroptilon repens	N.W. Himalaya
Ainsliaea angustifolia	East Himalaya
Anaphalis aristata	Western Ghats, central India
Anaphalis barnesii	Western Ghats
Anaphalis beddomei	Western Ghats
Anaphalis elliptica	Western Ghats
Anaphalis himachalensis	N.W. Himalaya (Lahaul-Spiti)
Anaphalis lawii	Western Ghats, West Bengal.

Name of the species	Distribution
	Orissa
Anaphalis leptophylla	Western Ghtas
Anaphalis meeboldii	Western Ghats
Anaphalis neelgerryana	Western Ghats
Anaphalis notoniana	Western Ghats
Anaphalis travancorica	Western Ghats
Anaphalis wightiana	Western Ghats
Bidens minuta	N.W. Himalaya (J&K : on floating Islands)
Artemisia elegantissima var. *kumaonensis*	N.W. Himalaya (Askote)
Artemisia eriocephala	N.W. Himalaya (Uttaranchal)
Artemisia filiformilobulata	N.W. Himalaya (H.P., Uttaranchal)
Artemisia incisa var. *kunawarensis*	N.W. Himalaya (Himachal Pradesh)
Artemisia indica var. *dissecta*	Assam
Artemisia strongylocephala	N.W. Himalaya
Artemisia thellungiana	Eastern Himalaya (Sikkim)
Blepharispermum subsessile	Western Ghats
Blumea belangeriana	Western Ghats, Maharashtra, Nagaland
Blumea eriantha	Uttar Pradesh, Bihar, Orissa, Madhya Pradesh, Rajasthan, Maharashtra, Goa
Blumea hookeri	Sikkim, Meghalaya, A&N Is.
Blumea malcolmii	Madhya Pradesh, Western Ghats
Blumea membranacea var. *jacquemontii*	Uttar Pradesh, Bihar, West Bengal, Orissa, Madhya Pradesh, Rajasthan, Maharashtra, Tamil Nadu
Blumea venkataramanii	Maharashtra
Blumea sikkimensis	Sikkim

Name of the species	Distribution
Cacalia chola	Eastern Himalaya (Sikkim)
Cacalia levingii	N.W. Himalaya (J & K)
Carpesium cernuum var. *nilagiricum*	Western Ghats (Tamil Nadu)
Chondrilla setulosa	N.W. Himalaya (J & K)
Cyathocline lutea	Western Ghats, Deccan plataeu
Cyathocline purpurea var. *alba*	Maharashtra
Cyathocline purpurea var. *bicolor*	Maharashtra
Cissampelopsis ansteadi	Western Ghats (Tamil Nadu)
Cissampelopsis calcadensis	Western Ghats (Tamil Nadu)
Cirsium interpositum	Eastern Himalaya (Arunachal Pradesh, Manipur)
Cicerbita filicina	N.W.Himalaya (Uttaranchal)
Cremanthodium arnicoides	N.W. Himalaya
Cremanthodium decaisnei	Himalaya (J & K, Uttaranchal, Sikkim)
Crepis dachigamensis	N.W. Himalaya (J & K)
Dichrocephala hamiltonii	Assam
Doronicum roylei var. epapposa	N.W. Himalaya (J & K)
Doronicum pardalianches	N.W. Himalaya (J & K)
Emilia ramulosa	Western Ghats
Emilia sonchifolia var. mucronata	Western Ghats
Emilia zeylanica var. *paludosa*	Western Ghats (Swamps)
Erigeron wightii	Western Ghats (Tamil Nadu)
Epaltes pygmaea	Western Ghats
Gynura nitida	Western Ghats
Gynura travancorica	Western Ghats
Glossocardia bosvallea	Throughout India
Glossocardia setosa	Rajasthan
Helichrysum perlanigerum	Western Ghats (Tamil Nadu)
Helichrysum cutchicum	Gujarat

Name of the species	Distribution
Helichrysum wightii	Western Ghats (Tamil Nadu)
Inula kalapani	N.E. India (Meghalaya)
Inula macrosperma	Eastern Himalaya (Sikkim)
Inula racemosa	Western Himalaya (J & K)
Kleinia balsamica	Western Ghats
Kleinia grandiflora var. *major*	Tamil Nadu
Kleinia shevaroyensis	Shevaroy hills (in swamps)
Lamprachaenium microcephalum	Western Ghats
Lactuca benthamii	N.W. Himalaya (J & K)
Lactuca cooperi	Eastern Himalaya
Lactuca decipiens var. *multifida*	N.W. Himalaya (J & K)
Ligularia dux	Eastern Himalaya (Sikkim)
Ligularia hookeri	Eastern Himalaya (Sikkim)
Ligularia pachycarpa	Eastern Himalaya (Sikkim)
Ligularia jacquemontiana	N.W. Himalaya
Ligularia japonica	Meghalaya
Ligularia kingiana	Eastern Himalaya (Sikkim)
Ligularia pachycarpa	Eastern Himalaya (Sikkim)
Myriactis assamensis	N.E. India (Meghalaya, Nagaland)
Myriactis wightii var. *bellidioides*	Western Ghats (Tamil Nadu)
Nanothamnus sericeus	Western Ghats
Olgaea thomsonii	N.W. Himalaya (J & K)
Phyllocephalum hookeri	Maharashtra
Phyllocephalum mayurii	Western Ghats
Phyllocephalum phyllolaenum	Western Ghats, Rajasthan
Phyllocephalum rangacharii	Western Ghats
Phyllocephalum ritchiei	Western Ghats
Phyllocephalum scabridum	Western Ghats, Gujarat, Madhya Pradesh
Phyllocephalum sengaltherianum	Western Ghats
Phyllocenhalum tenue	Western Ghats

Name of the species	Distribution
Petasites kamengicus	Eastern Himalaya (Arunachal Pradesh)
Pseudojacoboea lavandulaefolius	Western Ghats
Prenanthes khasiana	Meghalaya
Psiadia ceylanica var. *beddomei*	Western Ghats (Tamil Nadu)
Pulicaria rajputanae	Rajasthan
Saussurea andersonii	Eastern Himalaya (Sikkim and West Bengal)
Saussurea atkinsonii	N.W. Himalaya (cold deserts)
Saussurea bracteata	Trans Himalaya and W. Himalaya
Saussurea clarkei	Western Himalaya (J & K)
Saussurea gossypiphora var. *lilliputa*	Eastern Himalaya (Sikkim)
Saussurea laneana	Eastern Himalaya (Sikim)
Saussurea nagensis	Nagaland
Saussurea nimborum	Eastern Himalaya (Sikkim)
Saussurea obscura	Eastern Himalaya (Sikkim)
Saussurea pantlingiana	Eastern Himalaya (Sikkim)
Saussurea sudhanshui	Western Himalaya (Uttaranchal)
Senecio belgaumensis	Western Ghats
Senecio bombayensis	Western Ghats, Gujarat, Rajasthan, Madhya Pradesh
Senecio candicans	Western Ghats (Tamil Nadu)
Senecio dalzelli	Western Ghats
Senecio edgeworthii	Western Ghats, Central India
Senecio gibsoni	Westernern Ghats (Maharashtra)
Senecio hewrensis	Maharashtra
Senecio hohenackeri	Andhra Pradesh, Tamil Nadu
Senecio intermedius	Western Ghats (Tamil Nadu)

Name of the species	Distribution
Senecio kundaicus	Western Ghats (Tamil Nadu)
Senecio lawsonii	Western Ghats (Tamil Nadu)
Senecio lesingianus	Western Ghats (Nilgiri)
Senecio linifolius	Meghalaya
Senecio mayurii	Western Ghats (Karnataka)
Senecio mishmi	Eastern Himalaya (Arunachal Pradesh)
Senecio multiceps	Western Ghats (Tamil Nadu)
Senecio neelgherryanus	Western Ghats
Senecio rhabdos	Eastern Himalaya (Nagaland)
Senecio tetrandrus	Eastern Himalaya (Sikkim, Darjeeling)
Sonchus jainii	Tamil Nadu
Synolis ainsliaeifolia	Eastern Himalaya (Arunachal Pradesh)
Synotis lushaensis	Mizoram
Synotis simonsii	Assam
Synotis borii	N.E. India
Synotis jowaienensis	Meghalaya
Taraxacum amblylepidocarpum	N.W.Himalaya (J&K)
Taraxacum aurorum	N.W. Himalaya
Taraxacum banhyhalensis	N.W. Himalaya (J&K)
Taraxacum coronatum	N.W. Himalaya (J&K)
Taraxacum eriocarpum	N.W.Himalaya (J&K)
Taraxacum flavum	N.W. Himalaya (J&K)
Taraxacum forestii	N.W. Himalaya (Uttaranchal)
Taraxacum fulvescens	N.W. Himalaya (J&K)
Taraxacum fulvo-brunneum	N.W.Himalaya (J&K)
Taraxacum harbhajan-singhii	N.W. Himalaya (J&K)
Taraxacum harbhajan-singhii var. *pahalgamense*	N.W. Himalaya (J&K)

Name of the species	Distribution
Taraxacum helianthum	N.W. Himalaya (J&K)
Taraxacum heteroloma	N.W.Himalaya (J&K)
Taraxacum heybroeckii	N.W. Himalaya (J&K)
Taraxacum insigne	Darjeeling
Taraxacum laevigatum	N.W. Himalaya (J&K)
Taraxacum lahulense	N.W.Himalaya
Taraxacum latibasis	N.W. Himalaya (J&K)
Taraxacum lobbichleri	N.W. Himalaya (J&K)
Taraxacum longicarpum	N.W. Himalaya (J&K, Uttaranchal)
Taraxacum melleum	N.W.Himalaya (J&K)
Taraxacum mucronulatum	Eastern Himalaya
Taraxacum nagaricum	N.W. Himalaya (J&K)
Taraxacum nigrum	N.W. Himalaya (J&K)
Taraxacum nivale	N.W.Himalaya (J&K)
Taraxacum paludosum var. *tenuifolium*	N.W. Himalaya (J&K)
Taraxacum parvuliforme	N.W. Himalaya (J&K)
Taraxacum phoenicolepis	N.W. Himalaya (J&K)
Taraxacum polyodon	N.W.Himalaya (J&K)
Taraxacum primogenium	N.W. Himalaya (J&K)
Taraxacum pseudobicorne	N.W. Himalaya (J&K)
Taraxacum pseudoeriopodum	N.W. Himalaya (J&K)
Taraxacum pseudostenolepium	N.W.Himalaya (J&K, Uttaranchal)
Taraxacum pseudostevenii	N.W. Himalaya (J&K)
Taraxacum sherriffii	N.W. Himalaya (H.P.)
Taraxacum spiticum	N.W. Himalaya (H.P.)
Taraxacum staticifolium	N.W.Himalaya (J&K)
Taraxacum stereodiforme	N.W. Himalaya
Taraxacum stevenii	N.W. Himalaya (J&K)

Name of the species	Distribution
Taraxacum stewartii	N.W. Himalaya (J&K)
Taraxacum tenebrystylum	N.W. Himalaya (J&K)
Taraxacum tricuspidatum	N.W. Himalaya
Taraxacum violaceo-maculatum	N.W. Himalaya (J&K)
Taraxacum vulpinum	N.W. Himalaya (J&K)
Taraxacum xanthophyllum	N.W. Himalaya (J&K)
Tricholepis amplexicaulis	Western Ghats
Tricholepis angustifolia	Western Ghats
Tricholepis elongata	N.W. Himalaya
Tricholepis glaberrima	Western Ghats, Madhya Pradesh, Rajasthan
Uechtritzia lacei	N.W. Himalaya
Vernonia anamallica	Kerala
Vernonia anaimudica	Kerala
Vernonia andamanica	Andaman
Vernonia beddomei	Kerala
Vernonia bourdillonii	Western Ghats
Vernonia bourneana	Western Ghats
Vernonia comorinensis	Western Ghats
Vernonia conyzoides	Western Ghats, Rajasthan
Vernonia fysonii	Tamil Nadu
Vernonia gossypina	Tamil Nadu
Vernonia heynei	Western Ghats
Vernonia indica	Western Ghats, Deccan plataeu
Vernonia malabarica	Western Ghats
Vernonia meeboldii	Kerala
Vernonia multibracteata	Western Ghats
Vernonia parryae	Mizoram
Vernonia patula	Andaman & Nicobar Is.
Vernonia peninsularis	Western Ghats
Vernonia pulneyensis	Western Ghats
Vernonia ramaswamii	Western Ghats

Name of the species	Distribution
Vernonia rauii	Tamil Nadu
Vernonia saligna var. *nilghirensis*	Western Ghats
Vernonia salvifolia	Western Ghats
Vernonia shevaroyensis	Tamil Nadu
Vernonia travancorica	Western Ghats
Youngia nilgiriensis	Tamil Nadu

EXOTIC SPECIES

Asteraceae include a large number of species, some of which are amongst the world's most obnoxious weeds, like *Mikania micrantha, Parthenium hysterophorous, Eupatorium adenophorum, E. odoratum, Xanthum spinosum, X. strumarium, Sonchus oleraceous, Breea arvensis, Ageratum conyzoides, Ambrosia artemisifolia, Acanthospermum hispidum,* etc. Many of these adventive aliens, following their immigration, have completely naturalised in India because of their broad ecological amplitudes. Majority of the Asteraceae weeds were introduced in India during early 15th century with Portugese settlement (Rao & Datt, 1996). Most of these dominate the roadsides, wastelands and agricultural fields across the country and have also invaded the prime forest areas, where they have not only masked the native elements of flora, but have also replaced them probably because of their strong alleopathic effect (Rao & Rao, 1977). While extinction of native species due to the alien weeds,had been recognised long back by Darwin (1872) and Wallace (1902), Maheshwari (1962) assigned causes, like deforestation, faulty pasturage methods, shifting cultivation, etc. for spread and naturalisation of exotic species in our country. Amongst the recently introduced alien weeds of Asteraceae, *Parthenium hysterophorous* is the most obnoxious and dominant. Reported for the first time in Indian flora in mid 1950 from Pune, (Rao, 1956), this tropical American species has now spread to almost every part of the country, ascending up to 2300 m in the Himalaya. The intensity and obnoxiousity of its invasiveness is evident from the fact that it can complete four generations in a year (Rao, 1996). The plants are also allergic to both humans as well as cattle. Similarly, the pollen of *Ambrosia artemisiifolia,* another North American weed in Indian flora, is reported to cause hay fever (Heywood, 1993). Some of the common exotic species of Asteraceae are listed in Table VII

Table VII
Some exotic species of Asteraceae in India

Name of the species	Native country/region
Acanthospermum hispidum	Brazil
Adenostemma laevenia	South America
Ageratum conyzoides	South America
Ambrosia artemisifolia	North America
Bidens biternata	South America
Bidens pilosa	South America
Chrysanthemum cinerarifolium	Yugoslavia, Italy
Conyza canadensis	South America
Conyza bonariensis	South America
Cotula australis	Southern Temperate regions (Australia)
Crassocephalum crepidioides	Tropical America
Elephantopus scaber	Australia, America
Emlia sonchifolia	Afro-Asian
Erechtites valerianifolia	Tropical America
Erigeron karvinskianus	Mexico
Eupatorium adenophorum	Mexico
Eupatorium odoratum	Tropical America
Eupatorium riparium	Tropical America
Flaveria trinervia	America
Galinsoga quadriradiata	Central America
Galinsoga. parviflora	South America
Hypochaeris radicata	Europe
Laggera aurita	Afro-Asian
Lagascea mollis	Mexico
Mikania micrantha	Tropical America

Name of the species	Native country/region
Parthenium hysterophorus	Tropical America
Sclerocarpus africanus	Tropical Africa
Sonchus oleraceous	Europe
Sonchus wightianus	Africa
Sphaeranthus indicus	Africa
Syndrella nodiflora	Tropical Africa
Tagetes minuta	Tropical Africa.
Taraxacum officinale	Europe
Tithonia diversifolia	Mexico
Wedelia chinensis	Astro-Asian
Xanthium strumarium	South America

ECONOMIC IMPORTANCE

Asteraceae are of considerable economic significance to the mankind. This includes food plants, sources of raw materials, medicinal and drug plants and ornamentals. The commercially important edible plants of the family include *Lactuca sativa* (lettuce), *Cichorium endiva* (endive), *C. intybus* (cichory), *Tragopogon porrifolius* and the culinary herb, *Aretmisia dracunculus*, etc. Asteraceae members are also rich source of essential oils. *Helianthus annuus* (sunflower), *Carthamus tinctorius* (safflower) and *Guizotia abyssinica* (niger seed) are extensively cultivated for healthy edible oil.

A number of species of this chemically rich family have long been used in folk medicine as well as source of essential oils. *Ligularia jacquemontiana*, an endemic species growing in Jammu & Kashmir and Himachal Pradesh, and locally known as 'Poshhar', is rich in essential oil content. The roots of this species are locally used in preparation of a 'nervine tonic' and also as an adulterant for 'Kuth' (*Saussurea cosuts*). *Artemisia maritima* yields 'Santon' which is used as a vermifuge, *A. absinthium* produces an essential oil used as a flavouring agent. Similarly, *Anthemis nobitis* is a good source of 'chamomile'. Some of the medicinally important species and their uses are given in Table VIII.

Table VIII
Some important medicinal plants of Asteraceae

Name of the species	Parts used	Uses
Crassocephalum crepidioides	Whole plant, mainly leaves	For improving digestion. as a stomachache, in epilepey, nose bleeding and also as anaelgesic in headache.
Emilia sonchifolia	Root and leaves	Root extract for curing cataract and night blindness, diarrhoea. Leaf extract for cooling effect against boils and inflammation.
Gynura procumbens	Whole plant	Kidney troubles, dysentery, as an febrifuge in rheumatic pains.
Doronicum falconeri	Roots	Tonic
Doronicum hookeri	Roots	Tonic
Doronicum pardalianches	Roots	Used to prevent giddiness caused on ascending heights.
Kleinia grandiflora	Fresh stems	Used as a cure for pimples and also as a remedy for hydrophobia
Elephantopus scaber	Leaves, roots	Useful in blood diseases, heart disease, bronchitis and also in kidney problems.
Centipeda minima	Whole plant	The powdered herb is used as a drug for cold and toothache
Achillea millefolium	Flowers	It is used as an important ingradient of a Unani drug "Brinjase" which is used for removing pus. It is also diuretic and expels kidney stones. In Homoeopathy the medicine is used in influenza.

Name of the species	Parts used	Uses
Inula racemosa	Roots	Used as a good cure of Rheumatism; seeds are known to be aphrodisiac
Siegesbeckia orientalis	Whole plant	The whole plant is used as a tonic for heart patients. This is also useful in healing gangrenous ulcers and sores and also many skin diseases. As a diuretic it is given in gout, rheumatism and dropsy.
Eclipta alba	Whole plant	The alcoholic extract of the entire plant has been reported to possess antiviral properties against "Ranikhet disease" virus (Dhar *et al.* 1968). The juice of the herbs is applied on the effected parts of leucoderma. The roots are used in preparation of antidote for snake bite and scorpion sting (Chopra *et al.*, 1955). It is also used in preparation of digestive tonic like, 'Stimuliv' and also as an important 'Hair-tonic'.
Tricholepis glaberrima	Whole plant	It is also known as 'Brahamdandi'. It is useful in curing leprosy and tuberculosis.
Silybum marianum	Whole plant	These plants are useful in curing intermittent fevers, dropsy, jaundice and cirrhosis of liver.
Tridax procumbens	Whole plant	This plant is a rich source of vitamin 'K', the blood

Name of the species	Parts used	Uses
		coagulating agent, hence the whole plant is used as blood coagulant and as an antiseptic in wounds, etc.
		The important medicinal property of this plant lies in removing the kidney stones.
Splanthes paniculata	Flowers	The flowers of this plant are used for extracting 'Spilanthes' which is useful in reliving toothache as it possess anaesthetic property.
		The fresh flowers when chewed are useful for the children suffering from stammering defect.
Arctium lappa	Whole plant, leaves	Useful in Scrofula, constitutional syphilis, skin-diseases like psoriasis, scurvy and in urinary deposits, rheumatism. The extract of the plant is used as an external application for 'baldness'.
Matricaria chamomilla	Dried flower	The cold infusion is used as a stomach tonic and given in "Summer-diarrhoea." It is also useful in Malerial fever, asthama and hysteria.
Arnica montana	Rhizome and flowers	This is used as an antipyretic, in typhoid fevers, internal haemorrhages, in chronic cataract. It is very effective in hysteria, bronchitis and whooping cough.

Name of the species	Parts used	Uses
Vernonia cinerea	Whole plant, flowers	The flowers are used for curing cough. The entire plant is very beneficial and is useful in fevers, as a blood purifier. It suppresses mental distress, helps in curing hysteria in women.
Artemisia maritina	Flowers	It is a reputed ancient wormicide and useful in expelling intestinal worms. The medicine prepared from this drug is well known 'Santonin'. This drug is also a remedy for dropsy.
Glossogyne pinnatifida	Leaves, whole plant	It is used in curing vomiting, headache. It is also considered to be useful in fractured bones, especially in case of cattle.
Bidens biternata	Achenes (fruits)	The juice extraction from the Achenes helps in retaining the stamina while keeping fast, as it suppresses the appetite, even for number of days.
Glossocardia bosvallea	Whole plant	These plants are known to be emmenagogue and useful in female diseases.
Sphaeranthus indicus	Whole plant	It is an important anti-tubercular drug.
Echinops echinatus	Roots	It is useful in cases of hysteria, dyspepsia, impotency.
Solidago virga-aurea	Roots and whole herbs	The drugs prepared is used as carminative, diuretic, nervine tonic.

Name of the species	Parts used	Uses
Xanthium strumarium	Roots, flowering tops and achenes	The drug is diaphoretic, sedative, used in chronic cases of maleria and also useful in cancer. The achne's extract has got a cooling effect and is given in smallpox.
Taraxacum officinale	Leaves	Paste of leaves applied on dislocated joints and extract of the plant is useful in many female complaints.
Cotula anthemoides	Leaves and flowers	Useful in rheumatism
Centaurea iberica	Leaves	The drug obtained is useful in eczema.
Eupatorium odoratum	Whole plant	It is used as a remedy for sprains and also for bone fractures. Leaf juice is applied on cuts to stop bleeding
Dichrocephala bicolor	Flowers and tender shoots	Used in blinorrhagia and for insect bites and stings.
Laggera pterodonta	Whole plant	It is useful in reducing high blood pressure.
Sonchus arvensis	Whole herbs	The extract of the plants is useful in treating dysentry and cholera.
Blumea lacera	Whole plant	It is used in the treatment of 'Prickly-Heat', fevers and bronchitis. It is also known to be a strong mosquito repellent.
Ageratum conyzoides	Whole plant	The dried plant powder is used as an application on the skin diseases, wounds and leprosy and also to stop continuous haemorrhage.

Name of the species	Parts used	Uses
Tussilago farfara	Whole plant	It is useful as an demulcent, diuretic, expectorant and used in dyspepsia, diarrhoea, rheumatism, nervous disorders.
Conyza canadensis	Whole plant	Used as a special haemostatic drug in uterine and intestinal haemorrhage.
Bellis perennis		Useful in muscular soreness, especially of lower limbs.
Gynura pseudo-china	Roots	It is used in regulating the circulation of blood. when interfered particularly from the sharp blows, producing blood spots and blotches due to blood clotting. It is also useful as a cooling agent in leprosy.
Tanacetum dolichophyllum	Flowering tops	It is used in making a medicated oil which is used in curing gout, rheumatism, chronic ulcers.
Grangea maderaspatana	Leaves	It is used in curing earache, hysteria and also as an antiseptic medicine.
Carthamus oxycantha	Seeds (achenes)	The seed oil is used in preparation of medicated ointment for dressing of bad ulcers and also as a remedy for itch.

The family Asteraceae, however, contribute largely as ornamental plants. The species or the hybrids in this category usually belong to genera *Gerbera, Arctotis, Echinops, Bellis, Aster, Senecio, Calotis, Centaurea, Chrysanthemum, Coreopsis, Cosmos, Gaillardia, Rudbeckia, Filicia, Helichrysum, Dimorphotheca, Emilia, Calendula,* *Brachycome, Helianthus, Tagetes, Zinnia,* etc. But *Dahlia, Dendranthema* and *Callistephus,* each with thousands of hybrids, are the most important. Some species of *Kleinia* and *Senecio* are also grown as succulent.

THREATS AND CONSERVATION

Though the members of Asteraceae exhibit high ecological amplitude and easily adapt to literally all habitat conditions, still there are a number of species, which are unable to survive competition with other floristic elements. The causes of rarity of certain species can also be attributed to their relatively recent origin due to which they have still not been able to spread (Rao & Datt, 1996). While *Vernonia recurva,* an endemic to Anamalai Hills in Western Ghats, could never be collected again since 1857 and the species has possibly become extinct (Vivekanathan, 1987) some other species which are known through type only, are *Anaphalis barnesii, Lactuca benthamii, Lactuca cooperi, Senecio kundaicus, S. mayurii, S. mishmi, Vernonia pulneyensis, Youngia nilgiriensis, Chondrilla setulosa, Synotis simonii,* etc. Besides, the distribution and population size of a number of Asteraceae members have shown a perceptible decline in recent time because of habitat degradation, as well as over exploitation of species, like *Saussurea costus* (Kuth). Some of the rare and threatened species of Asteraceae are listed in Table IX.

Table IX
Some rare and threatened species of Asteraceae in India

Name of the species	Status	Remarks
Anaphalis barnesii	Endangered	Iduki (Kerala), endemic. Known from type only.
Anaphalis brevifolia	Rare, endangered	Western Ghats, (Tamil Nadu: Anamallai hill)
Catamixis baccharoides	Vulnerable	Uttaranchal, Nepal
Chondrilla setulosa	Rare	Jammu & Kashmir, endemic. Known from type only.
Cicerbita filicina	Endangered	Uttaranchal, endemic. Known from type only

Name of the species	Status	Remarks
Cremanthodium plantaginium forma *ellisii*	Rare	J.&K., Himachal Pradesh
Cyathocline lutea	Rare	Western Ghats (Maharashtra, Karnataka), endemic.
Helichrysum cutchicum	Rare	Gujarat, endemic
Helichrysum perlanigerum	Rare	South-western Ghats, endemic
Inula racemosa	Vulnerable	Jammu & Kashmir, endemic
Inula kalapani	Rare	Khasi Hills (Meghalaya), endemic
Lactuca benthamii	Endangered	Kashmir, endemic. Known from type only
Lactuca cooperi	Endangered	Sikkim, Endemic. Known from type locality only.
Lactuca undulata	Endangered	Kahmir
Nanothamnus sericeus	Endangered	Western Ghats (Maharashtra, Karnataka), endemic
Saussurea bracteata	Rare	Western Himalaya (J&K, H.P., Uttaranchal), endemic
Saussurea clarkei	Rare	Kashmir, endemic.
Saussurea costus	Critically endangered	Western Himalaya (J&K, H.P., Uttaranchal), Pakistan.
Senecio kundaicus	Endangered	Nilgiris, endemic. Known only from its type.
Senecio mayurii	Rare	Karnataka, endemic. Known from type only.
Senecio mishmi	Vulnerable	Arunachal Pradesh (Mishmi Hills), endmeic. Known from type only.
Senecio rhabdos	Rare	Manipur, Nagaland, endemic.
Synotis simonsii	Rare	Assam, endemic. Known from type only.
Vernonia andamanica	Rare	North Andaman (Saddle Peak), endemic. Known from type only.

Name of the species	Status	Remarks
Vernonia multibracteata	Endangered	Western Ghats (Peermade). endemic. Known from type only.
Vernonia pulneyensis	Endangered	Western Ghats (Pulney Hills), endemic
Vernonia recurva	Endangered (possibly extinct)	Western Ghats (Anamalai Hills), endemic. Known from type collected in 1857.
Vernonia shevaroyensis	Rare	Shevaroy hills, endemic
Youngia nilgiriensis	Endangered	Western Ghats (Sispara), endemic. Known from type only.

India's elaborate Protected Area Network (PAN), comprising 89 National Parks and 489 Wildlife Sanctuaries, spreading through various altitudinal and ecological gradients across the country, is providing *in situ* conservation to a large number of species occurring within these areas. At the same time, to complement these *in situ* conservation measures, it is necessary to intensively as well as extensively search for the species, which could not be collected since their original collection/record, in not only their known localities of occurrence but also in regions with identical eco-climate conditions, and to bring them under *ex situ* conservation network of botanic gardens and gene-banks. The fact that *Lactuca cooperi* has recently been collected twice from its type locality after its original collection in 1913 (Maiti *et al.*, 1999) and certain other species (Singh & Hajra, 1996; Sharma & Singh, 2001) further highlight the need for such exploratory surveys. To create awareness about such taxa, while Botanical Survey of India has listed 38 taxa as rare or threatened (Jain & Sastry, 1983), 28 red Data Sheets have already been compiled by the department (Jain & Sastry, 1984; Nayar & Sastry, 1987, 1988, 1990). To strictly regulate the international trade in commercially exploited species, like *Saussurea costus*, it has been listed in Appendix-I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as well as in the Negative list of export of the Ministry of Commerce, Government of India. This species is also included in 'Schedule VI' of the Wildlife Protection Act of India (Anon. 1995), which makes its unauthorised collection from Wild a cognisable offence.

REFERENCES

Ahmedullah, M. 2000. Endemism in Indian flora. In : Singh,N.P., D.K. Singh, P.K. Hajra and B.D. Sharma (eds.) *Flora of India, Introductory Volume* Part-II. pp. 246-265. BSI, New Delhi.

Ahmedullah, M. and M.P. Nayar 1987. *Endemic Plants of Indian Region.* BSI, Calcutta.

Anonymous, 1995. *The Wildlife Protection Act, 1972.* Delhi.

Bremer, K., R.K. Jansen, P.O. Karis, M. Kallersjo, S.C. Keely, K.J. Kim, H.J. Michaels, J.D. Palmer and R.S. Wallace 1992. A review of the phylogeny and classification of Asteraceae. *Nord J. Bot.* **12:** 141-148.

Burman, N.L. 1768. *Flora Indica.* (Reprinted 1984). Dehradun.

Calder, C.C., V. Narayanaswami and M.S. Ramaswami 1926. List of species and genera of Indian Phanerogams not included in J.D. Hooker's Flora of British India. *Rec. Bot. Surv. India* **2:** 1-157.

Candolle, A.P. de 1838. *Prodromus Systematics Naturalis* 6. Germany.

Champion, H.G. and C. Trevor 1938. *Manual of Indian Silviculture.* London.

Chatterjee, D. 1940. Studies on the endemic flora of India and Burma. *J. Roy. Asiat. Soc. Bengal* (N.S.) **5**: 19-67.

Chopra, R.N., S.L. Nayar and I.C. Chopra 1956. *Glossary of Indian Medicinal Plants.* CSIR, New Delhi.

Clarke, C.B. 1876. *Compositae Indicae.* Calcutta.

Clarke, C.B. 1881. Compositae. In J.D. Hooker, *Flora of British India.* III. pp. 219-419. L. Reeve & Co., London.

Collett, C.S.H. 1902. *Flora Simalensis.* Simla.

Cooke, T. 1906. *Flora of the Presidency of Bombay.* 2. London.

Darwin, C. 1872. On the origin of species. London.

Dhar, M.I., M.M. Dhar, B.N. Dhawan, B.N. Mehrotra and C. Roy 1968. Screening of Indian plants for biological activity. I. *Indian J. Expt. Biol.* **6**: 232.

Duthie, J.F. 1902. *The Flora of Upper Gangetic Plain and the Adjacent Siwalik and sub-Himalayan Tracts.* 1. Calcutta.

Fischer, C.E.C. 1938. Flora of the Lushai Hills. *Rec. Bot. Surv. India* **12**: 75-161.

Fyson, P.F. 1914. *The Flora of the Nilgiri and Pulney Hill tops.* Madras.

Gamble, J.S. 1921. *Flora of the Presidency of Madras.* 2. London.

Ghosh, R.B. 1977. Sixth list of genera and species of Angiosperms not included in the Flora of British India. *Bull. Bot. Soc. Bengal* **31**: 84-89.

Ghosh, R.B. 1979. Seventh list of Angiosperms not included in the Flora of British India. *Bull. Bot. Soc. Bengal* **33**: 87-93.

Ghosh, R.B. and S.C. Dutta 1976. Angiosperms not included in the Flora of British Idnia : list V. *Bull. Bot. soc. Bengal* **30**: 1291-1333.

Haines, H.H. 1922. *The Botany of Bihar and Orissa.*

Hajra, P.K., R.R. Rao, D.K. Singh and B.P. Uniyal (eds.) 1995a. *Flora of India.* 12. *Asteraceae (Anthemidae Heliantheae).* BSI. New Delhi.

Hajra, P.K., R.R. Rao, D.K. Singh and B.P. Uniyal (eds.) 1995b. *Flora of India.* 13. *Asteraceae (Inulae Vernonieae).* New Delhi.

Heywood, V.H. (ed.) 1993. *Flowering plants of the world.* Oxford.

Hooker, J.D. 1906. *A sketch of the Flora of British India.* Oxford.

Jain, S.K. and A.R.K. Sastry (eds.) 1983. *Materials for a Catalogue of Threatened Plants of India.* BSI, Calcutta.

Jain, S.K. and A.R.K. Sastry (eds.) 1984. *The Indian Plant Red Data Book*-I. BSI, Calcutta.

Kanjilal, U.N., A. Das, P.C. Kanjilal and R.N. De 1939. *Flora of Assam*. III. Calcutta.

Karthikeyan, S. 2000. A stastistical analysis of flowering plants of India In : Singh, N.P., D.K. Singh, P.K.Hjara and B.D. Sharma (eds.) *Flora of India Introductory Volume, Part* II. pp. 201-217. BSI, New. Delhi.

Lakshminarasimhan, P. and P.S.N. Rao 1996. A supplementary list of Angiosperms recorded (1983-1993) from Andaman and Nicobar Islands. *J. Econ. Taxon. Bot.* **20**: 175-185.

Linnaeus, C. 1753. *Species Plantarum*. I-II. London.

Mabberley, D.J. 1998. *The Plant-Book*. ed. 2. Bath, U.K.

Maheshwari, J.K. 1962. Studies on the naturalised flora of India. In : Maheshwari, P. (ed.) *Proc. Summer. School. in Bot.* pp. 154-170. Darjeeling.

Maiti, A., B.K. Shukla and G.P. Sinha 1999. *Lactuca cooperi* Anthony (Asteraceae) recollection of an endemic and rare species from Sikkim. *Indian J. For.* **22**: 91-92.

Mudgal, V. and P.K. Hajra (eds.) 1999a, b. *Floristic Diversity and Conservation Strategies in India* : Vols. II & III. BSI, Dehradun.

Naithani, H.B. 1990. *Flowering Plants of India, Nepal & Bhutan (not recorded in Sir J.D. Hooker's Flora of British India)*. Dehradun.

Nayar, M.P. 1996. *Hotspots of endemic plants of India, Nepal and Bhutan*. Thiruvananthpuram.

Nayar, M.P. and A.R.K. Sastry (eds.) 1987-1990. *Red Data Book of Indian Plants*. Vols. 1-3. Calcutta.

Nayar, M.P. and K. Ramamurthy 1973. Third list of species and genera of Indian Phanerogams not included in J.D .Hookers' Flora of British India (excluding Bangladesh, Burma, Sri Lanka,, Malayan Peninsula and Pakistan) *Rec. Bot. Surv. India* **15**: 204-234.

Nayar, M.P. and S. Karthikeyan 1981. Fourth list of species and genera of Indian Phanerogams not included in J.D .Hookers' Flora of British India (excluding Bangladesh, Burma, Sri Lanka,, Malayan Peninsula and Pakistan *Rec. Bot. Surv. India* **21:** 121-152.

Prain, D. 1903. *Bengal Plants.* 1. London.

Rao, A.S. and R.R. Rao 1977. Changing pattern in the Indian flora. *Bull. Bot. Surv. India* **19**: 156-166.

Rao, R. 1914. *Flowering Plants of Travancore.* Trivandrum.

Rao, R.R. 1996. Compositae in the conservation of genetic diversity in Wild plants in India. In : Caligari, P.D.S., D.J.N. Hind and H.J. Beentje (eds.) *Compositae : Biology and Utilisation.* pp. 269-275. Kew.

Rao, R.R. and B. Datt. 1996. Diversity and phytogeography of Indian compositae. In : Caligari, P.D.S., D.J.N. Hind and H.J. Beentje (eds.) *Compositae : Biology and Utilisation.* pp. 445-461. Kew.

Rao, R.R., H.J. Chowdhery, P.K. Hajra, S. Kumar, P.C. Pant, B.D. Naithani, B.P. Uniyal, R. Mathur and S.K. Mamgain 1988. *Florae Indicae Enumeratio. Asteraceae.* BSI, Dehradun.

Rao, R.S. 1965. *Parthenium* a new record for India. *J. Bombay Nat Hist. Soc.* **54**: 218-220.

Razi, B.A. 1959. A second list of species and genera of Indian phanerogams not included in J.D. Hooker's Flora of British India. *Rec. Bot. Surv. India* 18: 1-56.

Rheede, H.A. van 1690. *Hortus Malabaricus.* 10. Amsterdam.

Roxburgh, W. 1832. *Flora Indica.* ed. 2. London.

Royle, J.F. 1839. *Illustrations of the Botany and other Branches of Natural History of the Himalayan Mountains and of the Flora of Cashmire.* 1. London.

Sharma, J.R. and D.K. Singh 2001. Status of Plant Diversity in India : An overview. In : Roy, P.S., S. Singh and A.G. Toxopeus (eds.) *Biodiversity & Environment.* pp. 69-105. IIRS, Dehradun.

Singh, D.K. and P.K. Hajra 1996. Floristic Diversity. In : Gujral, G.S. and V. Sharma (eds.) *Changing Perspectives of Biodiversity Status In the Himalaya.* pp. 23-38. British Council Division, New Delhi.

Singh, D.K., B.P. Uniyal and R. Mathur 1999. Jammu and Kashmir. In : Mudgal, V. and P.K. Hajra (eds.) *Floristic Diversity and Conservation Strategies in India.* II. pp. 905-974. BSI, Dehradun.

Steere, W.C. and H. Inoue 1972. Distribution patterns and speciation of bryophytes in the circumspecific regions : Introduction. *J. Hattori Bot.* Lab. 35: 1-2.

Uniyal, B.P. and R. Mathur 1994. Monotypic genera of Angiosperms in Indian flora need for conservation. *Bull. Bot. Surv. India* **36**: 169-177.

Vasudeva Rao, M.K. 1986. A preliminary report on the angiosperms of Andaman and Nicobar Islands. *J. Econ. Tax. Bot.* **8**(1): 107-184.

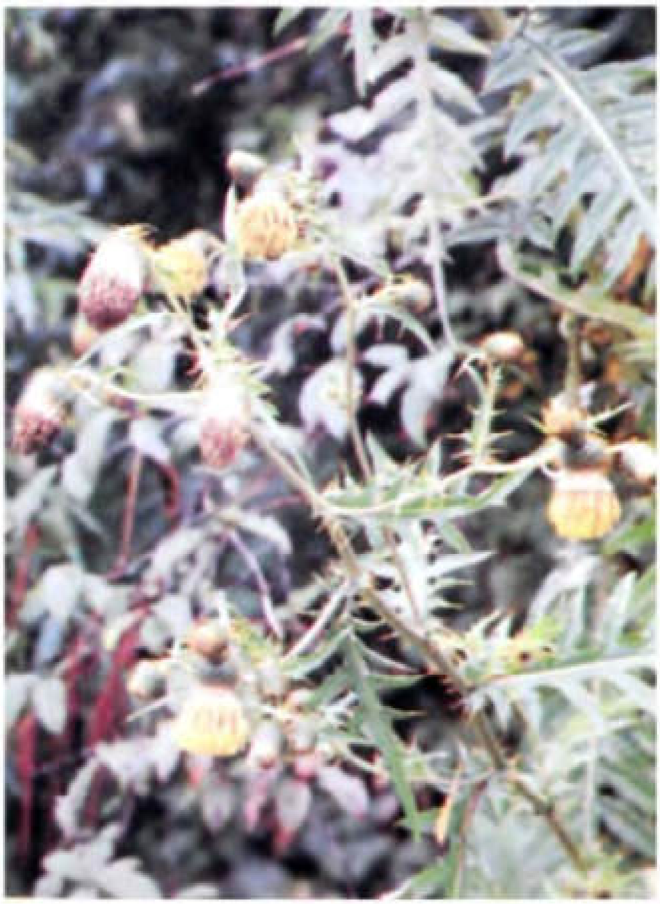
Vivekanathan, K. 1987. *Vernonia recurva* Bedd. ex S. Moore. In : Nayar, M.P. and A.R.K. Sastry (eds.) *Red Data Book of Indian Plants.* 1. pp. 92. BSI, Calcutta.

Wallacee, A.R. 1902. *Island life.* New York.

Wight, R. 1834. *Contribution to the Botany of India.* London.

S.K. Srivastava

Cousinia thomsonii



Cirsium wallichii

S.K. Srivastava

Psychrogeton andryaloides

Dev Raj Agarwal

Synotis rufinervis

Dev Raj Agarwal

Senecio laetus

Senecio wightianus

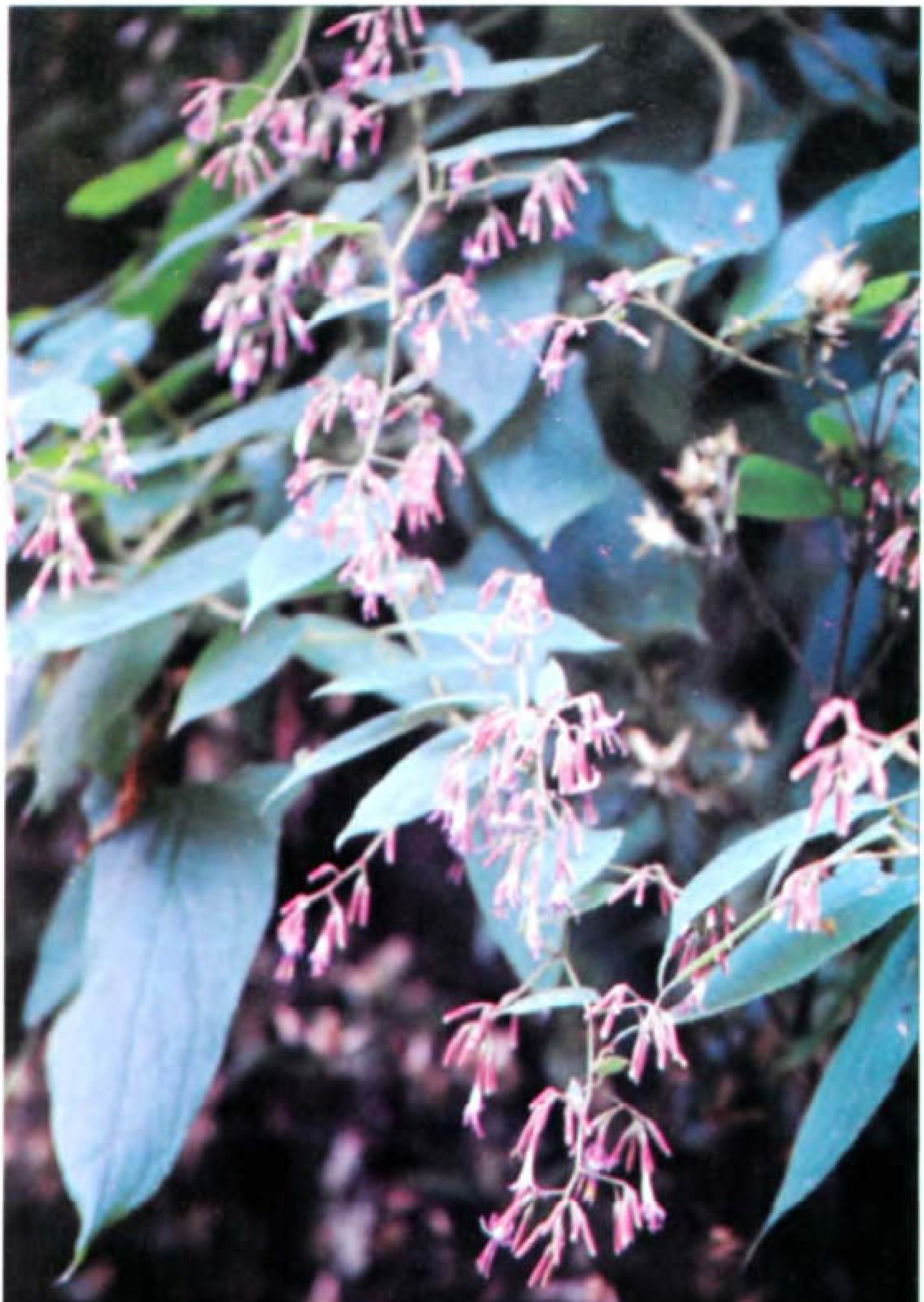
Dev Raj Agarwal

Senecio nudicaulis

Anaphalis adnata

Anaphalis busua

Anaphalis margaritacea



Prenanthes hookeri

Solidago virgaurea

Cicerbita macrorhiza

Inula cuspidata

1956

Picris hieracioides ssp. *Kaimaensis*

Dev Raj Agarwal

Inula racemosa

A.S. Chauhan

Saussurea gossypiphora

A.S. Chauhan

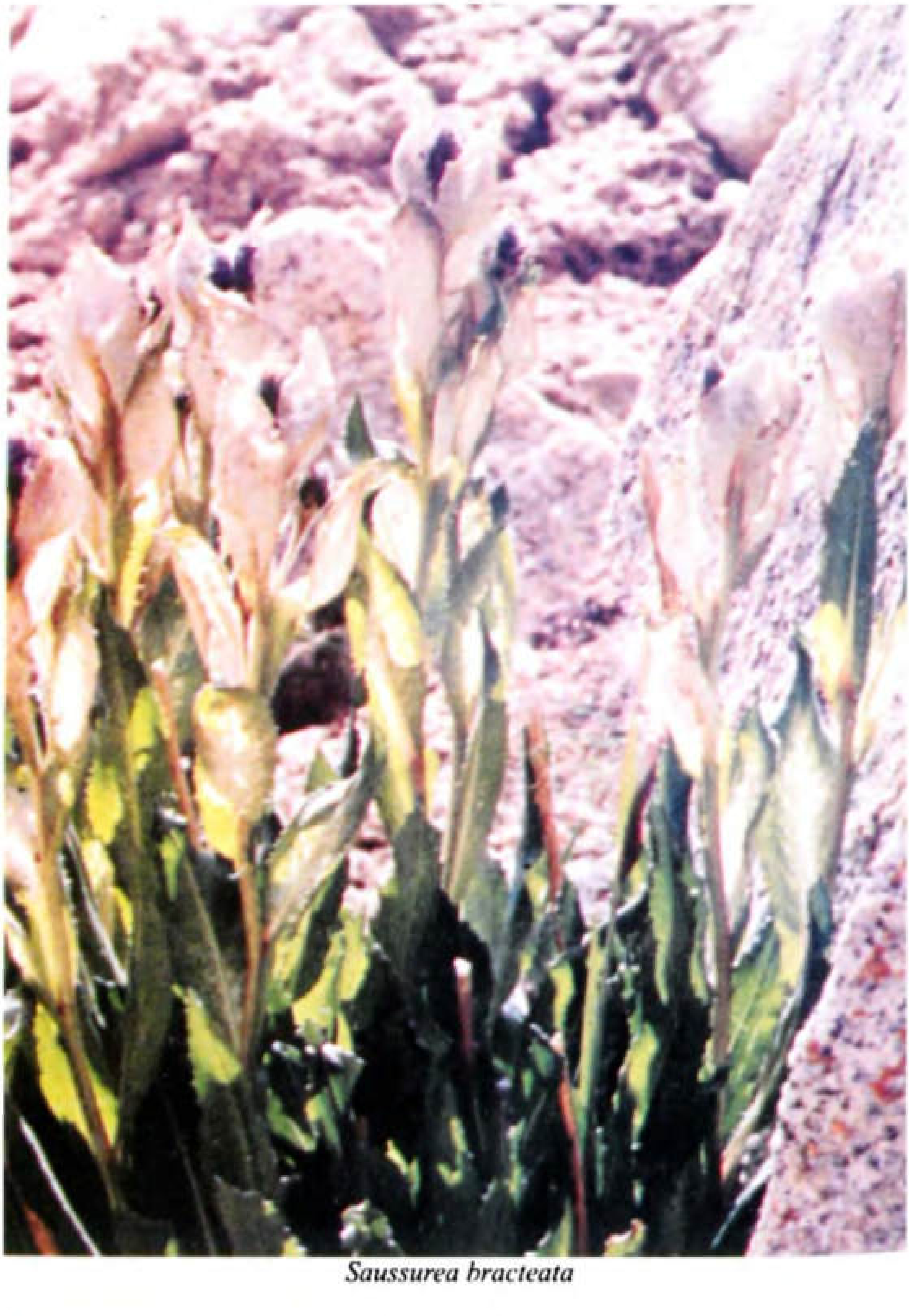
Saussurea obvallata - the sacred 'Brahmakamal'

Dev Raj Agarwal

Saussurea glacialis

Dev Raj Agarwal

Saussurea simpsoniana



Saussurea bracteata

Dev Raj Agarwal

RUBIACEAE

D.B. Deb

The Rubiaceae Jussieu has been accepted as a monophyletic family, ever since natural classification systems were presented. Long before the family was recognized, some genera and species were known as for an example *Galium aparine* (Theophrastus, Enquiry into Plants, *ca* 300 BC). Linnaeus (1753) listed more than 20 genera of Rubiaceae in as many as 6 different classes. *Carlemannia* and *Silvianthus* are no longer included in the Rubiaceae. Airy Shaw (1966) treated them under Carlemanniaceae. With the exclusion of disputed genera it is now accepted as a monophyletic family supported in cladistic analyses of morphological and molecular data. Jussieu (1789) placed the family close to Dipsacaceae and Caprifoliaceae. This placement was followed for many years. Endlicher (1841) indicated affinities between Rubiaceae and Loganiaceae of Contortae (= Gentianales). Wagenitz (1959) suggested a position close to or within Gentianales. Most systematists accept Rubiaceae within Gentianales. Cronquist (1981) placed the family in the order Rubiales putatively in between Gentianales and Dipsacales. However, a position in or close to Gentianales is supported by cladistic analysis of molecular data. At present the family is classified into 4 sub families viz. *Cinchonoideae*, *Ixoroideae*, *Antirheoideae* and *Rubioideae*.

The Rubiaceae are mostly a tropical, woody family. Distribution of the tribes is predominantly tropical and subtropical, barring the tribe Rubieae which is concentrated in temperate climate. Twenty nine of about 40 tribes are predominantly woody. Less than 20 per cent of the genera are herbaceous. Of the larger tribes only Hedyotideae and Spermacoceae are primarily herbaceous.

Chatterjee (1939) treated 6 genera in the Rubiaceae as endemic to India. He inadvertently reported *Paraophiorrhiza* (Hooker, 1880) as an endemic genus of Rubiaceae in India. The specimens on which this genus was founded were mislaid when Rubiaceae was described. This is in fact *Mitreola pedunculata*. *Carlemannia* and *Silvianthus*, which were treated by Chatterjee (*l.c.*) as endemic to India, were excluded from this family as already stated, as they are now are treated under Carlemanniaceae.

DIVERSITY

The Rubiaceae is the fourth largest family of Angiosperms comprising 4 sub-families, 40 tribes, 637 genera and 10,700 species in the world. In the present political delimitation of India also Rubiaceae represent the fifth largest family comprising 4 sub-families, 28 tribes, 113 genera and about 616 species (Deb, unpublished).

Galium and *Rubia* are tropical to temperate herbs with pseudowhorls of leaves. The Rubieae are the tribe where the evolution to the herbaceous habit is most extreme. The trend towards herbaceous habit exists in many of the essentially woody tribes. The Psychotreae have many large genera which are entirely woody. However, several woody genera contain herbaceous or semi-herbaceous species as well.

The sub-families, tribes and subtribes thereunder are given in Table-I, with the numbers of genera and species under each tribe.

Table I
A conspectus of family Rubiaceae in India.

Subfamily	Tribes		No. of genera	No. of species
Cinchonoideae	1.1.	Cinchoneae	1	7
	1.2.	Coptosapelteae (syn. Cinchoneae subtribe Mitragyninae)	4	15
	1.3.	Naucleae	7	9
		Subtribe Adeninae	4	5
		Subtribe Neolamarckiinae	1	1
		Subtribe Naucliinae	2	3
	1.4.	Rondeletieae	2	16
	1.5.	Condamineae	1	1
	1.6.	Catesbaeeae	1	1
	1.7.	Isertieae	6	29
	1.8.	Urophylleae	1	1
Ixoroideae	2.1.	Gardenieae	18	40

Subfamily	Tribes		No. of genera	No. of species
	2.2.	Pavetteae	3	60
	2.3.	Coffeeae	2	10
	2.4.	Aulacocalyceae	1	1
	2.5.	Octotropideae	4	4
Antirheoideae	3.1.	Vanguerieae	3	19
	3.2.	Guettardeae	1	1
	3.3.	Cephalantheae	1	1
	3.4.	Knoxieae	2	5
Rubioideae	4.1.	Hedyotideae	6	93
	4.2.	Ophiorrhizeae	3	52
	4.3.	Clarkelleae	1	1
	4.4.	Argostemateae	3	10
	4.5.	Hamelieae	1	1
	4.6.	Psychotreae	1	1
		Subtribe Psychotrinae		7
		Subtribe Hydnophytinae		2
	4.7.	Morindeae	11	90
	4.8.	Prismatomerideae	1	1
	4.9.	Paederieae DC. (syn. Putorieae)	2	9
	4.10.	Coprospermeae		
	4.11.	Spermacocceae	5	15
	4.12.	Rubieae	5	38

The genus *Hydyotis* with 68 species is the largest genus of Rubiaceae in India. The genera with 10 or more species occurring in India, which together represent 61.3 per cent of Rubiaceous species in the country, are presented in Table-II.

Table II
Dominent genera

Name of the genus	No. of species
Hedyotis	68
Ophiorrhiza	47
Psychotria	44
Ixora	32
Galium	24
Lasianthus	24
Neanotis	22
Pavetta	16
Mussaenda	14
Wendlandia	13
Rubia	11

Of the 113 genera, 10 genera comprising 14 species are exotics of South African, Malayasian, South American and Mexican origin. While some of them were introduced for their economic uses, the others are adventive in wild. Some of the economically important exotic genera naturalised in the country are :

Cinchona was introduced in India in 1861 from South America for antimalarial properties of the bark, and 4-5 species were initially cultivated in Darjeeling, Sikkim and the Nilgiris. Efforts to cultivate these plants in the western Himalaya failed. In the eastern Himalaya the plants grew very luxuriantly. Soon natural hybrids were formed by natural inter-corssing obliterating several specific delimitations.

Catesbaea is a monotypic genus. *Catesbaea spinosa* was introduced as an ornamental plant in the middle of the last century. This is a very small tree with very slow growth, but profusely flowering and fruiting twice a year.

Portlandia, a Mexican and Central American genus of 25 species, is represented by one species in gardens as a lovely plant with beautiful flowers.

Porterandia, comprising 14 species, of tropical Africa and Malaysia is represented by one species cultivated in the garden.

The genera *Coffea* and *Haemelia* are African in origin, but were introduced in India for their economic value and are widely cultivated in this country.

The genera *Mitracarpus*, *Richardia*, *Diodia* and *Diodella* are American in origin but, became adventive and naturalised in fallow land. The genus *Guettarda* is mainly a tropical American genus represented by a single species *Guettarda speciosa* in the coastal regions of India and Africa.

ENDEMISM

Twenty one genera and about 222 species of the family Rubiaceae are endemic to the Indian subcontinent. However, only 5 genera, viz. *Deccania, Ochreinandea, Octotropis* (peninsular India), *Keenania* (N.E. India), and *Pubistylus* (A & N Islands) and about 180 species are confined to the present political boundary of the country. Table-III presents the region-wise distribution of endemic species in India.

Table III
Endemic species of Rubiaceae in India.

Name of the species	Distribution
Argostemma courtalense	Peninsular India
Argostemma khasiana	Eastern Himalaya
Argostemma rostratum	Eastern Himalaya and Meghalaya
Argostemma sarmentosum	
Byrsophyllum tetrandrum	Peninsular India
Chassalia lushaensis	Eastern Himalaya and Mizoram
Chassalia staintonii	Eastern Himalaya and Sikkim
Coelospermum truncatum	Andamans
Coptophyllum nicobaricum	Andamans

Name of the species	Distribution
Deccania pubescens	Peninsular India
Discospermum apiocarpum	Peninsular India
Discospermum sphaerocarpum	Peninsular India
Dunnia assamica	Eastern Himalaya
Gardenia latifolia	N.W. India and Gangetic Plain
Greenea parkeri	Andamans
Gynochtodes macrophylla	Andamans
Hedyotis albonervis	Peninsular India
Hedyotis barberi	Peninsular India
Hedyotis beddomei	Peninsular India
Hedyotis bourdilonii	Peninsular India
Hedyotis buxifolia	Peninsular India
Hedyotis devicolamensis	Peninsular India
Hedyotis eualata	Peninsular India
Hedyotis hirsutissima	Peninsular India
Hedyotis hydrophila	Peninsular India
Hedyotis leschenaultiana	Peninsular India
Hedyotis membranacea	Peninsular India
Hedyotis pruinosa	Peninsular India
Hedyotis puberula	Peninsular India
Hedyotis purpurascens	Peninsular India
Hedyotis ramarawii	Peninsular India
Hedyotis stocksii	Peninsular and N.W. India
Hedyotis swartioides	Peninsular India
Hedyotis travancorica	Peninsular India
Hedyotis verticillaris	Peninsular India
Hedyotis villosistipulata	Peninsular India
Hedyotis viscida	Peninsular India

Name of the species	Distribution
Hydnophytum formicarium	Andamans
Hydrophyllux andamaninse	Andamans
Hymenodictyon obovatum	N.W. India and Gangetic Plain
Hymenodictyon flacidum	N.W. India and Gangetic Plain
Indopolysolenia wallichii	Eastern Himalaya and Meghalaya, Assam
Ixora anthroacantha	N.W. India and Gangetic Plain
Ixora arborea	N.W. India and Gangetic Plain
Ixora balakrishnii	N.W. India and Gangetic Plain
Ixora brachiana	N.W. India and Gangetic Plain
Ixora brunnescens	Andamans
Ixora elongata	Peninsular India
Ixora johnstonii	Peninsular India
Ixora lawsonii	Peninsular India
Ixora leucantha	Peninsular India
Ixora malabarica	Peninsular India
Ixora monticola	Peninsular India
Ixora notoniana	Peninsular India
Ixora polyantha	Peninsular India
Ixora sauliere	Peninsular India
Ixora undulata	N.W. India and Gangetic Plain
Keenania modesta	Eastern Himalaya and Cachar
Lasianthus acuminatus	Peninsular India
Lasianthus andamanicus	Andamans
Lasianthus blumeanus	Peninsular India
Lasianthus capitulatus	Peninsular India
Lasianthus ciliata	Peninsular India
Lasianthus cinereus	Peninsular India
Lasianthus dichotoma	Peninsular India

Name of the species	Distribution
Lasianthus helferi	Andamans
Lasianthus jackianus	Peninsular India
Lasianthus longicauda	Eastern Himalaya
Lasianthus meeboldii	Peninsular India
Lasianthus oblongifolius	Peninsular India
Lasianthus obovatus	Peninsular India
Lasianthus sessilis	Peninsular India
Lasianthus strigillosus	Peninsular India
Lasianthus truncatus	Eastern Himalaya
Leptodermis lanceolata	N.W. India and Gangetic Plain
Leptodermis micranthus	Eastern Himalaya
Leptodermis parkeri	N.W. India and Gangetic Plain
Leptodermis scabrida	Eastern Himalaya and Assam
Meyna laxiflora	Peninsular India
Meyna spinosa	Eastern Himalaya
Meyna velutina	Eastern Himalaya
Morinda pubescens	Eastern Himalaya
Morinda reticulata	Peninsular India
Morinda umbellata	Eastern Himalaya
Morinda villosa	Eastern Himalaya
Mussaenda parryorum	Eastern Himalayas and Mizoram
Mussaenda treutleri	N.W. India, Gangetic Plain and Western Himalaya to Meghalaya
Mycetia acuminata	Peninsular India
Mycetia listeri	Eastern Himalaya and Arunachal Pradesh
Mycetia mukerjiana	Eastern Himalaya and Mizoram

Name of the species	Distribution
Mycetia radiciflora	Eastern Himalaya, Nagaland
Mycetia stipulata	Eastern Himalaya
Neanotis carnosa	Peninsular India
Neanotis concanensis	Peninsular India
Neanotis decipiens	Peninsular India
Neanotis hohenackeri	Peninsular and N.W. India
Neanotis hutchinsonii	Peninsular India
Neanotis indica	Peninsular India
Neanotis latifolia	Peninsular and N.W. India
Neanotis monosperma	Peninsular India
Neanotis nummularis	Peninsular and N.W. India
Neanotis prainiana	Peninsular India
Neanotis rheedii	Peninsular India
Neohymenopogon parasitica	Eastern Himalaya
Neonauclea gageana	Andamans
Neonauclea purpurea	Peninsular and N.W. India
Nastolachma jenkinsiana	Eastern Himalaya
Nastolachma khasiana	Eastern Himalaya
Ochreinauclea missionis	Peninsular India
Octotropis travancorica	Peninsular India
Ophiorrhiza barberi	Peninsular India
Ophiorrhiza borii	Eastern Himalaya
Ophiorrhiza gracilis	Eastern Himalaya
Ophiorrhiza griffithii	Eastern Himalaya
Ophiorrhiza lurida	Eastern Himalaya
Ophirrhiza barnesii	Peninsular India
Ophirrhiza brunonis	Peninsular India
Ophirrhiza caudata	Peninsular India

Name of the species	Distribution
Ophirrhiza chandrasekharanii	Peninsular India
Ophirrhiza codyensia	Peninsular India
Ophirrhiza grandiflora	Peninsular India
Ophirrhiza hirsuta	Peninsular and N.W. India
Ophirrhiza incarnata	Peninsular India
Ophirrhiza munnarensis	Peninsular India
Ophirrhiza oriantha	Peninsular India
Ophirrhiza pykarensis	Peninsular India
Ophirrhiza roxburghiana	Peninsular India
Ophirrhiza tirunelvelica	Peninsular India
Oxyceros griffithii	Eastern Himalaya, Meghalaya and Nagaland
Pavetta breviflora	Peninsular and N.W. India
Pavetta brunonis	Peninsular India
Pavetta crassicaulis	Peninsular and N.W. India
Pavetta hispidula	Peninsular India
Pavetta hohenackeri	Peninsular India
Pavetta madrasica	Peninsular India
Pavetta memoralis	Peninsular India
Pavetta minor	Peninsular India
Pavetta oblanceolata	Peninsular India
Pavetta praeterita	Peninsular India
Pavetta subcapitata	N.W. India and Gangetic Plain
Pavetta travancorica	Peninsular India
Polyura geminata	Eastern Himalaya
Porterandia sikkimensis	Eastern Himalaya
Prismatomeris andamanica	Andamans
Psilanthus benghalensis	Eastern Himalaya

Name of the species	Distribution
Psychotria andamanensis	Andamans
Psychotria annamalayana	Peninsular India
Psychotria arborensis	Eastern Himalaya
Psychotria balakrishnae	Andamans
Psychotria beddomei	Peninsular India
Psychotria berberi	Peninsular India
Psychotria bisulcata	Peninsular India
Psychotria burkillii	Eastern Himalaya
Psychotria canarensis	Peninsular India
Psychotria connata	Peninsular India
Psychotria dalzelii	Peninsular India
Psychotria erratica	Eastern Himalaya
Psychotria flavida	Peninsular India
Psychotria fulva	Peninsular India
Psychotria globicephala	Peninsular India
Psychotria johnsonii	Peninsular India
Psychotria keralensis	Peninsular India
Psychotria kurzii	Andamans
Psychotria macrocarpa	Peninsular India
Psychotria meeboldii	Peninsular India
Psychotria nicobarica	Andamans
Psychotria nigra	Peninsular India
Psychotria nilgiriensis	Peninsular India
Psychotria nudiflora	Peninsular India
Psychotria octosulcata	Peninsular India
Psychotria pendula	Andamans
Psychotria platyneura	Andamans
Psychotria subintegra	Peninsular India
Psychotria truncata	Peninsular India
Psychotria tylophora	Andamans

Name of the species	Distribution
Pubistylus andamanica	Andamans
Rennellia speciosa	Andamans
Rothmannia schumannii	Andamans
Rubia alata	N.W. India and Gangetic Plain
Rubia albicaulis	N.W. India and Gangetic Plain
Rubia angustissima	N.W. India and Gangetic Plain
Rubia chaerifolia	N.W. India and Gangetic Plain
Rubia edgeworthii	N.W. India and Gangetic Plain
Rubia sikkimensis	N.W. India and Gangetic Plain
Saprosma corymbosa	Peninsular India
Saprosma fragrans	Peninsular India
Saprosma glomerata	Peninsular India
Spermacoce laevis	Andamans
Spermadictyon suaveolens	Eastern Himalaya
Spiradiclis arunachalensis	Eastern Himalaya
Spiradiclis bifida	Eastern Himalaya
Spiradiclis seshagirii	Eastern Himalaya
Tarenna agumbensis	N.W. India and Gangetic Plain
Tarenna obovata	N.W. India and Gangetic Plain
Tarenna pumila	N.W. India and Gangetic Plain
Terenna verbaenifolia	Andamans
Timonius jamboselia	Andamans
Uncaria macrophylla	Eastern Himalaya
Urophyllum andamanicus	Andamans
Wendlandia andamanica	Andamans
Wendlandia angustifolia	Peninsular India
Wendlandia gamblei	Peninsular India and Madhya Pradesh
Wendlandia heyneana	Peninsular India
Wendlandia speciosa	Eastern Himalaya

Besides, a number of species show a very restricted range of distribution between India, Sri Lanka, Bangladesh, Nepal, Myanmar and Thailand. Such species are listed in Table-IV.

Table IV
Species confined to Indian Subcontinent

Name of the species	Distribution
Benkara malabarica	India (PI), Sri Lanka
Fergusonia zeylanica	India (PI), Sri Lanka
Geophila repens	India (PI, A&N), Sri Lanka, Nepal
Hedyotis aspera	India (PI), Sri Lanka
Hedyotis biflora	India (PI, NW), Sri Lanka
Hedyotis cyathii	India (PI), Sri Lanka
Hedyotis fruticosa	India (PI), Sri Lanka and Bangladesh
Hedyotis graminifolia	India (PI), Sri Lanka
Hydrophyllax maritima	India (PI), Sri Lanka
Ixora thwaitesii	India (PI), Sri Lanka
Ixora calycina	India (PI, Andamans), Sri Lanka
Lasianthus hookeri	India (PI), Sri Lanka and Nepal
Lasianthus inconspicuus	India (PI), Sri Lanka and Nepal
Lasianthus lancifolius	India (PI), Sri Lanka
Lasianthus sikkimensis	India (PI), Sri Lanka
Lasianthus tentaculatus	India (PI), Sri Lanka
Lasianthus tubiferus	India (PI), Sri Lanka and Bangladesh
Lasianthus wallichii	India (PI), Sri Lanka
Leptodermis griffithii	India (PI), Sri Lanka
Leptodermis kumaonensis	India (PI, WH), Sri Lanka and Myanmar
Leptodermis reparia	India (PI, WH) Sri Lanka and Myanmar
Luculia gratissima	India (PI), Sri Lanka and Bangladesh

Name of the species	Distribution
Mitragyna tabulosa	India (PI), Sri Lanka
Mussaenda corymbosa	India (PI), Sri Lanka, Assam and Bangladesh
Mussaenda frondosa	India (PI, EI), Sri Lanka
Mussaenda glabrata	India (PI), Sri Lanka
Mussaenda intuspilosa	India (PI), Sri Lanka
Mussaenda keenani	India (PI), Sri Lanka
Mussaenda roxburghii	India (PI, WH), Sri Lanka and Myanmar
Neurocalyx calycinus	India (PI), Sri Lanka
Ophiorrhiza pectinata	India (PI), Sri Lanka
Ophiorrhiza radicans	India (PI), Sri Lanka
Psilanethus travancorensis	India (PI), Sri Lanka
Psilanethus wightianus	India (PI), Sri Lanka
Psychotria erratica	India (PI), Sri Lanka
Psychotria fosbergii	India (PI), Sri Lanka
Psychotria truncata	India (PI), Sri Lanka
Saprosma foetens	India (PI), Sri Lanka

PI = Peninsula India; A & N = Andaman & Nicobar Island; WH = Western Himalaya; EI = Eastern India

ECONOMIC IMPORTANCE

The most well known economic product of family Rubiaceae are Coffee, obtained from *Coffea arabica* and *Coffea canephora*, and Quinine, obtained from *Cinchona* species. The family is also an important source of drug ipecacuanha (*Cephaelis* spp.), dyes madder (*Rubia* spp.) and gambier (*Uncaria* spp.). Rubiaceae also provide a large number of ornamentals, like species of *Gardenia*, *Bouvardia*, *Hamelia*, *Manettia*, *Randia*, *Rondeletia*, *Asperula*, *Galuim*, *Houstomia*, etc. Some of the economically important species of the family are given below.

Timber, pulp, fuelwood

Haldina cordifolia, Himalrandia tetrasperma, Gardenia coronaria, Hydrophylax maritima, Petunga roxburghii, Mitragyna tubulosa, Timonius jumbosella, etc.

Medicinal

Chasalia chartacea, Cephaelis ipecacuanha, Canthium dicoccum, Deutella repens, Galium aparine, G. rotundifolium, G. trifolium, Geophila herbacea, Guettarda speciosa, Hedyotis auriculata, H. biflora, Hydrophylum andamanense, Ixora pavetta, I. chinensis, etc.

Edible

Anthocephalus chinensis, Canthium parviflorum, Gardenia angusta, G. campanulata, Ceriscoides turgida, Hydiotis capitellata, Morinda citrifolia, Morinda umbellata, Nauclea orientalis, Pavetta indica, P. tomentosa, Catunaregam malabarica, Ixora coccinea, etc.

Fodder

Spermacoce hispida, Hymenodictyon orixense, Morinda pubescens, Catunaregam spinosa, C. nilotica, Mitragyna parviflora, Wendlandia heynei, etc.

Dyes and Tannins

Galium aparine, Galium verum, Rubia cordifolia, R. sikkimensis, Hedytis herbacea, H. puberula, Luculia gratissima, Morinda citrifolia, Morinda umbellata, Musaenda roxburghii, Randia exaltata, Haldina cordifolia, Hymenodictyon orixense.

Ornamentals

Gardina angusta, G. jasmenoides, Hamelia pattens, Ixora spp., *Galium* spp., etc.

RARE AND THREATENED TAXA

The factors, like deforestation for various developmental activities and expansion of agriculture leading to the loss and fragmentations of habitat, over-exploitation and introduction of alien species have together resulted into depletion of populations of a number of species. While species, like *Hedyotis hirsutissima, Ophiorrhiza barnesii, O. brunonis, O. radicans, O. pyharensis, Psychotria tylophora, Pavetta wightii,* etc. have possibly become extinct as all attempts to locate them in wild for a period ranging up to 15 decades have been in vain (Table V) a number of other species have also slipped into various category of threats (Nayar & Sastry, 1987, 1988, 1990).

A number of rare and threatened species growing within Wildlife Sanctuary or a National Park are well protected now *in situ*. However, for the species growing outside the Protected Area Network of the country cultivation, multiplication and *ex situ* conservation in botanic gardens is suggested. At the same time an intensive and extensive surrey programme also needs to be launched to locate the species, which have not been collected for a long time and bring them under *ex situ* conservation network.

Table V
Some rare and threatened plants of Rubiaceae in India

Name of the species	Status	Distribution
Acranthera grandiflora	Endangered	Tamil Nadu, Tirunelveli. Endemic.
Acranthera tomentosa	Vulnerable	Meghalaya, Assam, Nagaland. Endemic.
Argostemma khasianum	Indeterminate; known from type	North east India (Meghalaya). Endemic.
Clarkella nana	Rare	Western Himalaya
Dendlandia andamanica	Endangered	Andaman Islands, (Port Blair)
Hedyotis albonervia	Endangered	Tamil Naru, Tirunelveli Dist. Endemic.
Hedyotis barberi	Vulnerable	Tamil Nadu. Endemic.
Hedyotis beddomei	Endangered	Palghat Hills, Kerala. Endemic.
Hedyotis bourdillonii	Vulnerbale	Kerala. Endemic.
Hedyotis brunonis	Rare	West Bengal, Assam; Bengladesh, Myanmar
Hedyotis buxifolia	Rare	Tamil Nadu Kerala. Endemic.
Hedyotis cualata	Rare	Tamil Nadu, Kerala. Endemic.
Hedyotis cynantha	Rare	Tamil Nadu, Maharashtra; Karnataka; Sri Lanka

Name of the species	Status	Distribution
Hedyotis fruticosa	Rare	India (Travancore); Sri Lanka, Myanmar
Hedyotis hirsutissima	Possibly Extinct	Tamil Nadu. Endemic.
Hedyotis ramrowii	Vulnerable	Tamil Nadu, Kerala. Endemic.
Hedyotis scabra	Rare	West Bengal, Assam, Arunachal Pradesh; Bangladesh
Hedyotis swertioides	Rare	Kerala, Tamil Nadu. Endemic.
Indopolysolenia wallichii	Rare	North-east India (Meghalaya). Endemic.
Nauclea gageana	Indeterminate; no collection after King (1884)	Andaman Islands. Endemic.
Neanotis carnosa	Indeterminate; known only from type in 1897	Karnataka. Endemic.
Neanotis oxyphylla	Rare	Meghalaya. Endemic.
Neanotis prainiana	Vulnerable	Karnataka. Endemic.
Ochreinauclea missionis	Vulnerable	Central and southern Western Ghats. Endemic.
Ophiorrhiza brunonis	Presumed Extinct	Tamil Nadu, Karnataka. Endemic.
Ophiorrhiza caudata	Presumed Extinct	Kerala
Ophiorrhiza griffithii	Indeterminate (not collected since 1837)	Nagaland; Myanmar

Name of the species	Status	Distribution
Ophiorrhiza hispida	Endangerd	Meghalaya, Assam; Myanmar.
Ophiorrhiza incarnata	Endangered	Kerala. Endemic.
Ophiorrhiza lurida	Rare	Sikkim, West Bengal (Darjeeling) Manipur: East Tibet, South West China.
Ophiorrhiza pykarensis	Possibly Extinct	Nilgiri hills. Endemic.
Ophiorrhiza radicans	Possibly Extinct; not collected after 1893	Kerala; Sri Lanka.
Ophiorrhiza subcapitata	Endangered	Meghalaya (Khasi and Jaintia hills). Endemic.
Ophiorrhiza tingens	Vulnerable	Meghalaya, Assam, Tripura State, Nagaland; Myanmar.
Ophiorrhiza wattii	Endangered	Meghalaya, Nangaland, Manipur.
Opliorrhiza barnesii	Possibly Extinct	Kerala (Travancore). Endemic.
Opliorrhiza gracilis	Indeterminate; not collected after original discovery more than a century ago	Nagaland (Kohima); Myanmar (Tenasserim)
Pavetta hohenackeri	Vulnerable, no collection since original record	Peninsular India (Tamil Nadu). Endemic.

Name of the species	Status	Distribution
Pavetta oblanceolata	Indeterminate or possibly Extinct; known from type only in 1847	South Western Ghats. (Kerala). Endemic.
Pavetta wightii	Possibly Extinct; known only from type collection in 1848	Tamil Nadu (Nilgiri Hills, Coonoor). Endemic.
Prismatomeris andamanica	Indeterminate; known only from type collection.	South Andaman Islands. Endemic.
Pshychotria globicephala	Endangered	Tamil Nadu (Courtallum district).Endemic.
Psychotria aborensis	Endangered	Arunachal Pradesh (Abor hills)
Psychotria andamanica	Rare	South Andaman and Great Nicobar Islands.
Psychotria pendula	Indeterminate; known only from type collection.	South Andaman Islands. Endemic.
Psychotria tylophora	Possibly Extinct	Nicobar Islands.
Rubia edgeworthii	Vulnerable	Western Himalaya.
Rubia himalayensis	Vulnerable	Western Himalayas (Kashmir); Pakistan, Afghanistan
Tarena agumbensis	Vulnerable	Karnataka. Endemic.
Wendlandia angustifolia	Presumed Extinct	Tamil Nadu (Courtallum, Tirunelvelli). Endemic.

REFERENCES

Airy-Shaw, H.K. 1966. *Willis' Dictionary of Flowering Plants.* Cambridge Univ. Press, Cambridge

Chatterjee, D. 1939. Studies on the Endemic flora of India and Burma. *J. Roy. Asiat. Soc. Bengal* (Science) **5:** 9-67.

Conquist, A. 1981. *An Integrated System of Classification of Flowering Plants.* Columbia Univ. Press, New York.

Deb. D.B. Rubiaceae In: *Fasc. Fl. India* **23:** (In press).

Endlicher, S.L. 1838-41. *Iconographia generum plantarum.* Wien.

Hooker, J.D. 1880. Rubiaceae. In: *Flora of British India*, 3: 17-210. L. Reeve & Co., London.

Jussieu, A.L. De 1789. *Genera Plantarum.* Paris.

Linnaeus, C. 1953. *Species Plantarum.* London.

Nayar, M.P. and A.R.K. Sastry (eds.). 1987-90. *Red Data Book of Indian Plants.* Vols. 1-3. BSI, Calcutta.

CYPERACEAE

N.P. Singh
V.P. Prasad

Cyperaceae or the sedge family is one of the largest plant groups with *ca* 4000 species known from throughout the world. It is one of the most widely distributed family and hence attracted the attention of phytogeographers since long. Sedges are characterised by the grass-like or rush-like habit with or without rhizomes or stolons, the minute inconspicuous flowers enclosed by the glumes in spikelets and the indehiscent fruits known as nuts or achenes. Sedges are always herbs, except the African genus *Microdracoides* which is tree-like. Though most of the sedges are grass-like in appearance, both can be differentiated by a few characters. In sedges stems are usually solid and triquetrous, leaf-sheaths generally closed, flowers always axillary and subtended by a single glume. But in grasses stems are usually hollow and cylindrical, leaf-sheaths generally open, flowers terminal and subtended by ligules, and lodicules besides the glumes. But there are many exceptions in sedges to the above mentioned characters.

Sedges are supposed to be a difficult plant group and for an inexperienced person many species look alike. Hence, sometimes even botanists avoid collecting sedges due to the difficulty in their identification. Moreover, in many old herbarium collections, specimens are not complete as they lack either underground parts, like rhizomes, stolons, tubers, etc. or the mature spikelets with achenes.

HISTORICAL BACKGROUND

History of Cyperaceae can be traced to Pre-Linnaean contributions to the family by Tournefort (1719) and Micheli (1729). Linnaeus (1753, 1754), in his historical *Species Plantarum* and *Genera Plantarum* described 5 genera and 81 species of the family. Many subsequent workers had contributed to the family by describing many species while doing the floristics in different parts of the world. Burman (1768), Linnaeus (1767, 1771), Rottboell (1773), Retzius (1786-1791), Willdenow (1797-1830), Vahl (1805-1806), R. Brown (1810), Roxburgh (1820-1824, 1832) and Miquel (1855-1859) also described many Cyperaceae members for the first time. However, in nineteenth century detailed study on the family was carried out by Nees (1834), Kunth (1837), Steudel (1854-55), Boott (1858-1867), Boeckler (1868-1877), Bentham (1881, 1883) and Pax (1888). Clarke's (1884-1909) work on the family extends from late 19th Century to early 20th century. Besides the Indian region he worked on sedges of Thailand, China, Taiwan, Korea, Malaya, Philippines and Tropical Africa. His *Illustrations of Cyperaceae* (Clarke, 1909) is very useful for the identification of many Indian species of sedges.

Monographic study on the whole family is rather impossible due to the presence of very large number of species and their wide range of geographic distribution. But monographic study on various smaller groups of Cyperaceae was done by Kukenthal (1909, 1935-1936, 1938-1942). Svenson (1929-1939) and Blake (1939) did monographic study on the genus *Eleocharis*. Blake (1940) also carried out monographic study on the genus *Fimbristylis*. The genus *Scirpus* was worked out in details by Beetle (1940-1946, 1949). *Carex* is a widely studied group of the family. Nelmes (1938-1948, 1951, 1954, 1955) did extensive studies on the genus, especially of Malaysian region. Akiyama (1931-1955) also did detailed study on the same group of Far Eastern region, particularly of Japan. Mackenzie (1931-1935, 1940) worked on *Cariceae* of North America. Nooteboom (1978) revised the genus *Uncinia* of Malaysia and Australia.

Extensive studies were done by many botanists in South and South East Asia. Ohwi (1936, 1938, 1944) studied Cyperaceae of Japan. He had worked on sedges of South Asia also. Raymond (1955-1966) did detailed study on sedges of South East Asia especially of Vietnam and Thailand. Kreczetowicz (1932-1946) studied the Cyperaceae of erstwhile USSR. In the African region many workers, like Gray (1965-1966), Hooper and Napper (1972) and Hanies and Lye (1978, 1983) have studied the family Cyperaceae.

Detailed studies on the family by Kern (1952-1974) especially of the South East Asia and particularly of Malaysian region are probably the best work done in the recent past. He devoted his life to study the sedges of this region. Koyama (1955-1988) is probably the recent world authority on family Cyperaceae. His important floristic works on the family are of eastern Asia and South East Asia, especially of Japan, Thailand, China, Nepal, Afganistan, Pakistan, eastern Himalaya and Sri Lanka. He has also discussed in detail about the classification of the family (Koyama, 1961-1962). His work on the family for Sri Lanka (Ceylon) (Koyama, 1985) is the only detailed account available on the family from any of the South Asian nations.

Many workers mentioned earlier included Indian Cyperaceae also in their works. Even though as far as Indian Cyperaceae is concerned, Clarke (1884-1898) is the first one to do detailed study on this plant group. Subsequent works on sedges of Indian region are actually based on his classic work on the family, which is included in Hooker's (1893-1894) *Flora of British India*. Regional Floras published subsequently in the first half of 20th century also deal in details the sedges of respective regions as Bengal (Prain, 1903), Bihar and Orissa (Haines, 1924), Gangetic plains (Parker & Turill, 1929) and erstwhile Presidencies of Bombay (Cooke, 1908; Sedgewick, 1918) and Madras (Fischer, 1931). Blatter and McCann (1934-1935) added many species of sedges to the Flora of Bombay Presidency while revising the flora of this region. Floristics of different states, districts and other small areas published later on also include accounts on sedges of respective areas.

Not many Indian Botanists have worked exclusively on this family. The late Prof. Govindarajalu (1966-1998) was the most important Cyperologist of Independent India. He devoted more than 30 years to the study of sedges of India and described many new species mostly from South India. Majority of the endemic species of sedges reported from peninsular India are described by him. He has done extensive studies on the vegetative anatomy also of many new species described by him. He made scanning electron microscopic observations to study the micromorphology of epicarpic structures of nuts in some species described by him.

Verma and Chandra (1981) enumerated the sedges of Madhya Pradesh. They also revised the genera *Rhynchospora* and *Scleria* in India (Verma & Chandra, 1982, 1992). Rao and Verma (1982) studied the sedges of Assam region and brought out the Cyperaceae of North East India. The area covered by them is the old Assam region which at present forms the states of Arunachal Pradesh, Assam, Nagaland, Meghalaya, Manipur, Tripura and Mizoram.

Shah (1963-1967) worked on Cyperaceae of Gujarat which includes some anatomical, ecological and phytogeographical studies also. Sabnis (1962a,b) and his associates (Sabnis & Chavan 1967; Sabnis & Joshi, 1971; Sabnis & Bedi, 1979) also worked on the Cyperaceae of Gujarat. G.L. Shah and Suryanarayana (1967), G.L. Shah and Deshpande (1968) and G.L. Shah and Bhatt (1974) also worked on family Cyperaceae. Naithani and Raizada (1977) published some new records of Cyperaceae for the country.

Besides, the systematics of Cyperaceae, some other aspects like morphology, anatomy, cytology, ecology etc. of the family were also studied by different workers in India. Rao and Verma (1981) discussed the morphology and important taxonomic characters of sedges which is useful, especially for the beginners in Cyperology. Ahuja (1962) studied the epidermis of some Cyperaceae members. Ecological studies on sedges, especially on *Cyperus rotundus*, were done by Ambasht (1964) and Jha and Sen (1985). Shah (1967) used sedges as material for ecological and phytogeographical studies. Cytological investigation of some sedges were carried out by Sharma and Bal (1956). Shah (1964, 1965) have done some embryological studies also on the family. Distribution of the sedges is discussed by Verma and Chandra (1979).

MORPHOLOGY

Sedges are usually annuals or perennials, which is often difficult to make out in the herbarium specimens when the underground portion is missing or when the annual or perennial habit is variable. The rhizomes are usually small, woody, but sometimes long-creeping or emitting stolons which often bear tubers as in *Bolboschoenus maritimus* and *Cyperus rotundus*.

Stems are usually tufted but could be occasionally solitary also when the rhizome or stolons are long-creeping. Stems can be capillary to very stout, few millimetres to several metres long as in some species of the genus *Scleria*, without nodes or nodose as in the species of *Scleria* and *Fuirena*, solid or hollow, at times septate as in *Eleocharis dulcis* and *Schoenoplectus articulatus*, trigonous, triquetrous or even almost 3-winged and at times terete.

Leaves are usually 3-ranked when the stems are trigonous or triquetrous, but may also be often distichous or polystichous. They are usually in a basal cluster, but at times a few or almost all cauline may be as well as in the species of *Fuirena*, *Scleria* and *Diplacrum*. In the genus *Eleocharis* and some species of *Fimbristylis* leaves are reduced to bladeless sheaths. Ligule is generally absent but sometimes represented by a fringe of short hairs or a membrane. In *Scleria* mouth of the sheath is produced beyond the base of the leaf-blade on its opposite side which is known as contraligule.

Inflorescence in this family is constituted by the arrangement of spikelets. It is always terminal, but sometimes appears to be lateral (in fact pseudolateral). In the genus *Eleocharis*, and in certain species of *Fimbristylis*, inflorescence is reduced to a single spikelet. Otherwise the inflorescence is normally anthelate or capitate. Anthelate or umbellate inflorescence can be simple, compound, decompound or supradecompound. Number of bracts vary from one to several.

There are small scale-like organs called prophylls of varying form and size attached to different parts of the inflorescence. Pistillate flowers in the species of *Carex* are enclosed in a sac-like structure known as utricle or perigynia which are also prophylls.

Spikelets in Cyperaceae vary in their size, shape and colour, and are found either solitary or in inflorescence. It consists of a rachilla, bearing glumes and flowers. Glumes are arranged distichously in *Cyperus* and allied genera or spirally in genera like *Eleocharis*, *Fuirena*, *Schoenoplectus*, etc. Flowers are minute and inconspicuous in the family Cyperaceae. But there are many useful floral characters, like presence or absence of perianth bristles or scales, number of stamens, size of anthers, nature of connective appendages of anthers, continuous or articulated nature of the style on the ovary, number and length of the stigmas, etc.

Fruits in Cyperaceae are usually one-seeded, indehiscent nuts or achenes. Most of the nut characters are stable and hence, reliable in the taxonomy of the family. Nuts can be lenticular, planoconvex or trigonal and the shape vary as oblong, obovoid, ovoid or globose. Colour of the nuts also vary from different shades of brown, black to yellow. In *Scleria* nuts are usually white and rarely bluish. Surface of the nuts vary according to the species as smooth or with different kinds of ornamentation. In

Bulbostylis apex of the nut is crowned with a persistent, button-like style base. The shape and size of the hypogynium or disc is very important in the identification of species of *Scleria*.

Classification :

The sedge family has close affinity to Poaceae, the grass family and the former is usually placed just before the latter. Both the families come under the division Glumiflorae, but in separate orders viz., *Cyperales* and *Graminales*. Cyperaceae has some affinity to *Juncales* and *Pandanales* also.

Taxonomy and classification of the family Cyperaceae is interesting, but a bit complicated due to the presence of large number of species and the highly complex nature of certain floral parts. Koyama (1961) has discussed the history of classification of the family in detail, and hence, it is preferred here to avoid a detailed discussion of it.

The main characters used for the major division of the family have been sex of flowers, number of fruit-bearing flowers within a spikelet and to an extent presence or absence of the terminal flowers. Bentham and Hooker (1883) used sex of the flowers for the first time to divide the family into two main groups as Monoclines, having bisexual flowers, and Diclines bearing unisexual flowers. *Monoclines* and *Diclines* were later changed to Scirpoideae and Caricoideae respectively by subsequent workers as subfamilies. Clarke (1902) divided the family into three suborders (subfamilies) viz., Scirposchoeneae, Mapanieae and Cariceae.

According to Koyama (*l.c.*) sex of flowers is less important to make major divisions in the family. By giving more importance to presence or absence of terminal flowers and the prophyll he proposed to divide the family into six tribes under four subfamilies as shown below.

Subfam. I	Mapanioideae	Tribe I. *Hypolytreae*
Subfam. II	Scirpoideae	Tribe I. *Scirpeae* Tribe 3. *Cypereae*
Subfam. III	Rhynchosporoideae	Tribe 4. *Rhynchosporeae* Tribe 5. *Sclerieae*

Subfam. IV Caricoideae Tribe 6. *Cariceae*

The subfamilies Scirpoideae and Rhynchosporoideae are usually treated together under Scirpoideae. But Koyama (*l.c.*) separated them based on number of flowers.

Kern (1974 a) classified the family into five tribes under two subfamilies as shown below and this system seems to be more convenient to follow.

A.	Subfamily	:	CYPEROIDEAE
	I. Tribe		*Hypolytreae*
	II. Tribe		*Cypereae*
	III. Tribe		*Rhynchosporeae*
B.	Subfamily	:	CARICOIDEAE
	IV. Tribe		*Sclerieae*
	V. Tribe		*Cariceae*

Recently Bruhl (1995) proposed a new classification of the family.

DIVERSITY

Clarke (1893-94) enumerated a total number of 449 species and 97 varieties of sedges under 28 genera from the British India, including countries, like Pakistan, Afganistan, Nepal, Tibet, Bangladesh, Myanmar, Sri Lanka and even Malay Peninsula. Naturally many taxa reported from these neighbouring countries were actually not found within the present political boundaries of India. According to Karthikeyan (1999) 6 genera, 85 species and 22 varieties of Cyperaceae reported in *Flora of British India* are actually from outside India. This leaves only 22 genera, 364 species and 75 varieties, enumerated in *Flora of British India*, to be actually occurring in the present political boundary of India.

Number of genera and species of Cyperaceae reported in the regional Floras during the first half of 20th Century, which followed the publication of *Flora of British India*, are summarised in the Table I.

Table I
Number of Cyperaceae genera and species reported in regional Floras.

Floras	Author	Year	Genera	Species
Bengal Plants	D. Prain	1903	21	140
Flora of Presidency of Bombay	T. Cooke	1909	14	102
Sedges of Bombay Presidency	Sedgewick	1918	16	117
Botany of Bihar & Orissa	H.H. Haines	1924	16	111
Flora of Upper Gangetic Plain	R.N. Parker & W.B. Turill	1929	15	76
Flora of Presidency of Madras	C. E.C. Fischer	1931	20	171

From the above table it is apparent that diversity of sedges is more in the South India, followed by eastern India. Floristics of different states, districts and other small areas published later on also include accounts on sedges of respective areas. Explorations in the second half of the 20th Century, especially after the reorganisation of Botanical Survey of India resulted in the collection of Sedge species from different regions and states. Several new taxa have been published since then under this family. Sedges of eastern India were enumerated by Mitra (1958) along with other flowering plants of the region. Cyperaceae of many states were enumerated or listed by different workers while doing the Flora of these states, like Sabnis (1962), Maheshwari (1963), Tiwari and Maheshwari (1964), Stewart (1967), Sahani *et al.* (1972), Saxena (1973), Rath, Choudhary and Patnaik (1979), Sharma (1981), Sharma and Kachroo (1981), Verma and Chandra (1981), Rao and Verma (1982), Deb (1983), Sharma *et al.* (1984), Wadhwa and Chowdhery (1984), Rao (1986) Bhargavan (1989), Parmar, (1993), Hajra and Verma (1996), Srivastava (1996), Lakshminarasimhan (1996) and Pullaiah and Hanumanthappa (1997). Number of genera and species reported from most of the Indian States and some regions are listed in Table II.

Table II
A census of Cyperaceae genera and species as reported in some of the State or Regional Floras published in the second half of 20th century.

State or Region	No. of genera	No. of species
Kashmir	9	146
Jammu and neighbourhood	7	38
Himachal Pradesh	11	107
Punjab	7	38
Delhi	7	37
Rajasthan	15	93
Gujarat	13	64
Madhya Pradesh	12	131
Orissa	19	112
Andhra Pradesh	23	136
Maharashtra	23	154
Goa	11	53
Diu, Daman, Dadra & Nagar Haveli	8	37
Karnataka	22	155
Tamil Nadu	12	185
East India	22	249
North East India	14	173
Sikkim	18	145
Tripura	10	33
Andaman & Nicobar Islands	12	74

In the above table some of the authors treated the genera *Cyperus* and *Scirpus* in a wide sense as done by Rao (1986) while listing the indigenous species of *Cyperus*. In fact *Cyperus* in Andaman & Nicobar Islands may be split up into genera like, *Anosporum, Cyperus, Kyllinga, Mariscus, Pycreus*, etc. as done by many other workers. Similarly, the species treated under the genus *Scirpus* by many botanists also can be split into genera, like *Bolboschoenus, Schoenoplectus, Rikliella, Scirpus*, etc.

The number of taxa in most of the states mentioned above in the table have to be made up-to-date. In most of the above states especially where the Flora was worked out long back, it is necessary to do a taxonomic revision of the family to know the actual diversity of Sedges in the respective states. For example, though Sharma *et al.* (1984) reported 22 genera, 155 species, 1 subspecies and 11 varieties from Karnataka, a revision of the family in the state (Prasad, 1999) revealed that there are 23 genera, 161 species, 7 subspecies and 8 varieties in the state after the exclusions, additions and new combinations of some taxa.

Similarly a comprehensive State Flora is lacking for a few states like Kerala and Uttar Pradesh, where scattered information on the family have to be gathered from different sources. Recently Manilal and Raveendrakumar (1999) compiled the information of all the Angiosperm taxa reported from Kerala after the publication of *The Flora of Madras Presidency* by Gamble (1915-1936). It may be mentioned that the whole Kerala comprising the erstwhile states of Travancore, Cochin and Malabar was part of Madras Presidency. In the table provided by them it is mentioned that there are reports of 8 new species, 7 new records and 2 new varieties of Cyperaceae from Kerala in addition to the 86 species reported by Fischer (1931) from the state. Hence, the total number of species goes up to 101. But it seems they missed 3 species, viz. *Fimbristylis angamoozhiensis, F. pseudonarayanii* and *F. stigmatotecta* which are not included in the list provided. So the total number of sedge species presently reported from Kerala is 104. Similarly there are subsequent reports of members of Cyperaceae from different states. Joshy *et al.* (1998) enumerated 11 species as additions to the Cyperaceae of Goa. Bhellum and Rani (1994) added 2 species of sedges to the Flora of Jammu & Kashmir. Sharma (1994) reported 2 additional species of Cyperaceae to the check-list of Punjab Plants. Bir and Singh (1989) also added one Cyperaceae species to the Flora of Punjab.

Rao (1986) reported 74 species, 2 subspecies and 2 varieties of sedges from Andaman & Nicobar Islands under 12 genera and listed another 2 species and 1 variety as of doubtful species from these islands. Probably he missed 2 species reported earlier by Kern (1961). Later on 6 more species and 1 variety were reported by different workers like Karthikeyan *et al.* (1989), Govindarajalu (1990) and Mathew and Sreekumar (1992), thereby making the total number as 85 species, 2 subspecies and 4 varieties. Govindarajalu (1972-1998) described many species from different states which are additions to the Flora of these states. Similarly for most states there must be additions of taxa and a revision of the family will give the exact number of taxa in each state.

Karthikeyan *et al.* (1989) listed 537 species, 14 subspecies and 92 varieties of Cyperaceae (excluding the typical subspecies and varieties) under 38 genera (including the taxa mentioned in the Addenda and Corregenda) as shown in Table III below:

Table III
Number of species and infraspecific taxa under each genus in India as reported by Karthikeyan *et al.* (1989).

S.No.	Genera	No. of species	No. of subsp.	No. of varieties
1.	*Carex*	160	1	29
2.	*Fimbristylis*	91	2	10
3.	*Cyperus*	72	2	13
4.	*Kobresia*	35	–	4
5.	*Scleria*	29	–	3
6.	*Eleocharis*	20	1	1
7.	*Schoenoplectus*	17	3	1
8.	*Pycreus*	15	3	11
9.	*Mariscus*	14	–	8
10.	*Scirpus*	12	–	–
11.	*Rhynchospora*	10	–	2
12.	*Fuirena*	8	–	2
13.	*Kyllinga*	7	1	2
14.	*Juncellus*	6	–	–
15.	*Bulbostylis*	5	–	2
16.	*Hypolytrum*	3	1	–
17.	*Eriophorum*	3	–	–
18.	*Lipocarpha*	4	–	–
19.	*Mapania*	3	–	–

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S.No.	Genera	No. of species	No. of subsp.	No. of varieties
20.	*Baeothryon*	2	–	–
21.	*Cladium*	2	–	
22.	*Rikliella*	2	–	–
23.	*Sorostachys*	2	–	–
24.	*Anosporum*	1	–	–
25.	*Ascopholis*	1	–	–
26.	*Blysmus*	1	–	3
27.	*Diplacrum*	1	–	–
28.	*Hemicarpha*	1	–	–
29.	*Indocourtoisia*	1	–	–
30.	*Isolepis*	1	–	
31.	*Kyllingiella*	1	–	–
32.	*Lepironia*	1	–	–
33.	*Machaerina*	1	–	–
34.	*Microschoenus*	1	–	–
35.	*Queenslandiella*	1	–	–
36.	*Remirea*	1	–	–
37.	*Schoenus*	1	–	–
38.	*Scirpodendron*	1	–	–
	Total	537	14	92

After the publication of the above work many taxa were added to the Indian Sedge Flora, mostly the new species published by different workers and a few new distributional records. Hence, recently Karthikeyan (1999) updated the number as 580 species under 39 genera without providing a list of these additions. However, during the present study 52 species and 2 subspecies were found as additions to the earlier number reported by Karthikeyan *et al.* (1989). Hence, the total number of species would have gone up to 589 unless some of the taxa reported by them are not excluded from Indian Flora as their distribution is shown as Nepal, rarely Bhutan or with doubtful distribution in India. The taxa either not reported from within the present political boundaries of the country or of doubtful distribution are listed in the Table IV.

Table IV
Taxa reported by Karthikeyan *et al.* (1989) but considered of doubtful record.

Sl. No.	Species	Distribution
1.	*Carex bhutanica*	Bhutan
2.	*Carex dietrichiae*	India ?
3.	*Carex dispalata* ssp. *laxiflorens*	Nepal
4.	*Carex fastigiata*	"
5.	*Carex hemineuros*	"
6.	*Carex himalaica*	"
7.	*Carex pisanensis*	"
8.	*Carex rhombifructa*	"
9.	*Carex rufulistolon*	"
10.	*Cyperus setifolius*	"
11.	*Cyperus trisulcus*	"
12.	*Eleocharis confervoides*	India ?
13.	*Eleocharis congesta* ssp. *japonica*	"
14.	*F. dura*	"
15.	*F. thouarsii*	"
16.	*Kobresia fragilis*	Nepal
17.	*Kobresia nepalansis* var. *elachista*	"
18.	*Kobresia williamsii*	"
19.	*Kyllinga brevifolia* var. *leiolepis*	"
20.	*Rhynchospora chinensis*	India ?
21.	*Schoenoplectus fuscorubens*	Nepal
22.	*Scirpus quadrangulus*	"
23.	*Scleria mikawana*	India ?

In the above list most of the species, especially those of *Carex* are found in Nepal. It may be mentioned that, because of the geographical contiguity and climatic overlap with this Himalayan Kingdom, there is every possibility of presence of at least a few of them in the Indian territory also. Still such species have to be excluded from Indian Flora till their presence in the country is verified.

Further Govindarajalu (1994) studied the type of *Carex christii* and found that type locality is actually not Nilgiris but in South Alps and hence this species has to be excluded from Indian Flora. Similarly Verma and Chandra (1992), who revised Indian *Scleria*, treated *S. hookeriana* and *S. thomsoniana* as varieties of *S. terrestris* and elevated *S. bracteata* var. *assamica* to species level as *S. assamica.*

In the light of the above discussion it is difficult to conclude about the exact number of species and infraspecific taxa of the family occurring in India, even though the diversity of Cyperaceae in India can be considered as about 570 species 15 subspecies and 90 varieties under 39 genera. This excludes taxa listed in Table-IV and species like *Carex christii* mentioned above. To get the actual numbers a revision of the family at national level is essential.

ENDEMISM

Cyperaceae is one of the most widely distributed plant family and hence, attracted the attention of most phytogeographers. Distribution pattern of the family is being used as an index for phytogeographical interpretations (Clarke, 1898; Raymond, 1951; Shah, 1967). Clarke (*l.c.*) had based the Phytogeographical subareas of British India on the basis of the distribution of family Cyperaceae.

Most Cyperaceae members found in India show a wide range of distribution, especially in the tropical regions of Asia, Africa and eyen to Australia. Though most genera are tropical to subtropical in distribution, the largest genus *Carex* is mostly temperate. Of about 170 species of *Carex* found in India (*ca* 2000 in the whole world) majority is found in the Himalayan region. *Fimbristylis,* the second largest genus in India, is distributed mostly in Indo-Malaysia and Australia, while within India it shows maximum concentration in the Peninsular region. *Cyperus,* another dominant genus in the country is also predominant in the tropical region. A few genera extend to warm temperate countries, whereas *Eleocharis* extends up to the polar regions.

In India the Himalayan and Western Ghats in Peninsular region are the main centres of endemism for flowering plants. Most of the endemic Cyperaceae are also restricted to Himalaya followed by Peninsular India.

The family has only 2 endemic genera in India which are monotypic. These are *Ascopholis* endemic to Nilgiris and Southern Western ghats, and *Microschoenus* confined to western Himalaya. It is estimated that *ca* 5725 species of angiosperms are endemic to India and to this, family Cyperaceae contributes *ca* 150 species. Nayar (1996) reported 108 endemic taxa of Cyperaceae and listed these taxa separately according to their distribution in different phytogeographical regions. According to him 58 species and 7 varieties are endemic to peninsular India, 2 species in Andaman Islands and the remaining in the Himalayan region, including North East India. Ahmedullah and Nayar (1987) also reported 58 species and 7 varieties of Cyperaceae to be endemic to peninsular India.

Carex, the largest genus of the family has maximum endemics in India. Most of the *Carex* species in India are found in the Himalayan region and many are endemic to this region. Some species with restricted distribution extend to neighbouring countries, like Nepal, Bhutan, China, Afganistan and Pakistan. Similarly some species are endemic to Nilgiris and southern Western Ghats and a few restricted to South India extend to Sri Lanka also. *C. lindleyana* and *C. leucantha* are few such examples.

After *Carex*, the genus *Fimbristylis* shows maximum degree of endemism. Ahmedullah and Nayar (1987) reported 29 species of *Fimbristylis* endemic to peninsular India. Prasad and Singh (1997a) made a detailed study on the distribution and endemism of this genus and found that out of the 92 species reported till then from the country 37 are endemic. Subsequently Prasad and Singh (1997b) updated the number as 46 and at present 48 species of the genus are endemic to the country of which 39 are restricted to peninsular India (Prasad & Singh, 1999). It appears that endemism in *Fimbristylis* is more predominant in southern peninsular India followed by the North East India.

Verma and Chandra (1992) reported 2 species and 2 varieties of *Scleria* as endemic to North East India and one to central and South West India. They also reported that *Scleria benthamii, S. sumatrensis, S. alata, S. purpurascens* and *S. assamica*, which are known from very few, century old collections, may be extinct today. Other genera like *Fuirena, Lipocarpha, Mariscus*, etc. show relatively smaller degree of endemism.

USES

There is not much economic importance of the sedges when size of the family is taken into consideration. Though there are about 4000 species of Cyperaceae throughout the world, only a limited number of species are useful to man directly. But there are many species utilised by birds and animals in nature in the form of food, nesting and roosting place, etc. In India Cyperaceae is a less utilised plant group, even though a few species widely distributed in India are used in some other countries especially in Malesian region. Species, like *Eleocharis dulcis* and *Cyperus esculentus* are even cultivated in China and southern Europe respectively for their edible tubers.

Uses of sedges are reported by many workers, like Beetle (1943, 1950), Caius (1935), Chopra *et al.* (1956), Kirthikar and Basu (1918), Metcalf (1931), Mueller (1915), Pathak (1920) and Rubsy (1909). Dutta and Banerjee (1978) compiled the uses of weeds of rice fields in West Bengal, in which a few sedges are also included. Vartak (1982) recorded about 28 species of Cyperaceae for their utility in nature conservation and various domestic uses. Jain and De Pillips (1991) included sedges also in their compilation of Medicinal Plants of India. Recently Nayar *et al.* (1989, 1994) compiled the information on economic plants of India in which family Cyperaceae is also well represented. Uses of sedges can be divided as Medicinal, Food and Fodder, Mat making, Thatching, Nature conservation, etc. The uses of sedges given below are mostly as reported by the above mentioned workers or based on some personal observations.

Medicine

Most important use of sedges for mankind is probably medicinal, because tubers of many species have been found to be of medicinal value. *Cyperus rotundus* is the most widely used species for medicinal purpose. In Ayurveda its tubers are used for treating stomach disorders, leprosy and fever. In Kerala the tubers are ground, mixed with milk and given to children for worms and other stomach disorders. Other sedges having medicinal properties to cure stomach complaints are *Cyperus exallatus, C. iria, C. stoloniferus, Fimbristylis falcata, Kyllinga nemoralis* and

Schoenoplectus articulatus, *Cyperus articulatus*, *C. esculentus* and *C. stoloniferus* can be used as stimulants and the nuts of *Scleria levis* is used to cure cough.

Food and Fodder

Tubers of a few species are edible and in some parts of India these tubers are eaten either raw or cooked. *Eleocharis dulcis* is widely distributed in India and its tubers known as 'Chinese water chestnut' are eaten in many places. The bulb-like tubers of *Cyperus bulbosus,* found mostly in coastal areas, are also eaten. Tubers of *Cyperus esculentus* is also edible.

Species, like *Cyperus corymbosus*, *Schoenoplectus articulatus*, *S. littoralis*, etc., growing abundantly in marshy areas, are used as fodder. In coastal areas *Fimbristylis polytrichoides* forms a major part of fodder. Many other species of sedges growing in association with grasses in grasslands, wastelands, wetlands and other moist habitats also form part of herbage for the grazing cattle.

Mat making and Thatching

Rubsy (1909) stated that bulrushes (*Scirpus* spp.) represent 'one of the most important uncultivated textile material in the world' as many New World Species of the genus have been used by Red Indians for thatching, mat making, basket making, etc. Many species of tall sedges available in India can also be utilised for these purposes and to some extent such uses are reported from the country. *Cyperus corymbosus* known as 'Chinese matgrass' is used extensively for making mats especially in South India and Bengal (Maheshwari & Singh, 1965). Nayar *et al.* (1989) and Datta and Banerjee (1978) reported use of *Fimbristylis cymosa* and *Cyperus iria* respectively for making mats.

Conservation of Nature and Wildlife

Many species of sedges, because of their heavy root system and at times highly branched, elongating rhizomes and stolons act as good soil binder. *Cyperus corymbosus*, *C. malaccensis*, *C. arenarius*, *Remirea maritima*, *Schoenoplectus litoralis* etc. are good examples. These species, especially those growing in coastal areas or in saline marshy areas prevent soil erosion. Some species of sedges form food for wildlife especially for aquatic birds, some provide shelter and roosting place. In the world famous Keoladeo National Park at Bharatpur, Rajasthan it was observed that tubers of *Bolboschoenus maritimus* is the most preferred food of Siberian Crane (*Grus leucogeranus*), a highly endangered species wintering in this sanctuary (Prasad, 1988). Tubers of *Eleocharis dulcis* and *Cyperus rotundus* also form part of their food. The resident species Sarus Crane (*Grus antigone*) and wild boar were also found feeding on the tubers of the above species. Purple Moorhen (*Porphyrio porphyrio*), another water bird feed on the lower portion of the stems of *Eleocharis dulcis*. It is also found that purple moorhen usually nest in the central part of a tuft of partly submerged *Cyperus alopecuroides* a tall sedge (Prasad, *l.c.*). The long leaves of this species encircle the nest which protects the nest from raptors.

Miscellaneous

Dry tubers of *Cyperus rotundus* are used in perfumery and making incence sticks. Tubers of *Cyperus articulatus* are also used in perfumery (Maheshwari & Singh, 1965). Species, like *Cyperus malaccensis* and *Mariscus javanicus* have been tried in the production of paper pulp and the results seem to be encouraging. Some other sedges like *Eleocharis dulcis* which form large patches in open water bodies also may be tried for making paper pulp.

Cyperus flabelliformis is the only ornamental species found growing in gardens.

SEDGES AS WEEDS

There are many sedges found as weeds in agricultural fields, along roadsides, in lawns and in gardens. It is difficult to eradicate the perennial weeds belonging to Cyperaceae because of their well-established underground parts and very successful propogation through the rhizomes, stolons and tubers. *Cyperus rotundus* is probably the best example of the weed species among sedges. It is found everywhere and is among the most troublesome weeds, especially in the drier North-west or western India. It is cosmopolitan in distribution and one of the most serious weeds of the world (Sen, 1981). In a study conducted in the agricultural fields around Jodhpur this was found to be the most dominant species (Prasad, 1989). It spreads very fast, propagating by producing large number of nut-like tubers. There are many other sedge species found as weeds especially in agricultural fields. Majority of the sedge weeds are found in wet rice fields as most sedges prefer to grow in wetlands or moist soils. It may be mentioned that most rice varieties are grown in water saturated soils or even in shallow inundated areas. At times plenty of nuts (achenes) of some sedge species are found among the rice sold in markets. It happens if proper weeding is not done in highly infested rice fields and while harvesting, these sedges also get mixed with paddy. Common Cyperaceae members found in rice fields are *Courtoisina cyperoides, Pycreus macrostachyos, Cyperus difformis, C. haspan, C. iria, Schoenoplectus lateriflorus*, often forming large patches in fallow rice fields.

Other common weeds belonging to Cyperaceae found especially in cultivated fields are *Cyperus cuspidatus, C. leavigatus, C. nutans, C. procerus, C. tenuispica, Bulbostylis barbata, Eleocharis acutangula, E. atropurpurea, E. dulcis, Fimbristylis acuminata, F. aestivalis, F. bisumbellata, F. littoralis, Pycreus pumilus, Rikliella squarrosa, Schoenoplectus articulatus*, etc.

REFERENCES

Ahmedullah, M. and M.P. Nayar. 1987. *Endemic plants of the Indian Region* **1:** 213-215. BSI, Calcutta.

Ahuja, A. 1962. Studies in the epidermis of some members of Cyperaceae. *Curr. Sci.* **31:** 213-214.

Akiyama, S. 1931. Diagnoses specierum novarum Caricum Japonicarum. *Bot. Mag. Tokyo* **45:** 472-474.

Akiyama, S. 1931. Species Novae Caricum Japonicarum. I. *J. Fac. Sci. Hokkaido Imp. Univ.* **5**(1): 53-63.

Akiyama, S. 1935. Species Novae Caricum Japonicarum. II. *J. Fac. Sci. Hokkaido Imp. Univ.* **5**(3): 261-270.

Akiyama, S. 1933. Notes on some Japanese Carices. I. *J. Jap. Bot.* **9:** 539-539.

Akiyama, S. 1934. Notes on some Japanese Carices. II. *J. Jap. Bot.* **10:** 329-333.

Akiyama, S. 1935. Notes on some Japanese Carices. III. *J. Jap. Bot.* **11:** 286-290.

Akiyama, S. 1935. Notes on some Japanese Carices. IV. *J. Jap. Bot.* **11:** 494-499.

Akiyama, S. 1937. Notes on some Japanese Carices. V. *J. Jap. Bot.* **13:** 649-659.

Akiyama, S. 1940. Notes on some Japanese Carices. VI-VII. *J. Jap. Bot.* **16:** 98-101; 216-218.

Akiyama, S. 1943. On the classification of the Japanese Carices, especially of the subgenus *Eucarex* [Preliminary report]. *Act. Pytotax. Geobot.* **13:** 24-246.

Akiyama, S. 1949. On the classification of the Carices indigenous to the Far Eastern region of Asia. *Bot. Mag. Tokyo* **62:** 23.

Akiyama, S. 1951. Geographical distribution of Carices indigenous to the Far Eastern region of Asia. *J. Fac. Sci. Hokkaido Univ.* 5(7): 101-136.

Ambasht, R.S. 1964. Ecology of the underground parts of *Cyperus rotundus* L. *Trop. Ecol.* **5**: 67-74.

Beetle, A.A. 1940. Studies in the genus *Scirpus* L. I. *Amer. J. Bot.* **27**: 63-64.

Beetle, A.A. 1941. Studies in the genus *Scirpus* L. II-III. *Amer. J. Bot.* **28**: 469-476; 691-700.

Beetle, A.A. 1942. Studies in the genus *Scirpus* L. IV-V. *Amer. J. Bot.* **29**: 82-88; 653-656.

Beetle, A.A. 1943. Studies in the genus *Scirpus* L. VI. *Amer. J. Bot.* **30**: 395-401.

Beetle, A.A. 1943. A Key to the North American species of the genus *Scirpus* based on achene characters. *Amer. Midl. Nat.* **29**: 533-538.

Beetle, A.A. 1944. Studies in the genus *Scirpus* L. VII. *Amer. J. Bot.* **31**: 261-265.

Beetle, A.A. 1946. Studies in the genus *Scirpus* L. VIII. *Amer. J. Bot.* **33**: 660-666.

Beetle, A.A. 1949. Annotated list of original descriptions in *Scirpus*. *Amer. Midl. Nat.* **41**: 453-493.

Beetle, A.A. 1950. Bulrushes and their multiple uses. *Econ. Bot.* **4**: 132-138.

Bentham, G. 1881. Notes on Cyperaceae with special reference to Lestiboudois 'Eassai' on Beauvois Genera. *J. Linn. Soc.* (Bot.) **18**: 360-368.

Bentham, G. 1883. 'Cyperaceae' In: G. Bentham and J.D. Hooker, *Genera Plantarum* **3**: 1037-1073. London.

Bhargavan, P. 1989. 'Cyperaceae'. In: Henry, A.N., V. Chithra and N.P. Balakrishnan (eds.) *Flora of Tamil Nadu, India* Ser. 1, *Analysis*. **3:** 65-86. BSI, Coimbatore.

Bhellum, B.L. and R. Mangotra. 1994. Additions to the Flora of District Doda of Jammu and Kashmir State. *J. Nat. Bot. Soc.* **48:** 75.

Bir, S.S. and Charanpreet Singh. 1989. Additions to the Flora of Punjab State, North India. *J. Bombay Nat. Hist. Soc.* **86:** 37-41.

Blake, S.T. 1939. A monograph of the genus *Eleocharis* in Australia and New Zealand. *Proc. Roy. Soc. Queensl.* **50:** 88-132.

Blake, S.T. 1940. Monographic studies in the genus *Fimbristylis* (Cyperaceae). *Univ. Queensl. Papers, Dept. Biol.* 1 (13): 1-14.

Blatter, E. and C. McCann. 1934-35. Revision of the Flora of Bombay Presidency. *J. Bombay Nat. Hist. soc.* **37:** 15-35; 255-277; 532-548; 764-779; **38:** 6-18.

Boeckeler, O. 1868-1877. Die Cyperaceen des Koeniglichen Herbariums Zu Berlin. *Linnaea* **35:** 397-612; **36:** 271-512; 691-768; **37:** 1-128; 129-142; 520-544; 545-647; **38:** 223-544; **39:** 1-152; **40:** 327-452; **41:** 145-356.

Boott, F. 1867. *Illustrations of the genus carex* Pt. I. tt 1-600. London.

Brown, R. 1810. *Novae Cyperaceae. Prodrumus florae Novae Hollandiae et Insulae van-Diemen*. London.

Bruhl, J.J. 1995. Sedge genera of the world: relationships and a new classification of the Cyperaceae. *Austr. Syst. Bot.* **8:** 125-305.

Burman, N.L.B. 1768. *Flora Indica*. Amsterdam.

Caius, J.F. 1935. The medicinal and poisonous sedges of India. *J. Bombay Nat. Hist. Soc.* **38:** 163-170.

Chopra, R.N., S.L. Nayar and I.C. Chopra 1956. *Glossary of Indian Medicinal Plants*. C.S.I.R., New Delhi.

Clarke, C.B. 1884. On the Indian species of Cyperus: with remarks on some others that specially illustrate the subdivisions of the genus. *J. Linn. Soc. (Bot.)* **21:** 1-202.

Clarke, C.B. 1893-94. Cyperaceae. In: J.D. Hooker, *Flora of British India* **6:** 585-748. London.

Clarke, C.B. 1898. On the sub-subareas of British India, Illustrated by the detailed distribution of the Cyperaceae in that Empire. *J. Linn. Soc.* (Bot.) **34:** 1-146.

Clarke, C.B. 1901. Cyperaceae. In: J. Schmidt, Flora of Koh Chang. Contributions to the knowledge of vegetation in the Gulf of Siam. *Bot. Tidskr.* **24:** 23-38.

Clarke, C.B. 1901-1902. Cyperaceae. In: W.T. Thiselton Dyer, *Flora of Tropical Africa* **8:** 266-524.

Clarke, C.B. 1903. List of Carices of Malaya. *J. Linn. Soc.* **37:** 1-16.

Clarke, C.B. 1905. Cyperaceae. In: E.D. Merrill, New or noteworthy Philippine plants. *Bureau Sci. Public. Manila* **35:** 1-68.

Clarke, C.B. 1907. Cyperaceae in the Philippines: a list of the species in the Kew Herbarium. *Philip. J. Sci.* **2, C.** 77-110.

Clarke, C.B. 1909. *Illustrations of Cyperaceae.* London.

Cooke, T. 1908. Cyperaceae. In: *The Flora of the Presidency of Bombay* **3:** 364-421. London.

Datta, S.C. and A.K. Banarjee. 1978. Useful weeds in rice fields of West Bengal. *Econ. Bot.* **32**(3): 297-310.

Deb, D.B. 1983. Cyperaceae. In : *The Flora of Tripura State.* 2: 467-486. Today & Tomorrow's Printers and Publishers, New Delhi.

Fischer, C.E.C. 1931. Cyperaceae. In: J.S. Gamble, *Flora of the Presidency* of *Madras* **9:** 1620-1687.

Gordon-Gray, K.D. 1965. Studies in Cyperaceae in Southern Africa. I-II. *J. South Afr. Bot.* **31:** 137-143; 285-291.

Gordon-Gray, K.D. 1965. Studies in Cyperaceae in Southern Africa. III-IV. *J. South Afr. Bot.* **32:** 129-140; 141-152.

Govindarajalu, E. 1966. Studies in Cyperaceae. II. *Bull. Bot. Surv. India* **8:** 352.

Govindarajalu, E. 1970. Studies in Cyperaceae. III. *Proc. Indian Acad. Sci.* **71:** 221-223.

Govindarajalu, E. 1972a. Studies in Cyperaceae. IV. *J. Bombay Nat. Hist. Soc.* **69:** 246-249.

Govindarajalu, E. 1972b. Studies in Cyperaceae. V. *J. Bombay Nat. Hist. Soc.* **69:** 159-164.

Govindarajalu, E. 1972c. Studies in Cyperaceae. VIII. *Proc. Indian Acad. Sci.* **76:** 181-193.

Govindarajalu, E. 1973a. Studies in Cyperaceae. IX. *Proc. Indian Acad. Sci.* **78:** 45-58.

Govindarajalu, E. 1973b. Studies in Cyperaceae. X. *J. Indian Bot. Soc.* **52:** 72-81.

Govindarajalu, E. 1974a. Studies in Cyperaceae. XI. *Proc. Indian Acad. Sci.* **79:** 166-172.

Govindarajalu, E. 1974b. Studies in Cyperaceae. XII. *Proc. Indian Acad. Sci.* **80:** 41-50.

Govindarajalu, E. 1975. Studies in Cyperaceae. XIII. *Proc. Indian Acad. Sci.* **81:** 187-196.

Govindarajalu, E. 1979. Studies in Cyperaceae. XVI. *Proc. Indian Acad. Sci.* **88:** 229-242.

Govindarajalu, E. 1982. Studies in Cyperaceae. XVII. *Proc. Indian Acad. Sci.* **91:** 43-53.

Govindarajalu, E. 1982. Studies in Cyperaceae. XVIII. *Proc. Indian Acad. Sci.* **91:** 187-196.

Govindarajalu, E. 1985. Studies in Cyperaceae. XIX. *Proc. Indian Acad. Sci.* **94:** 11-31.

Govindarajalu, E. 1966. The systematic anatomy of South Indian Cyperaceae: *Bulbostylis* Kunth. *J. Linn. Soc.* (Bot.) **59:** 289-304.

Govindarajalu, E. 1969a. The systematic anatomy of South Indian Cyperaceae: *Fuirena* Rottb. *J. Linn. Soc.* (Bot.) **62:** 27-40.

Govindarajalu, E. 1969b. The systematic anatomy of South Indian Cyperaceae: *Cyperus* subgen. *Kyllinga* (Rottb.) *J. Linn. Soc.* (Bot.) **62:** 41-58.

Govindarajalu, E. 1974. The systematic anatomy of South Indian Cyperaceae: *Cyperus* subgen. *Juncellus*, *Cyperus* subgen. *Mariscus* and *Lipocarpha* R. Br. *J. Linn. Soc.* (Bot.) **68:** 235-266.

Govindarajalu, E. 1975. The systematic anatomy of South Indian Cyperaceae: *Eleocharis* R. Br., *Rhynchospora* Vahl & *Scleria* Berg. *Adansonia* **14:** 581-632.

Govindarajalu, E. 1978. The systematic anatomy of South Indian Cyperaceae: *Cyperus* subgen. *Pycreus* (P. Beauv.) C.B. Clarke *Adansonia* **18:** 95-128.

Govindarajalu, E. 1990. Cyperaceae Indiae Australis Precursores. *Proc. Ind. Acad. Sci.* **100:** 71-75; 77-84; 409-413; 415-422; 423-433.

Govindarajalu, E. 1994. Cyperaceae Indiae Australis Precursores - *Carex christii* Boeck. Species in India ignota et descreptione endata. *J. Econ. Tax. Bot.* **18**(2): 345-350.

Govindarajalu, E. 1996a. Cyperaceae Indiae Australis Precursores. *J. Econ. Tax. Bot.* **20:** 299-304.

Govindarajalu, E. 1996b. Monographia Indicorum *Fimbristylium* Precursores - Novelties in *Fimbristylis* Vahl. I. *Rheedia* **6:** 59-64.

Govindarajalu, E. 1997. Monographia Indicorum *Fimbristylium* Precursores Novelties in *Fimbristylis* Vahl. II. *Rheedia* **7:** 115-126.

Govindarajalu, E. 1998. Monographia Indicorum *Fimbristylium* Precursores Novelties in *Fimbristylis* Vahl. III. *Rheedia* **8:** 87-95.

Haines, H.H. 1924. Cyperaceae. In : *Botany of Bihar and Orissa* V. 888-937. Allahabad.

Haines, R.W. and K.A. Lye. 1978. Studies in African Cyperaceae - XVII. *Kyllingiella* R. Haines & K. Lye, gen. nov. *Bot. Notiser* **131:** 175-177.

Haines, R.W. and K.A. Lye. 1983. *The sedges and rushes of East Africa*. Nairobi.

Hooper, S. and D. Napper. 1972. Cyperaceae. In : J. Hutchinson and M.D. Dalziel, *Flora of West Tropical Africa* ed. 2, **3**(2): 278-349.

Jain, S.K. and A. De Phillips. 1991. *Medicinal plants of India*. 2 Vols. Michigan.

Jha, P.K. and D.N. Sen. 1985. *Biology and Ecology of Cyperus rotundus* Linn. Geobios International, Jodhpur.

Joshy, V.C., S. Rajkumar and M.K. Janarthanam. 1998. Additions to the sedges of Goa. *J. Econ. Tax. Bot.* **22:** 688-690.

Karthikeyan, S. 1999. Flowering plant diversity of India: Monocotyledons. In: Tandon, R.K. and Prithipal Singh (eds.) *Biodiversity, Taxonomy and Ecology*.

Karthikeyan, S., S.K. Jain, M.P. Nayar and M. Sanjappa 1989. Cyperaceae. In : *Florae Indicae Enumeratio: Monocotyledonae*. pp. 32-73. BSI, Calcutta.

Kern, J.H. 1952. Notes on Malaysian and some S.E. Asian Cyperaceae I. *Reinwardtia* **2:** 97-130.

Kern, J.H. 1954. Notes on Malaysian and some S.E. Asian Cyperaceae II. *Reinwardtia* **3:** 27-66.

Kern, J.H. 1955. Notes on Malaysian and some S.E. Asian Cyperaceae III. *Blumea* **8:** 110-169.

Kern, J.H. 1956. Notes on Malaysian and some S.E. Asian Cyperaceae IV. *Reinwardtia* **4:** 89-97.

Kern, J.H. 1958a. Notes on Malaysian and some S.E. Asian Cyperaceae V. *Blumea* **9:** 215-236.

Kern, J.H. 1958b. Notes on Malaysian and some S.E. Asian Cyperaceae VI. *Blumea* (Suppl.) **4:** 163-169.

Kern, J.H. 1958c. Notes on Malaysian and some S.E. Asian Cyperaceae VII. *Act. Bot. Neerl.* **7:** 786-800.

Kern, J.H. 1960. Notes on Malaysian and some S.E. Asian Cyperaceae VIII. *Blumea* **10:** 635-651.

Kern, J.H. 1961a. Cyperaceae of Siam (excl. *Carex*). *Reinwardtia* **6:** 25-83.

Kern, J.H. 1961b. Florae Malasianae Precursores XXX. The genus *Scleria* in Malaysia. *Blumea* **11:** 140-218.

Kern, J.H. 1962. Cyperaceae of Thailand II. *Reinwardtia* **6:** 145-154.

Kern, J.H. 1965. Notes on Malaysian and some S.E. Asian Cyperaceae IX. *Blumea* **13:** 117-125.

Kern, J.H. 1968. Notes on Malaysian and some S.E. Asian Cyperaceae X. *Blumea* **15:** 427-439.

Kern, J.H. 1974a. Cyperaceae (excl. genus *Carex*). In: C.G.G.J. van Steenis, *Flora Malesiana* 1, 7: Part **3:** 435-753.

Kern, J.H. 1974b. Cyperaceae (genus-*Carex*). In : C.G.G.J. van Steenis, *Flora Malesiana* 1, 9: Part **1:** 107-187.

Kirtikar, K.R. and B.D. Basu, *Indian Medicinal Plants*. 4: pp. 2632-2647. Allahabad. 1918 (Rev. ed. 1933).

Koyama. T. 1955a. Taxonmic studies of Cyperaceae in Eastern Asia-II. *J. Jap. Bot.* **30:** 309-318.

Koyama, T. 1955b. Taxonmic studies of Cyperaceae in Eastern Asia. III. *Act. Phytotax. Geobot.* **16:** 5-12.

Koyama, T. 1955c. Taxonmic studies of Cyperaceae in Eastern Asia. IV. *Acta. Phytotax. Geobot.* **16:** 33-41.

Koyama, T. 1956. Taxonmic studies of Cyperaceae in Eastern Asia. V. *Bot. Mag. Tokyo* **69:** 59-67.

Koyama, T. 1957a. Taxonmic studies of Cyperaceae in Eastern Asia. VI. *J. Jap. Bot.* **32:** 147-153.

Koyama, T. 1957b. Taxonmic studies of Cyperaceae in Eastern Asia. VII. *Bot. Mag. Tokyo* **70:** 347-357.

Koyama, T. 1958a. Taxonmic studies of Cyperaceae in Eastern Asia. VIII. *Acta. Phytotax. Geobot.* **17:** 97-102.

Koyama, T. 1958b. Taxonomic study of the genus *Scirpus* L. *J. Fac. Sci. Univ. Tokyo,* Sect. III. **8:** 271-366.

Koyama, T. 1959a. Taxonmic studies of Cyperaceae in Eastern Asia. IX. *Bull. Arts. & Sci. Div. Ryukyus Univ.* (Math. & Nat. Sci.) **3:** 65-76.

Koyama, T. 1959b. Taxonmic studies of Cyperaceae in Eastern Asia. X. *Bot. Mag. Tokyo* **72:** 298-308.

Koyama, T. 1959c. Taxonmic studies of Cyperaceae in Eastern Asia. XI. *Act. Phytotax. Geobot.* **18:** 20-26.

Koyama, T. 1961a. Taxonmic studies of Cyperaceae in Eastern Asia. XII. *Le Nat. Can.* **88:** 237-252.

Koyama, T. 1961b. Taxonmic studies of Cyperaceae in Eastern Asia. XIII. *Bot. Mag. Tokyo* **74:** 321-330.

Koyama, T. 1961a-62. Classification of family Cyperaceae-I & II. *J. Fac. Sci. Univ. Tokyo*, Sect. III. **8:** 37-148; 149-278.

Koyama, T. 1961b. Classification of family Cyperaceae-III. *Quart. J. Taiwan Mus.* **14:** 159-194.

Koyama, T. 1963. The genus *Scirpus* L. Critical species of the section *Pterolepis*. *Canad. J. Bot.* **41:** 1107-1131.

Koyama, T. 1971. Systematic interrelationships among Sclericae, Lagenocarpeae and Mapanieae (Cyperaceae). *Mitt. Bot. Staatssmml. Munchen* **10:** 604-617.

Koyama, T. 1972. Cyperaceae Rhynchosporeae Cladiae. *Mem. New York Bot. Gard.* **23:** 23-89.

Koyama, T. 1978. Cyperaceae. In : Hara *et al. An enumeration of the flowering plants of Nepal* **1:** 96-120.

Koyama, T. 1985. Cyperaceae. In: M.D. Dassanayake and F.R. Fosberg, *A Revised Handbook of Flora of Ceylon* **5:** 125-405.

Koyama, T. 1988. Variation of *Fimbristylis dichotoma* (L.) Vahl (Cyperaceae). Japan. *J. Jap. Bot.* **63:** 86-95.

Kreczetowicz, V.I. 1932. Contrebutiones ad cognitionem Carium, subgeneris Vignea (P.B.) Nees. *Bull. Jard. Bot. Acad. Sci. URSS.* **30:** 117-138.

Kreczetowicz, V.I. 1935. *Carex*. In : V.L. Komarov, *Fl. URSS*. **3:** 111-464.

Kreczetowicz, V.I. 1946. Cyperacearum novitates II. *Bot, Mat. Gerb. Bot. Inst. Komarov Acad. Nauk. SSSR*. **9** (4-12): 187-196.

Kukenthal, G. 1909. Cyperaceae Caricoideae. In: A. Engler, *Das Pflanzenreich* **IV**(20), Heft 38. Weinheim.

Kükenthal, G. 1935-36. Cyperaceae-Scirpoideae - Cypereae. In: A. Engler, *Das Pflanzenreich* **IV**(20), Heft 101. Leipzig.

Kukenthal, G. 1938a. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 1. *Schoenus* L. *Feddes Rep.* **44:** 13-32.

Kukenthal, G. 1938b. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 1. *Schoenus* II. *Feddes Rep.* **44:** 65-101.

Kukenthal, G. 1938c. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 1. *Schoenus*. III. *Feddes Rep.* **44:** 161-195.

Kukenthal, G. 1939a. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 2. *Costularia*. C.B. Clarke. IV. *Feddes Rep.* **46:** 13-32.

Kukenthal, G. 1939b. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 2. *Costularia* C.B. Clarke. V. *Feddes Rep.* **46:** 65-76.

Kukenthal, G. 1939c. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 3. *Carpha* Banks *et* Soland. VII. *Feddes Rep.* **47:** 101-119.

Kukenthal, G. 1939d. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 4. *Carpha* Banks *et* Soland. and *Ptilantheluim* Steudel. VIII. *Feddes Rep.* **47:** 209-216.

Kukenthal, G. 1940a. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 5. *Mesomelaena* Nees, 6. *Gmnosihoenus* Nees, 7. *Oreobolus* R. Br. VIII. *Feddes Rep.* **48:** 49-72.

Kukenthal, G. 1940b. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 8. *Tetraria* Beauv. IX. *Feddes Rep.* **48:** 195-250.

Kukenthal, G. 1941a. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 9. *Lepidosperma* Labill. X. *Feddes Rep.* **50:** 19-50.

Kukenthal, G. 1941b. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 9. *Lepidosperma* Labill. XI. *Feddes Rep.* **50:** 112-128.

Kukenthal, G. 1942. Vorarbeiten zu einer Monographie der Rhynchosporoideae. 10. *Cladium* Crantz. XII. *Feddes Rep.* **51**: 1-17; 139-193.

Kunth, C.S. 1837. *Enumeratio plantarum* (Cyperaceae) II. Stuttgart.

Lakshminarasimhan, P. Cyperaceae. In : Sharma, B.D., S. Karthikeyan and N.P. Singh (eds.) 1996. *Flora of Maharashtra State: Monocotyledones.* pp. 270-377. BSI, Pune.

Linnaeus, C. 1753. *Species plantarum,* ed. 1. Stockholm.

Linnaeus, C. 1754. *Genera plantarum*, ed. 5. Stockholm.

Linnaeus, C. 1767 & 1771. *Mantissa plantarum.* Stockholm.

Mackenzie, K.K. 1931-1935. Cyperaceae Tribe Cariceae. *North Amer. Fl.* **18:** 1-478.

Mackenzie, K.K. 1940. *North American Cariceae.* 2 Vols. New York.

Maheshwari, J.K. 1963. Cyperaceae. In : *The Flora of Delhi.* pp. 349-363. CSIR, New Delhi.

Maheshwari, P. and U. Singh. 1965. *Dictionary of Economic plants in India.* p. 54. ICAR, New Delhi.

Manilal, K.S. and K. Raveendra Kumar. 1999. Additions to the Flora of Kerala since Gamble (1935). *Rheedia* **8:** 179-241.

Mathew, S.P. and P.V. Sreekumar. 1992. *Mapania kurzii* Clarke (Cyperaceae) - A new record for India. *J. Bombay Nat. Hist. Soc.* **89:** 274-275.

Metcalf, F.P. 1931. Wild duck foods of North Dakota lakes. In : *U.S. Dept. Agri. Tech. Bull.* 221.

Micheli, P.T. 1729. *Nova Plantarum genera juxta Tournafortii deposita.* Florence.

Miquel, F.A.W. 1855-1859. *Flora van Nederlandsch Indie*-alternative title. *Flora Indiae Batavae*. Vols. 1-3. Amsterdam.

Mitra, J.N. 1958. Cyperaceae. In : *Flowering plants of Eastern India*. Vol. I. *Monocotyledons* pp. 94-124. The World Press Pvt. Ltd., Calcutta.

Mueller, T. 1915. The Industrial fibre plants of the Philippines. *J. New York Bot. Gard.* **16:** 75.

Naithani, H.B. and M.B. Raizada. 1977. New records of some Cyperaceae taxa in India. *Indian For.* **103:** 411-424.

Nayar, M.P. 1996. *Hot Spots of Endemic Plants of India, Nepal and Bhutan*. T.B.G.R.I., Trivandrum.

Nayar, M.P., K. Ramamurthy and V.S. Agarwal. 1989-1994. *Economic plants of India*. 2 Vols. BSI, Calcutta.

Nees, von Esenbeck. 1834. Cyperaceae Indicae praecipue juxta herbaria wightii, Wallichii, Royli et Lindleyi. In : R. Wight, *Contributions to the Botany of India*. London.

Nelmes, E. 1937. Notes on *Carex*. II. *Kew Bull.* **1937:** 472.

Nelmes, E. 1938. Notes on *Carex*. IV. *Kew Bull.* **1938:** 242-248.

Nelmes, E. 1939a. Notes on *Carex*. VI. *Kew Bull.* **1939:** 157-159.

Nelmes, E. 1939b. Notes on *Carex*. VII. *Kew Bull.* **1939:** 199-202.

Nelmes, E. 1939c. Notes on *Carex*. IX. *Kew Bull.* **1939:** 306-308.

Nelmes, E. 1939d. Notes on *Carex*. XI. *Kew Bull.* **1939:** 657-659.

Nelmes, E. 1948. Notes on *Carex*. XVI. *Kew Bull.* **1948:** 107-109.

Nelmes, E. 1951. The genus *Carex* in Malaysia. *Reinwardtia* **1:** 221-450.

Nelmes, E. 1954. Supplement to the genus *Carex* in Malaysia. *Reinwardtia* **2:** 373-383.

Nelmes, E. 1955. The genus *Carex* in Indo-China including Thailand and lower Burma. *Mem. Mus. Hist. Nat. Paris n.s.* Bot. **4:** 83-182.

Nooteboom, H.P. 1978. A taxonomic revision of the Malesian and Australian species of *Uncinia* (Cyperaceae). *Blumea* **24:** 511-520.

Ohwi, J. 1936. Cyperaceae Japonicae. I. A synopsis of the Caricoideae of Japan, including Sahalien Kuriles, Korea and Formosa. *Mem. Coll. Sci. Kyoto. Imp. Univ.* B. **11:** 229-530.

Ohwi, J. 1938. Notes on Japanese *Fimbristylis. J. Jap. Bot.* **14:** 564-579.

Ohwi, J. 1944. Cyperaceae Japonicae, pt. 2. *Mem. Coll. Sci. Kyoto Imp. Univ.* B, **18:** 1-182.

Parker, R.N. and W.B. Turill. 1929. Cyperaceae. In : J.F. Duthie, *Flora of the Upper Gangetic Plain and of the adjacent Siwalik and sub-Himalayan tracts* **3:** 320-371.

Parmar, P.J. 1993. Cyperaceae. In : Shetty, B.V. and V. Singh (eds.) *Flora of Rajasthan* 3. pp. 886-952. BSI, Calcutta.

Pathak, G.P. 1920. Some famine foods in Ahmedabad. *Agri. J. India* **15:** 40-45.

Pax, F. 1888. Cyperaceae. In : A. Engler and H. Prantl, *Die Naturlichen Pflanzenfamilien* 11. **2:** 98-126.

Prain, D. 1903. Cyperaceae. In : *Bengal Plants* **2:** 849-874. Calcutta.

Prasad, V.P. 1988. Wetland angiosperms of Keoladeo National Park, Bharatpur- Rajasthan. *J. Econ. Tax. Bot.* **12:** 457-466.

Prasad, V.P. 1989. *Ecological studies on Weed Flora in cultivated fields around Jodhpur.* M.Sc. Dissertation, Univ. Jodhpur.

Prasad, V.P. 1999. *A revision of Family Cyperaceae of Karnataka.* Ph.D. Thesis, Univ. of Pune.

Prasad, V.P. and N.P. Singh. 1997a. Notes on the distribution and endemism of Indian *Fimbristylis*. *J. Bombay Nat. Hist. Soc.* **94**(1): 22-26.

Prasad, V.P. and N.P. Singh. 1997b. Two new species of *Fimbristylis* (Cyperaceae) from Maharashtra, India. *J. Econ. Tax. Bot.* **21**(3): 671-675.

Prasad, V.P. and N.P. Singh. 1999. Two new species of *Fimbristylis* (Cyperaceae) from Western Peninsular India. *J. Bombay Nat. Hist. Soc.* **96**(3): 454-458.

Pullaiah, T. and K. Hanumanthappa. 1997. Cyperaceae. In : T. Pullaiah, *Flora of Andhra Pradesh* **3**: 1044-1117. Scientific Publishers, Jodhpur.

Rao, A.S. and D.M. Verma. 1981. Cyperaceae (Morphology and salient taxonomic characters). *Rec. Bot. Surv. India* **21**(2): 207-220.

Rao, A.S. and D.M. Verma. 1982a. Notes on Cyperaceae of Assam. *Bull. Bot. Surv. India* **22**: 80-90.

Rao, A.S. and D.M. Verma. 1982. *Cyperacae of North East India*. BSI, Howrah.

Rao, M.K.V. 1986. A preliminary report on the angiosperms of Andaman & Nicobar Islands. *J. Econ. Tax. Bot.* **8**: 107-184.

Rao, R.S. 1986. Cyperaceae. In : *Flora of Goa, Diu, Daman, Dadra and Nagarhaveli* **2**: 459-476. BSI, Howrah.

Rath, S.P., B.P. Chowdhary and S.N. Patnaik. 1979. Cyperaceae of Orissa. *Bull. Bot. Surv. India* **21**: 156-162.

Raymond, M. 1951. Sedges as Material for Phytogeographical studies in *Mem. Jard. Bot. Montreal* **20**: 1-23.

Raymond, M. 1955. Cyperacees d' Indo-Chine I. *Le Natur. Canad.* **82**: 145-165.

Raymond, M. 1957. Some new or critical *Scirpus* from Indo-China. *Le Natur. Canad.* **84**: 111-150.

Raymond, M. 1959. Carices Indochinenses Necnon Siamenses. *Mem. Jard. Bot. Montreal* **53:** 1-125.

Raymond, M. 1966. Cyperaceae. Studies in the Flora of Thailand-39. *Dansk. Bot. Ark.* **23:** 313-374.

Retzius, A.J. 1786-91. *Fasciculus observationum Botanicum*. Fasc. 4-6.

Rottboell. C.F. 1773. *Descriptionum et Iconum rariores*. Koebenhavn.

Roxburgh, W. 1820-24, 1832. *Flora Indica*, eds. 1 & 2. Serampore.

Rubsy, H.H. 1909. Report of the Botanical Work on the Pacific Coast. *J. New York Bot. Gard.* **10:** 229.

Sabnis, S.D. 1962a. Cyperaceae of Gujarat. *Bull. Bot. Surv. India* **4:** 193-197.

Sabnis, S.D. 1962b. A key to the identification of the Cyperaceae of Gujarat. *Bull. Bot. Surv. India* **4:** 199-201.

Sabnis, S.D. and A.R. Chavan. 1967. Cyperaceae of Dangs forests, Gujarat State. *Indian For.* **193:** 190-192.

Sabnis, S.D. and J.V. Joshi. 1979. Notes on two interesting sedges from Gujarat State, India. *J. Bombay Nat. Hist. Soc.* **76:** 210-211.

Sabnis, S.D. and S.J. Bedi. 1971. The genus *Fuirena* (Cyperaceae) in Gujarat. *J. Bombay Nat. Hist. Soc.* **68:** 857-858.

Sahani, K.C., K.M. Vaid and H.B. Naithani. 1972. Additions to the Cyperaceae of Madhya Pradesh. *Indian For.* **98:** 192-194.

Saxena, H.O. 1973. Contribution to the Flora of M.P. II (interesting records of Cyperaceae). *Indian For.* **99:** 505-507.

Sedgwick, L.J. 1918. The Cyperaceae of Bombay Presidency-I. *J. Bombay. Nat. Hist. Soc.* **25:** 682-700.

Sedgwick, L.J. 1919. The Cyperaceae of Bombay Presidency-II. *J. Bombay. Nat. Hist. Soc.* **26:** 192-209.

Sen, D.N. 1981. *Ecological Approaches to Indan Weeds*. Geobios International, Jodhpur.

Shah, C.K. 1963. The sedges of Sabarmati. *J. Gujarat Univ.* **6:** 179-186.

Shah, C.K. 1964. Embryo development in *Eleocharis palustaris* L. *Nat. Canad.* **111:** 40-49.

Shah, C.K. 1965. Embryogeny in some *Cyperaceae. Phytomorphology* **15:** 1-9.

Shah, C.K. 1967. Sedges as material for ecological and phytogeographical studies an appraisal. *J. Ind. Bot. Soc.* **46:** 428-456.

Shah, G.L. and B. Suryanarayana. 1967. A note on the distribtion of sexes in *Rhynchospora wightiana* (Nees) Steud. *Curr. Sci.* **36:** 157-158.

Shah, G.L. and M.B. Deshpande. 1968. A new species of *Fuirena* from Gujarat. *Fuirena tuwensis* Deshpande & Shah. *Bull. Bot. Surv. India* **10:** 239-240.

Shah, G.L. and R.G. Bhatt. 1974. Some interesting rare Cyperaceae of Gujarat as new record for erstwhile Bombay Presidency. *Indian For.* **100**(2): 121-122.

Sharma, A. and A.K. Bal. 1956. A Cytological investigation of some members of the family Cyperaceae. *Phyton* **6:** 7-22.

Sharma, B.D., N.P. Singh, R.S. Raghavan and U.R. Deshpande. 1984. Cyperaceae in: *Flora of Karnataka Analysis*. BSI, Calcutta.

Sharma, M. 1981. Sedges of Punjab - ecology, distribution and enumeration. *J. Bombay Nat. Hist. Soc.* **77:** 424-428.

Sharma, M. 1994. Additions to 'Punjab Plants, check-list'. *Indian J. For.* **17:** 353-355.

Srivastava, R.C. 1996. Cyperaceae. In : Hajra, P.K. and D.M. Verma (eds.) *Flora of Sikkim* 1 (*Monocotyledons*). pp. 198-237. BSI, Calcutta.

Steudel, E.G. 1854-55. *Synopsis plantarum glumacerum* 2. *Synopsis plantarum cyperacearum*. Fasc. **7:** 1-80. *et* Fasc. **8-10:** 81-348.

Stewart, R.R. 1967. The Cyperaceae of Kashmir A Check list. *Bull. Bot. Surv. India* **9:** 152-162.

Svenson, H.K. 1929. Monographic studies in the genus *Eleocharis* I. *Rhodora* **31:** 121-135; 152-163; 167-191; 199-219; 224-242.

Svenson, H.K. 1932. Monographic studies in the genus *Eleocharis* II. *Rhodora* **34:** 193-203; 215-227.

Svenson, H.K. 1934. Monographic studies in the genus *Eleocharis* III. *Rhodora* 377-389.

Svenson, H.K. 1937. Monographic studies in the genus *Eleocharis* IV. *Rhodora* **39:** 210-231; 236-273.

Svenson, H.K. 1939. Monographic studies in the genus *Eleocharis* V. *Rhodora* **41:** 1-19; 43-77; 90-110.

Tiwari, S.D.N. and J.K. Maheshwari. 1964. The Cyperaceae of Madhya Pradesh. *Indian For.* **90:** 147-159; 616-629.

Tournefort, J.P. de. 1719. *Institutiones rei herbariae,* ed. 3. Paris.

Vahl, M. 1805-06. *Enumeratio Plantarum* Vol. 2. Copenhagen.

Vartak, V.D. 1982. Observations on multifarious uses of sedges from Western India. *J. Econ. Tax. Bot.* **3:** 193-196.

Verma, D.M. and V. Chandra. 1979. Distributional notes on Cyperaceae in *Bull. Bot. Surv. India* **20:** 140-142.

Verma, D.M. and V. Chandra. 1981. Cyperaceae of Madhya Pradesh. *Rec. Bot. Surv. India* **21(2):** 221-275.

Verma, D.M. and V. Chandra. 1982. The genus *Rhynchospora* Vahl in India. *Bull. Bot. Surv. India* **22:** 126-135.

Verma, D.M. and V. Chandra. 1992. The genus *Scleria* Berg. in India. *Bull. Bot. Surv. India* **32**(1-4): 57-79.

Wadhwa, B.M. and H.J. Chowdhery. 1984. Cyperaceae. In : *Flora of Himachal Pradesh*. 3. pp. 737-755. BSI, Howrah.

Willdenow, C.L. 1797-1830. *Species Plantarum*, ed. 4. Vols. 1-6.

Cyperus malaccensis - forming large patches in brackish water

Cyperus rotundus - a weed and a medicinal herb

Cyperus alopecuroides

Fimbristylis tetragona

Schoenoplectus lateriflorus

Schoenoplectus mucronatus

Courtoisina cyperoides

Lipocarpha chinensis

ROSACEAE

S.K. Murti

Rosaceae or the "Rose" family is a large and economically important family of woody and herbaceous plants. Many fruit trees, shrubs and herbs of temperate regions, including apples, cherries, plums, peaches, raspberries, strawberries, and many popular horticultural oranmental species belong to this family. The family belongs to natural order Rosales.

Rosales are a large group with families of mostly woody plants and characterised by stipulate leaves, perigynous to epigynous flowers, with ovary mostly apocarpous to syncarpous, with central placentation, and seeds without endosperms. The family Rosaceae includes deciduous or evergreen trees, shrubs, undershrubs and herbs. There are a few climbers but no aquatics. The family is characterised by leaves simple or compound, alternate or rarely opposite, sometimes with glandular teeth; stipules usually paired, sometimes adnate to the petiole; flowers frequently large and showy and characteristically insect pollinated, mostly actinomorphic and bisexual, showing a series from hypogyny through perigyny to epigyny; calyx free or adnate to the ovary, lobes mostly 5, disk lining the tube of the calyx; petals mostly 5, free, rarely absent, stamens numerous, and whorled, rarely definite; filaments free, rarely connate, often more or less adnate to the calyx tube; fruits diverse, fleshy or dry. *Rosa* is unique in retaining free carpels although the flower is epigynous. A common feature of rosaceous flowers is the presence of an epicalyx. The colour range is wide but blue is almost completely absent. Apomixis, either facultative or obligate, is a feature of the reproduction of several genera of the family.

As per the fossil record the Rosaceae seems to be amongst the most ancient families of dicotyledons, and its general structure and anthecology suggest it to be among more primitive families. Hutchinson (1973) regards it as an offshoot of the woody magnolian line of decent.

The family is cosmopolitan, but is most abundant in the North temperate regions of the world, where *Rosa*, *Rubus*, *Geum* and *Potentilla* are often most conspicuous. *Spiraea*, *Aruncus*, *Prunus*, *Sorbus*, *Crataegus*, *Sanguisorba*, *Alchemilla*, *Cotoneaster*, etc., are spread right across this zone. *Chrysobalanus*, *Hirtella* and *Parinari* are common to tropical Africa and tropical America. *Cliffortia* is almost entirely South African. The genus *Acaena* is mostly in the southern hemisphere.

Historical background and delimitation of taxa

There are two kinds of families "definable" and "indefinable" (Walters, 1961). Definable families, such as Brassicaceae, Apiaceae, Acanthaceae, Poaceae, etc. are clearly delimited. On the other hand the "indefinable" families are those in which there is a great diversity of structures, both floral as well as vegetative. These families are very heterogeneous because these show diverse assemblage of characters. The Rosaceae is one such family which is taxonomically unparalleled in its heterogenecity (Hutchinson, 1973).

Jussieu (1789) established the family (Order) Rosaceae with *Rosa*, as its type, and included the genera *Rosa*, *Potentilla*, *Comarum*, *Fragaria* and *Sibbaldia* in it. Nestler (1816), however, attributed these 5 genera to the family Fragariaceae, which he proposed as an alternate name to the Rosaceae. However, Fragariaceae must be rejected as *nomen superfluous illegitimatum* for Rosaceae in the light of Art. 7.5 and Art. 52.1 of I.C.B.N. 2000.

Gray (1821) recognised as many as six families within the limits of the Rosaceae *sensu lato* and treated the family Rosaceae *sensu str.* as monogeneric with *Rosa* as its type. He also established Dryadaceae in which he included *Potentilla*, *Sibbaldia* and *Fragaria*. Hutchinson (1973) reduced as many as 27 family-names as synonym of Rosaceae *sensu lato* and recognised, instead, 20 tribes within the family Rosaceae. The Rosaceae *sensu* Hutchinson (1959, 1973) is one of broader concept and includes Amygdalaceae, Malaceae, Chrysobalanaceae and Neuradaceae. Cronquist (1968, 1981) and Takhtajan (1969, 1980) recognise three families with the same limits as Rosaceae (inclusive of Amygdalaceae and Malaceae), Chrysobalanaceae and Neuradaceae. Thorne (1983) includes Neuradaceae in the Rosaceae as a subfamily and keeps Chrysobalanaceae as distinct one. On the other hand Dahlgren (1983) splits Rosaceae *sensu* Takhtajan into Rosaceae, Malaceae and Amygdalaceae and keeps Chrysobalanaceae in a separate Order Chrysobalanales under Myrtiflorae. Robertson (1974) treats Neuradaceae and Chrysobalanaceae as distinct from the Rosaceae *sensu* Takhtajan and follows Focke (1888) in recognising four subfamilies-Amygdaloideae, Maloideae, Spiraeoideae and Rosoideae under Rosaceae *sensu str.* Panigrahi and his associates (Purohit & Panigrahi, 1991; Ghora & Panigrahi, 1995; Kumar & Panigrahi, 1995 and Dikshit & Panigrahi, 1998), while revising the family Rosaceae for Flora of India, outlined the main principles for recognition of taxonomic categories in relation to the order Rosales. They have supported Takhtajan (1969, 1980), Cronquist (1968, 1981) and Robertson (1974) and accepted the segregation of Rosaceae *sensu lato* into Rosaceae *sensu str.*, Chrysobalanaceae and Neuradaceae, and have also accepted four subfamilies, viz., Spiraeoideae, Rosoideae, Maloideae (Pomoideae) and Amygdaloideae (Prunoideae) under Rosaceae *sensu str.* Out of 34 genera indigenous to and/or introduced and cultivated in India, they have so far revised 24 genera.

The four subfamilies of Rosaceae *sensu str.* are divided into several tribes. The subfamily Spiraeoideae is divided into three tribes, viz. Neillieae, Gillenieae and Spiraeae. The subfamily Amygdaloideae has a single tribe Amygdaleae. The subfamily Rosoideae is divided into 7 tribes, viz. Dryadeae, Kerrieae, Potentilleae, Roseae, Rubeae, Sanguisorbeae and Ulmarieae. The subfamily Maloideae is divided into 3 tribes, viz. Crataegeae, Sorbeae and Maleae.

Tournefort (1700) was the first to recognise six genera, viz., *Prunus*., *Armeniaca, Persica, Cerasus, Amygdalus,* and *Laurocerasus*. Linnaeus (1753, 1754) recognised only two genera, viz. *Amygdalus* (including *Persica*) and *Prunus* (including the remaining three genera and also *Padus sensu* Linnaeus (1737) and described briefly 13 species with 14 varieties. Of these *Prunus domestica* was selected as the lectotype species of *Prunus* by Britton and Brown (1913).

Linnaeus (1753, 1754) established as many as 22 genera, viz. *Agrimonia, Alchemilla, Aphanes, Cliffortia, Crataegus, Dryas,* Fragaria, *Geum, Mespilus, Potentilla, Prunus, Pyrus, Rosa, Rubus, Sanguisorba, Sibbaldia, Sorbus, Spiraea, Chrysobalanus, Hirtella, Grielum* and *Neurada*.

Linnaeus (1753, 1754) described 12 species and 3 varieties under the genus *Rosa*, mainly from Europe, one species from China and one from America. The genus *Rosa* comprises 30 numbered species, 7 unnumbered species, 1 subspecies, 8 additional varieties in India

(Ghora & Panigrahi, 1995). Of these, 23 species, 1 subspecies and 7 varieties grow wild or naturalised; the others are maintained solely in cultivation. This represents almost 30 per cent of the genus *Rosa* in the world flora (Ghora & Panigrahi, 1995).

In 1753 Linnaeus described two species of *Sibbaldia* viz., *S. procumbens* and *S. erecta*. Subsequently, in 1754, he described the genus *Sibbaldia* as distinct from *Potentilla*. Hooker (1878), on the other hand, reduced *Sibbaldia* as a section of the genus *Potentilla*. Bunge (in Ledebour, 1830) segregated *Sibbaldia erecta*, and established a distinct genus *Chamaerhodos*, which is accredited with 11 species.

Linnaeus (1753, 1754) established the genus *Spiraea*, comprising 11 species from Europe and North America. Of these, 6 species were transferred to genera *Filipendula*, *Aruncus*, *Sorbaria*, *Physocarpus*, and *Gielenia* by Maximowicz (1879). *Spiraea*, with about 82 species is largely restricted to the North temperate regions of the world and widespread in North America, south central Mexico, the eastern Europe (absent in western and middle Europe) and Asia. There are 31 species with 1 subspecies and 3 varieties in India, most of which are endemic in the Himalaya.

Jussieu (1789) recognised 7 tribes including the tribe Amygdaleae under the family Rosaceae and assigned to the latter, *Prunus pro part. Armeniaca* (including *Persica*) and *Cerasus* as good genera. He included *Laurocerasus*, *Padus*, *Prunus pro part.* as congeneric synonyms of *Cerasus*. *Pyrus* was first described by Linnaeus (1753, 1754) with 4 species including 11 varieties; of these *P. malus* was assigned 4 varieties. Miller (1754) segregated *P. malus* as a distinct genus and named it *Malus*. Ghora and Panigrahi, (1995) recognised *Prunus* to be an all inclusive genus. They reinstated *Pyrus* and *Malus* as distinct genera, which were earlier reduced as subgenera/sections by Robertson (1974) and Hooker (1878).

The genus *Chaenomeles* is assigned to the subfamily Maloideae. This natural division, under the name Pomaceae was suggested as a "fragmentum" by Linnaeus in 1763, who listed under it several genera such as *Pyrus* and *Crataegus* and also included *Punica* and *Ribes*, which are now placed in Punicaceae and Saxifragaceae respectively. The genus *Chaenomeles* is closely related to the genus

Cydonia. It is also related to *Pyrus* and *Malus*. According to Sax (1932) the Maloideae originated by hybridization of members of two different subfamilies, most likely belonging to Spiraeoideae and Rosoideae. The Maloideae would thus be allotetraploid.

Royle (1839) and Lindley (1830), assigned *Prinsepia* to Chrysobalanoideae, but Bentham and Hooker (1862) and subsequent authors referred the genus to the Prunoideae, although Robertson (1974) says that taxonomic position of *Prinsepia* is debatable. *Maddenia* was monotypic (*M. himalaica*) when first described. Subsequently Hooker (1878) added another species *M. pedicillata*. Hutchinson (1964), Robertson (1974) and Mabberley (1987) agree with Hooker (*l.c.*) that it is a good genus.

Alchemilla is primarily a non-sexual, apomictic genus. The variations in the number of taxa recognised depending on whether or not, innumerable pure lines propagated exactly by their peculiar uniparental mode of reproduction are to be recognised as distinct species (Stace, 1978). There is a preponderance of interspecific hybridization, resulting in agamospermy and vegetative apomixis in *Alchemilla* (Walters, 1966; Stace, 1978). *Sorbus* and *Rubus* are also more or less completely apomictic. *Agrimonia* is a genus comprising several sexual semi-cryptic species (Stace, 1978), within which the differences between infrageneric units are often more quantitative than qualitative.

Dikshit and Panigrahi (1981) in course of their revisionary study on the family Rosaceae, established and described *Brachycaulos* based on a collection of W.W. Smith, identified as *Potentilla microphylla* var. *commutata*. This is a monotypic genus. The single species *B. simplicifolius* has been described from Sikkim. *Brachycaulos* shares with *Chamaerhodos*, the 'absence of bracteoles' but differs from it in having simple leaves. Burmmitt (1992) reduced *Brachycaulos* as a congeneric synonym of *Chamaerhodos*. Mabberley (1993) treats *Brachycaulos* as a good genus (Table II).

DIVERSITY

In the present state of our knowledge the family Rosaceae is represented in India by about 450 species in 34 genera, spreading over to 14 tribes and four subfamilies (Table I and II).

Table I
Number of genera and species in Rosaceae

	Number of Genera		Number of Species	
	India	World	India	World
Hutchinson (1959, 1964)	–	124*	--	3375*
Airy Shaw (1973)	–	100	...	2000
Brummitt (1992)	–	97	..	..
Mabberley (1993)	–	107	..	3100
Heywood (1993)	–	122**	..	3370**
Kumar & Panigrahi (1995)	34	100	450	3000

*Rosaceae *sensu* Hutchinson includes Chrysobalanaceae and Neuradaceae
** Rosaceae *sensu* Heywood includes Neuradaceae

Table II
A conspectus of family Rosaceae in India

Sl. No.	Name of the Taxa	Number of species: World*	Number of species: India**	General distribution
	Sub family : SPIRAEOIDEAE Tribe : **Gillenieae**			
1.	***Sorbaria***	4	2	Eastern Asia
	Tribe : **Neillieae**			
2.	***Neillia***	11	2 and 1 var.	Eastern Himalaya to China, western Malesia, Sumatra, Java
	Tribe : **Spiraeae**			
3.	***Aruncus***	1	1 and 1 ssp.	North temperate and sub arctic
4.	***Spiraea***	80-100	31. 3 vars. 1 ssp. and 3 under cult.	North temperate, south to Mexico and Himalaya
	Sub-family : AMYGDALOIDEAE Tribe : **Amygdaleae**			
5.	***Maddenia***	4	2	Himalaya, China
6.	***Prinsepia***	4	1	Himalaya to North China and Taiwan

Sl. No.	Name of the Taxa	Number of species World*	India**	General distribution
7.	*Prunus*	200+	38, 6 var. and 1 ssp	North temperate, tropical mountains
	Sub-family : ROSOIDEAE Tribe : **Dryadeae**			
8.	*Geum*	40	6 and 1 var.	North and South Temperate Arctic
	Tribe : **Roseae**			
9.	*Rosa*	100-150	37 and 9 vars.	North temperate and tropical mountains
	Tribe : **Sanguisorbeae**			
10.	*Agrimonia*	15	2 and 3 vars.	North temperate to central and South Africa
11.	*Alchemilla*	250	26	North temperate and tropical mountains
12.	*Sanguisorba*	10	4 and 1 var.	North temperate
	Tribe : **Ulmarieae**			
13.	*Filipendula*	**10**	**2**	North temperate

Sl. No.	Name of the Taxa	Number of species		General distribution
		World*	India**	
	Tribe : Potentilleae			
14.	***Potentilla***	500	63, 17 vars. 1 spp.	Nearly cosmopolitan, chiefly North temperate and arctic
15.	***Sibbaldia***	18	12 and 2 vars.	Temperate Eurasia to Himalaya
16.	***Brachycaulos***	1	1	Sikkim
17.	***Fragaria***	12	4	North temperate, Chile, Eurasia to South India
18.	***Chamaerhodos***	11	2	Siberia and central Asia to North China and temperate North America
	Tribe : Rubeae			
19.	***Rubus***	250	50	Cosmopolitan, especially North temperate
	Tribe : Kerrieae			
20.	*Kerria*	1	1	Temperate eastern Asia, cultivated ornamental in India

Sl. No.	Name of the Taxa	Number of species		General distribution
		World*	India**	
	Sub-family : MALOIDEAE			
	Tribe . Crataegeae			
21.	*Cotoneaster*	261	59	North temperate
22.	*Pyracantha*	9	1	South-East Europe to central China and Indo-China
23.	*Crataegus*	186(+78)	2	North temperate
	Tribe : **Maleae**			
24.	*Malus*	55	4 and 1 var.	North temperate
25.	*Pyrus*	25	4 and 3 vars.	Eurasia, Mediterrinean
26.	*Rhaphiolepis*	9	1	Sub tropical East and South East Asia, cultivated in Calcutta garden
	Tribe : **Sorbeae**			
27.	*Chaenomeles*	4	1	Eastern Asia
28.	*Cydonia*	2	1	Western Asia, China
29.	*Docynia*	2	2	Himalaya, Myanmar, South East Asia

Sl. No.	Name of the Taxa	Number of species World*	India**	General distribution
30.	***Eriobotrya***	26	9	Himalaya to Japan, South East Asia, western Malesia
31.	***Micromeles***	15	1	South and eastern Asia, western Malesia, cultivated in India
32.	***Photinia***	65	7	Himalaya to Japan and Sumatra, East, central and North America
33.	***Sorbus***	193	7	Northern hemisphere
34.	***Spenceria***	2	2	Western China

*Mabberley (1998)
**Santapau and Henry (1973), Purohit and Panigrahi (1991), Ghora and Panigrahi (1995), Kumar and Panigrahi (1995) and Dikshit and Panigrahi (1998).

ENDEMISM

In India the Rosaceae are largely restricted to the subtropical-temperate to alpine zone of the Himalaya in the North and to the Nilgiri and Palni hills in the South. According to Purohit and Panigrahi (1983) 8 taxa belonging to *Spiraea* are endemic to the Himalaya. According to Ghora and Panigrahi (1995) 3 taxa of *Prunus* are endemic to Himalaya. Out of 46 taxa of *Rosa*, 11 taxa are endemic to India. *Cotoneaster* is represented in India by 59 taxa, out of which 12 are endemic to this region. *Potentilla* and *Sibbaldia* are represented in India by 81 and 14 taxa respectively, out of which 15 of the former and 5 of the latter are endemic to India. *Brachycaulos* is an endemic genus, confined to Sikkim. Table III shows endemic species of Rosaceae in India.

Table III
Species endemic to India

Species	Region	Locality
Spiraea amoena	Uttaranchal	Kumaon
Spiraea arunachalensis	Arunachal Pradesh	Kameng
Spiraea canescens ssp. *pyramidata*	J & K	Pahalgam to Chandanwari
Spiraea darjeelingensis	West Bengal	Darjeeling
Spiraea emarginata	J & K	Banihal
Spiraea micrantha var. *glabricarpa*	Sikkim	Zemu Valley
Spiraea nayarii	Sikkim	Tiatong, above Tallum, Sumdong
Spiraea rhamniphylla	Uttaranchal, J & K, Himachal Pradesh	Kumaon, Simla, Kullu, Rohtang Pass
Spiraea subdioica	Arunachal Pradesh	Kameng
Spiraea subrotundifolia	Sikkim	Tiamphong
Spiraea tanguensis	Sikkim	Tangu
Spiraea chambaensis	Himachal Pradesh	Chamba
Spiraea duthieana	Uttaranchal	Kumaon
Spiraea panchananii	Uttaranchal	Pithoragarh

Species	Region	Locality
Spiraea panigrahiana	Uttaranchal	Pithoragarh
Spiraea parkeri	Uttaranchal	Almora
Spiraea raizadae	Uttaranchal	Uttarkashi
Spiraea villosicarpa	West Bengal	Darjeeling
Geum aequilobatum	Uttaranchal	Tehri, on way to Ghuttu
Agrimonia aitchisonii var. *pedicellata*	Uttaranchal	Mussoorie, Dhanaulti
Alchemilla aksharmae	J & K	Panchtarni
Alchemilla brumittii	J & K	Sedan
Alchemilla cecilii	J & K	Muzaffarabad, Thilan
Alchemilla chthamalea	J & K, Uttaranchal	Sambliali, Kumaon
Alchemilla duthieana	J & K	Gulmarg
Alchemilla gilgitensis	J & K	Gilgit
Alchemilla kishangangensis	J & K	Kishanganga valley, Sonapind pass
Alchemilla kungwatannensis	J & K	Kungwatan
Alchemilla mantonii	J & K	Ladakh
Alchemilla nicolsonii	J & K	Jhelum valley, Hamal basin
Alchemilla niltarensis	J & K	Niltar Valley
Alchemilla palii	Uttaranchal	Kumaon, Martoli
Alchemilla plocekii	J & K	Yusmarg
Alchemilla rothmaleri	J & K	Gulmarg
Alchemilla samantaraii	J & K	Gulmarg
Alchemilla sarojinii	J & K	Kishanganga valley
Alchemilla rojakii	J & K	Amarnath
Alchemilla waltersii	J & K	Kungwatan
Alchemilla ypsilotoma	J & K	Sonmarg
Alchemilla harae	Tamil Nadu	Nilgiri, Bangi, Tappal
Alchemilla madurensis	Tamil Nadu	Madurai
Alchemilla panigrahiana	Tamil Nadu	Kodaikanal

Species	Region	Locality
Alchemilla parijae	Tamil Nadu	Nilgiri peak R. F.
Potentilla arbuscula var. *glabrata*	Sikkim	No precise locality
Potentilla sericophylla var. *longifolia*	J & K	Kishanganga valley
Potentilla lineata var. *intermedia*	Sikkim, Uttaranchal	Jongri, Phalloot Chamoli, Namik
Potentilla peduncularis var. *clarkei*	Sikkim	Yakla
Potentilla peduncularis var. *obscura*	Uttaranchal	Kumaon Kalari
Potentilla khasiana	Arunachal Pradesh, Meghalaya, Manipur	Kameng, Myang Khong, Jowai, Khasi Hill, Shillong
Potentilla multifida var. *glabrata*	J & K, Himachal Pradesh	Rupshu, N.W. India
Potentilla breviscissa	J & K	Ladakh
Potentilla ornithopoda var. *impexa*	J & K	Indus valley, Khalatze
Potentilla karakoromica	J & K	Karakoram mountains
Potentilla leschenaultiana	Tamil Nadu	Nilgiri mountains
Potentilla sojakii	J & K, Himachal Pradesh	Lahul valley, Chotadara, Ladakh
Potentilla clarkei	J & K	Srinagar
Potentilla kashmirica	J & K	Nowgung
sibthorpioides monanthes var. *sibthorpioides*	J & K, Himachal Pradesh, Uttaranchal,Sikkim and Arunachal Pradesh	Deotsoo, Lahul, Kumaon, Changu, Kameng
Sibbaldia axilliflora	Uttaranchal	Kumaon
Sibbaldia perpusilla	J & K, Himachal Pradesh, Uttaranchal, Sikkim	Lahul valley, Tehri, Chola

Species	Region	Locality
Sibbaldia compacta	Sikkim	Coraphuchu
Sibbaldia pusilla	Sikkim	Sherabthang
Brachycaulos simplicifolius	Sikkim	Gaoring
Cotoneaster assamensis	Arunachal Pradesh	Balipara Frontier
Cotoneaster buxifolius	Tamil Nadu	Nilgiri
Cotoneaster garhwalensis	Uttaranchal	Nilang valley, Phuladaru
Cotoneaster gilgitensis	J & K, Himachal Pradesh	Nittar Valley, Lahul, Khoksar
Cotoneaster khasiensis	Meghalaya	Laitlyngkot
Cotoneaster lambertii	J & K	Pahalgam
Cotoneaster osmastonii	Himachal Pradesh, Uttaranchal	Bashahr-Jaunsar, Kumaon, Niti Valley
Cotoneaster pangiensis	Uttaranchal, Himachal Pradesh	Pangi, Kinnaur, Lahaul, Chamba Garhwal, Rani Khanda
Cotoneaster parkinsonii	Uttaranchal	Kumaon, Almora Pindar valley
Cotoneaster prostratus	Uttaranchal, Himachal Pradesh	Garhwal, Mana, Kumaon, Ralikot, Mussoorie.
Cotoneaster stracheyi	Himachal Pradesh, Uttaranchal	Jaunsar Mundali, Kumaon, Dwali
Cotoneaster wallichianus	Sikkim	Tankara, Dikchu valley
Cotoneaster wattii	Uttaranchal, Himachal Pradesh	Simla, Garhwal, Pajidhar, Kaliphat Tolla.
Prunus hargaonensis	Himachal Pradesh	Lahul
Prunus cornuta var. *integrifolia*	Uttaranchal	Pithoragarh
Prunus glauciphylla	West Bengal, Sikkim	Tongloo to Phalloot, Chandoogiri, Fungpong

Species	Region	Locality
Rosa clinophylla var. *parvifolia*	Uttaranchal, Jharkhand	Kumaon, Chotangapur
Rosa hookeriana Bertol	Himachal Pradesh	Lahaul
Rosa macrophylla var. *hookeriana*	J & K, Uttaranchal	Pirpanjal, Upper Chenab, Kumaon, Melam
Rosa hirsuta	Uttaranchal	Kumaon, Melam
Rosa leschenaultiana	Tamil Nadu	Nilgiri Hills
Pyrus jacquemontiana	Himachal Pradesh	No precise locality

ECONOMIC IMPORTANCE

The family is notable for the large number of genera which are cultivated either for food or ornamental purpose. Most of the important fruit species of temperate regions fall within Rosaceae. Economically by far the most important is the apple (*Malus* spp.), now grown in numerous hybrid cultivars, with over 2000 named varieties. The next most important genus is *Prunus*, which produces almonds, apricots, cherries, peaches, plums, etc., all of which are grown extensively for consumption as fresh fruits and for canning and making into jams, etc.

Other major rosaceous fruits are blackberries, loganberries and raspberries (*Rubus*), loquats (*Eriobotrya*), pears (*Pyrus*), strawberries (*Fragaria*) and quinces (*Cydonia*). Many *Prunus* species are also cultivated as ornamentals. Rose the 'queen of flowers', is probably the most popular and widely cultivated garden flower in the world. Modern roses are complex hybrids descended from about nine of the wild species (Rowley, 1993). There are more than 5000 named cultivars estimated to be in cultivation. Other popular cultivated genera are *Alchemilla*, *Geum*, *Filipendula* and *Potentilla*.

Some edible species of the family are :

1. *Prunus bokhariensis*
2. *Prunus cerasifera*
3. *Prunus domestica*

4. *Prunus salicina*
5. *Prunus armeniaca* Plant is also used as a root stock for peach and apricot.
6. *Prunus amygdalus*
7. *Prunus persica*
8. *Prunus avium*
9. *Prunus nepaulensis*
10. *Prinsepia utilis*
11. *Pyrus communis*
12. *Malus pumila*
13. *Malus baccata*

Some ornamental species of the family are :

1. *Rosa*
2. *Aruncus dioicus*
3. *Spiraea bella*
4. *Spiraea cantoniensis*
5. *Potentilla lineata*
6. *Kerria japonica*
7. *Rhaphiolepis indica*
8. *Chaenomeles japonica*
9. *Prunus cerasifera*
10. *Malus hupehensis*
11. *Alchemilla*
12. *Geum*
13. *Filipendula*

Some medicinally important species of the family are :

1. *Potentilla supina* - roots astringent and tonic; used in fever.

2. *Potentilla anserina* - astringent, spasmolytic, tonic; decoction cures diarrhoea, arthrites, cramps; infusion of herb is said to stop excessive and painful flow of menses.

3. *Potentilla reptans* possesses febrifugal and haemostatic properties; its infusion cures diarrhoea and constipation.

4. *Potentilla sericea* astringent.

5. *Potentilla gerardiana* astringent.

6. *Geum roylei* astringent, styptic, febrifuge, stomachic, tonic; useful in diarrhoea, sore throat and leucorrhoea.

7. *Geum elatum* almost similar properties as above.

8. *Cotoneaster nummularioides* - aperient, expectorant and stomachic.

RARE TAXA

There are several species of the family Rosaceae which are rare in occurrence and distribution. *Cotoneaster buxifolius* is endemic to Tamil Nadu (Nilgiri, Palni, Kodaikanal). There are only 10 collections available in Indian herbaria, which have been collected between 1878 and 1911 (Nayar & Sastry, 1987). Another species, *Cotoneaster simonsii,* is also an endemic species, confined to Lachung Valley in North Sikkim, which is represented by only 4 collections, collected between1884 and 1909 (Nayar & Sastry, *l.c.*). Some other rare species worth mentioning are *Spiraea arunachalensis, Sibbaldia trullifolia, S. axilliflora, S. purpusilla, Potentilla flagellaris, P. baltistana, P. karakoromica, P. thomsonii, P. polyschista* etc. Besides, a number of species, like *Cotoneaster assamensis, C. parkinsonii, Spiraea emarginata, S. nayarii, S. subdioica, S. tanguensis, S. chambaensis, S. panchananii, S. panigrahiana, S. parkeri, S. raizadae, S. villosicarpa, Geum aequilobatum, Alchemilla duthieana, A. sojakii, Agrimonia aitchisonii* var. *Pedicellata* are represented by type collection only.

Intensive search for such species, in not only their known areas of occurrence but also in regions with similar eco-climatic conditions, should be undertaken to locate the populations in nature. They should be introduced in botanic garden for their *ex situ* conservation.

REFERENCES

Airy Shaw, H.K. 1973. *J.C. Willis. A Dictionary of the Flowering Plants & Ferns. ed. 8* Cambridge University, Press, Cambridge. U.K.

Bentham, G. and J.D. Hooker. 1862. *Genera Plantarum.* Vols. 1-3. London.

Braun, A. 1860. In : Ascherson, *Flora der Provinz Brandenburg.* Berlin.

Britton, N.L. and A. Brown 1913. *An illustrated flora of the Northern United States, Canada and the British Possessions.* ed 2. Vols. 1-3. New York.

Brummitt, R.K. 1992. *Vascular Plant Families and Genera.* Royal Botanic Gardens, Kew.

Cronquist, A. 1968. *The Evolution and classification of flowering plants.* Nelson & Sons, Boston, Edinburgh.

Cronquist, A. 1981. *An Integrated System of Classification of Flowering Plants.* Columba University Press, New York.

Dahlgren, R.M.T. 1980. A revised system of classification of the angiosperms. *Bot. Journ. Linn. Soc.* **80**: 91-124.

Dahlgren, R.M.T. 1983. General aspects of angiosperm evolution and macrosystematics. *Nord. Journ. Bot.* **3**: 119-149.

Dikshit, B.K. and G. Panigrahi 1981. *Brachycaulos* (Rosaceae) a new genus from India. *Adansonia* 1: 57-60.

Dikshit, B.K. and G. Panigrahi 1998. *The family Rosaceae in India. Vol. 4.* Bishen Singh Mahendra Pal Singh, Dehradun.

Focke, W.O. 1888. *Rosaceae.* In : Engler, H.G.A. & K.A.E. Prantl (eds.) *Die Naturlichen Pflanzenfamilien Teil* 3, *Abteilung 3. Lieferung* **24**: 1-48. Berlin.

Ghora, C. and G. Panigrahi 1995. *The family Rosaceae in India.* Vol. 2. Bishen Singh Mahendra Pal Singh, Dehradun.

Gray, S.F. 1821. *A Natural Arrangement of British Plants.* Vol. 1 & 2. London.

Heywood, V. (ed.) 1993. *Flowering Plants of the World.* Reprinted edition 1996. B.T. Batsford Ltd., London.

Hooker, J.D. 1878. Rosaceae. In: *Flora of British India* Vol. **2**: 307-388. L. Reeve & Co., London.

Hutchinson, J. 1959. *The Families of Flowering Plants.* Vol. 1. ed. 2. Clarendon Press. Oxford.

Hutchinson, J. 1964. *The Genera of Flowering Plants.* Vol. I. Clarendon Press, Oxford.

Hutchinson, J. 1973. *The Families of Flowering Plants.* ed. 3. Clarendon Press, Oxford.

Jussieu, A.L. de. 1789. *Genera Plantarum.* Zurich, Paris.

Kumar, A. and G. Panigrahi 1995. *The family Rosaceae in India.* Vol. 3. Bishen Singh Mahendra Pal Singh, Dehradun.

Ledebour. C.F. Von 1830. *Flora Altaica.* Berlin (adjutoribus C.A. Meyer & A.V. Bunge).

Lindley, J. 1830. *An Introduction to the Natural System of Botany.* London.

Linnaeus, C. 1737. *Critica Botanica.* Leiden.

Linnaeus, C. 1753. *Species Plantarum.* ed. 1. Vols. 1 & 2. Stockholm. Fascimile ed. London (1957,1959).

Linnaeus, C. 1754. *Genera Plantarum* ed. 5 Stockholm. Fascimile ed. Weinheim Bergster Codicote Herts (1960).

Linnaeus C. 1758. *Opera Varia.*Lucca.

Linnaeus C. 1763. *Species Plantarum*. Ed. 2. Vols. 1 & 2. Stockholm.

Mabberley, D.J. 1987. *The Plants Book.* Cambridge University Press. Cambridge, U.K.

Mabberley, D.J. 1998. *The Plants Book.* Repr. ed. Cambridge University Press, Cambridge. U.K.

Maximowicz, C.J. 1879. Adnotationes de Spiraeaceis. *Act. Hort. Petrop.* **6**(1): XI. 105-258.

Miller, P. 1754. *The Gardeners Dictionary.* Abridged ed. 4. Vols. 1-3. London.

Möench, C. 1794. Methodus Plantas horti botanici et Agri marburgensis : Marburg Fascimili edition Koenigstein Taunus 1966.

Nayar, M.P. and A.R.K. Sastry (eds.) 1987. *Red Data Book of Indian Plants.* I: 317-321. BSI, Calcutta.

Nestler, C.G. 1816. *Monographia de Potentilla Praemissia nonnullis observationibus circa familium Rosacearum.* Paris.

Purohit, K.M. and G. Panigrahi. 1983. Studies on the distribution of the genus *Spiraea* L. (Rosaceae). *Bull. Bot. Surv. India* **24**(1-4): 225-227.

Purohit, K.M. and G. Panigrahi. 1991. *The family Rosaceae in India.* Vol. 1 Bishen Singh Mahendra Pal Singh, Dehradun.

Robertson, K.R. 1974. The genera of Rosaceae in South eastern United States. *Journ. Arn. Arbor.* **55**(2): 303-332; **55**(3): 344-401; & **55**(4): 611-662.

Rowley, G.D. 1993. *Rosaceae.* In: Heywood, V.H. (ed.) *Flowering Plants of the World.* pp. 141-144. B.T. Batsford Ltd., London.

Royle, J.F. 1839. ***Illustrations of the botany and other branches of the natural history of the Himalayan mountains.*** **Vols. 1 & 2. London. (Reprint edition Today & Tomorrow's Printers & Publishers, New Delhi, 1970).**

Santapau, H. and A.N. Henry 1973. *A Dictionary of the Flowering Plants in India.* P.I.D., C.S.I.R., New Delhi.

Sax, K. 1932. Chromosome relationship in the Pomoideae. *Journ. Arn. Arbor.* **13**: 363-367.

Stace, C.A. 1978. Breeding systems, variation patterns and species delimitation. In : Street, H.E. (ed.) *Essays in Plant Taxonomy.* pp. 57-78. Academic Press, London, New York, San Francisco.

Takhtajan, A.L. 1969. *Flowering Plants-Origin and Dispersal* (English translation by C. Jeffrey) Oliver & Boyd Ltd., Edinburgh.

Takhtajan, A.L. 1980. Outline of the classification of flowering plants (Magnoliophyta). *Botanical Review* **46**: 225-359.

Thorne, R.F. 1983. Proposed new realignments in the Angiosperms. *Nord. Journ. Bot.* **3**: 85-117.

Tournefort, J.P. de 1700. *Institutions rej herbariae, editia altera* Ed. 1. Paris.

Walters, S.M. 1961. The shaping of Angiosperm Taxonomy. *New Phytol.* **60**: 74-84.

Walters, S.M. 1966. The taxonomic implications of apomixis. In : Hawkes, J.G. (ed.) *Reproductive biology and taxonomy of vascular plants.* pp. 162-168. Pergamon Press, Oxford, London, Edinburgh, New York, Toronto, Paris.

D.K. Singh

Rosa webbiana

S.K. Srivastava

Cotoneaster pruinosus

D.K. Singh

Pyrus pashia - a wild relative of pear

S.K. Srivastava

Rosa macrophylla

D.K. Singh

Malus baccata - the apple

EUPHORBIACEAE

N.P. Balakrishnan

Euphorbiaceae, the Spurge family consisting of about 317 genera and about 6000 species, is predominantly cosmopolitan with the strongest representation in the humid tropical and subtropical regions of both hemispheres (Webster, 1987, 1994). Although most of the members of the family are readily discernible in the field by the unisexual and mostly apetalous flowers, floral glands, the tricarpellary syncarpous pistil, and schizocarpic capsular fruits with 3 cocci and persistent columella or rarely with drupaceous fruits. Exceptions can be found to every one of the above characteristics. No single character is universal in the family. Further, the inter-relationships among the genera are not sufficiently understood. The family includes many economically important and potentially useful and medicinally usable species. It is the sixth largest family in the world (Radcliffe-Smith, 1987) and occupies the seventh position in Indian flora.

Inspite of its medicinal and economical importance very little attention has been paid to it by Indian taxonomists. The last revision of the family for India was done by J.D. Hooker (1887) published in *The Flora of British India* (FBI), more than a century ago. Since then no detailed taxonomic revision of the family for the whole country has been undertaken, except for some regional floras or state floras.

A detailed taxonomic revision of the family has now been attempted as a precursor to Volume 23 of the new Flora of India (FI). J.D. Hooker (*l.c.*) includes 58 genera and 325 species, to be occurring within the present political boundaries of India. The present revision reveals the presence of about 70 genera and 410 species in India. During the work several interesting aspects on diversity, endemism, rarity and utilities of the species in the family came to the fore and these are presented here.

The family is largely complex and forms a heterogenous assemblage of diverse growth forms and morphological features. It exhibits wide diversity in grwoth forms, from herbs and shrubs to succulent stunted shrubs or tall canopy trees, caused by diverse selection pressures of different habitats from arid regions to wet humid tropical and temperate regions. Members of the family can be found in almost every ecological habitat, except the alpine regions and aquatic habitats. The diversity of generic features in the family can be understood by the fact that over 20 segregate families, comprising one or more genera, have been proposed by different authors. Although the family seems to be a well-defined one, questions about the taxonomic affiliation of certain genera have persisted for over a century between the lumpers and splitters. Attempts by several experts to split the family into several families have not produced any satisfactory results. The most prominent among the splitters are Hurusawa and Airy Shaw (1965, 1966). Hurusawa (1954) proposed Antidesmataceae, Ricinocarpaceae and Porantheraceae as separate families. Airy Shaw (1965, 1966) recognised 7 segregate families: Androstachydaceae, Bischofiaceae, Hymenocardiaceae, Peraceae, Picrodendraceae, Stilaginaceae and Uapacaceae. Among recent authors the most extreme splitter was Meeuse (1990), who recognised nine segregate families. Radcliff-Smith *in* Carter and Radcliff (1988) regards the status of the segregate families of Airy Shaw (*l.c.*) as uncertain, and appears to have particular reservations about recognising the Stilaginaceae to accommodate *Antidesma*, but partially followed him in recognising the Hymenocardiaceae and Pandaceae. Leonard and Mosango (1985) have supported Airy Shaw's recognition of the family Hymenocardiaceae. Takhtajan (1980) and Cronquist (1981) recognise only Pandaceae as a distinct family. The recent classification of the family by Webster (1994) follows Cronquist and Takhtahjan in treating the family as *sensu lato*, excluding Pandaceae. He divides the family into 5 subfamilies, 49 tribes and 317 genera and his classification is now generally accepted.

The family is pantropical in distribution, with concentration of species in Tropical America, Africa, Asia and Australia. Bentham (1878) *in* his essay on Euphorbiaceae suggests that the centre of origin of the family is Old World and during a remote period several migrated to the New World through possible land connections. The widely accepted 'continental drift' theory confirms this possibility. Webster (1994) made a detailed analysis of world-wide distribution of the genera in the family and a relevant extract is given below.

Globally America exhibits the largest diversity with 83 endemic genera, followed by Africa clubbed with Madagascar having 71 endemic genera. This is followed by Asia with 45 endemic genera and Australasia with 32 endemic genera (Table I). Though the diversity is more or less evenly equated among the tropical continents, if one takes up the Old World and New World as separate entities, then we can find that the Old World far surpasses the New World in generic diversity.

Table I
Euphorbiaceae: Genera World distribution

Subfamily	America	Africa	Madagascar	Asia	Australia
Acalyphoideae	36 (26)	33 (17)	22 (9)	52 (26)	23 (7)
Crotonoideae	22 (19)	18 (11)	6 (2)	23 (13)	15 (9)
Euphorbioideae	24 (18)	13 (8)	4 (0)	8 (1)	9 (2)
Oldfieldioideae	8 (8)	5 (4)	3 (2)	3 (2)	13 (12)
Phyllanthoideae	21 (12)	33 (4)	16 (4)	21 (3)	17 (2)
Total	111 (83)	102 (54)	51 (17)	107 (45)	77 (32)

(Numbers in parantheses indicate endemic genera)

All the five subfamilies are represented in India, among them the subfamily. Oldfieldiodeae has only one genus with one species. The distribution of Indian genera and species are summarised in the following two tables (II and III), the first one depicting the genera in subfamilies and the second one showing species and endemics under each genus in India.

Table II
Euphorbiaceae: genera - World *vs* India

Subfamily	World	India	Endemic to India
I. Acalyphoideae	116	26	
II. Crotonoideae	67	17	1
III. Euphorbioideae	40	7	
IV. Oldfieldioideae	28	1	–
V. Phyllanthoideae	61	19	–
Incertae sedis	5	–	–
Total	317	70	1

Table III
Euphorbiaceae: species - World *vs* India

Genera	World (appx.)	INDIA		
		FBI 1887	FI 2000	Endemic to India*
Acalypha	450	9	11	5
Actephila	20	2	2	–
Agrostistachys	10	3	2	1
Alchornea	50	3	3	–
Aleurites	8	2	2	–
Andrachne	15	3	3	–
Antidesma	200	16	17	1
*Aporusa*80	5	5	1	
Baccaurea	75	2	3	1
Baliospermum	12	5	2	–
Bischofia	1	1	1	–
Blachia	10	5	3	1
Blumeodendron	6	1	2	–
Breynia	15	2	3	–
Bridelia	60	9	10	1
Chaetocarpus	12	1	1	–
Chrozophora	10	3	4	–
Claoxylon	80	10	9	3
Cleidion	25	2	2	–
Cleistanthus	100	6	7	3
Cnesmone	10	1	1	–
Codiaeum	15	1	1	–
Croton	800	12	16	4
Dalechampia	100	2	6	2
Dimorphocalyx	15	2	3	3
Doryxylon	2	1	1	–

Genera	World (appx.)	INDIA FBI 1887	FI 2000	Endemic to India*
Drypetes	200	17	21	10
Endospermum	10	2	3	–
Epiprinus	6	1	1	1
Euphorbia	1250	52	82	31
Excoecaria	40	6	7	1
Flueggia	14	2	2	–
Givotia	4	1	1	–
Glochidion	200	29	21	8
Hevea	10	–	1	–
Homonoia	3	2	3	2
Hura	2	–	1	–
Hymenocardia	8	1	1	–
Jatropha	175	7	11	5
Koilodepas	10	1	1	1
Lasiococca	3	1	2	1
Leptopus	10	–	1	–
Macaranga	300	8	11	2
Mallotus	150	15	19	4
Manihot	60	1	2	–
Margaritaria	14	–	1	–
Meinickia	20	–	4	3
Mercurialis	8	–	1	–
Mischodon	1	1	1	–
Neoscortechinia	6	1	1	–
Ostodes	4	2	1	–
Pachystylidium	1	–	–	–
Paracroton	3	–	2	1
Pedilanthes	15	1	1	–

Genera	World (appx.)	INDIA FBI 1887	FI 2000	Endemic to India*
Phyllanthus	750	33	46	26
Plukenetia	15	1	1	–
Ptycopyxis	10	1	1	–
Putranjiva	3	1	1	–
Ricinus	1	1	1	–
Sapium	90	5	4	–
Sauropus	50	10	12	6
Sebastiania	100	1	1	–
Sphyranthera	2	1	2	2
Suregada	40	3	2	–
Symphyllia	3	2	1	–
Synadenium	15	–	1	–
Tragia	125	1	5	3
Trewia	1	2	1	–
Trigonostemon	60	3	5	–
Vernicia	3	–	2	–
Total:	5976	325	410	133

* Only wholesome species are included in this list, the endemic varieties whose species are not wholly endemic are excluded.

ENDEMIC SPECIES

The family exhibits rich endemism in the Indian region with about 133 species, representing 31per cent of 410 species in India, being endemic to the country. Balakrishnan (1998) in an earlier estimate indicated that there are 144 endemic species among the 421 species in India. Further critical studies on some genera revealed that some of the supposed endemics are synonymous to other widespread species, and hence the reduction in number of species and endemics.

The Table IV compares Indian endemism with the West Asia and South-east Asian regions. The data for South-east Asia are taken from van Welzen (1997) and for Arabia from Ghazanfar (1998).

Table IV
A comparative account of endemism in West and South-east Asian region.

Country/area	No. species	No. endemics	% of endemism
India	410	133	32
Arabia	121	37	31
Thailand	388	157	40
Malaya	377	75	20
Sumatra	314	52	17
Java	209	48	28
Borneo	440	151	34
Philippines	412	177	43
New Guinea	461	335	73

The highest percentage of endemism is found in New Guinea (73 %), followed by Philippines (43 %), Thailand (40 %) and Borneo (34 %). India (with 32 %) and Arabia (with 31 %) share the fifth and sixth positions. The data shows that endemism is usually higher than 10 per cent in the tropical regions of Asia. Eventhough the number of endemics depends, to some extent, on the area of a country, there seems to be an interesting trend of increase in endemism as we move eastwards from West Asia to South-east Asia. It is also interesting to note that the tropical islands of South-east Asia, i. e. Borneo, Philippines and New Guinea, though much smaller than India, show greater diversity in number of species and endemism. Closer home, Thailand shows greater endemism than India. These facts indicate that the family exhibits greatest diversity in humid evergreen tropical habitats. Data from Indo-china, Myanmar, Sri Lanka and Bangladesh are not available as there are no recent monographic work on the family from these countries.

The table V and VI indicates species which are endemic to the various states or regions in India, arranged in the order of strength.

Table V
State-wise endemism in India

Andaman & Nicobar Islands	17
Tamil Nadu	15
Andhra Pradesh	6
Karnataka	5
Maharashtra	4
Jammu & Kashmir	3
Kerala	3
Sikkim	3
Arunachal Pradesh	2
Meghalaya	1
Rajasthan	1

Table VI
Endemic species, region-wise

1.	Peninsular India (Tamil Nadu, Kerala, Karnataka, Andhra Pradesh and Maharashtra)	–	77 species
2.	Andaman & Nicobar Islands	–	17 species
3.	North-east India (West Bengal, Assam, Meghalaya, Tripura, Mizoram, Manipur and Nagaland)	–	7 species
4.	Eastern Himalaya (North Bengal, Sikkim and Arunachal Pradesh)	–	5 species
5.	North West Himalaya (Jammu & Kashmir, Himachal Pradesh and Uttaranchal)	–	4 species
6.	Central India (Orissa, Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat, Punjab and Haryana)		1 species
7.	Overlapping (in two or more regions)	–	22 species

The remaining states do not have any endemics of their own. As can be seen from the table the Andaman & Nicobar Islands have the largest number of endemics. There are 40 genera with 110 species occurring in these islands and among them one genus (with 2 species) and another 15 species are endemic to these islands (Chakrabarty & Balakrishnan, 1992). Such rich diversity could be explained by the fact that apart from being isolated islands, they show warm humid tropical climate with heavy rainfall and luxuriant tropical evergreen forests similar to South-east Asian regions. The next in rank is Tamil Nadu with 15 endemic species.

Ahmedullah and Nayar (1987) in their study of endemic plants of Peninsular India, reported 73 species and 3 varieties as endemic to Peninsular India, whereas the present study indicates that there are 77 species endemic to the region, amounting to about 58 per cent of the endemics in India. This is followed by Andaman & Nicobar Islands, where 17 species are endemic, amounting to about 11 per cent of the endemics in India. Thus, the largest concentration of endemics are in Peninsular India, followed by Andaman & Nicobar Islands, on the expected lines, indicating that the family exhibits greatest diversity in humid tropical regions near to the equator. However, it is significant that considering the area-size of Andaman & Nicobar Islands (about 8400 sq. km) being only as large as an average district in Peninsular India, these islands should supercede all other regions in richness of endemics. Further, the only endemic genus of the family in India (*Shyranthera* with 2 speceis) is found in these islands. Table VII shows genera with five or more endemic species to India.

Table VII
Dominent endemic genera in India

Genus	Species in World	Species in India	Endemic species in India
Euphorbia	1250	82	31
Phyllanthus	750	46	27
Drypetes	200	20	10
Glochidion	200	21	6
Sauropus	50	12	5

It is seen that the genera *Euphorbia* and *Phyllanthus* exhibit maximum species diversity in India, followed by *Drypetes*, *Glochidion* and *Sauropus*.

USEFUL PLANT RESOURCES

The Euphorbiaceae are of considerable economic importance for India. The major economically important plants which are usefull and are potentially useful are the following.

Dye yielding plants

Chrozophora rottleri

Diffuse herbs or undershrubs, found throughout the country in tropical areas, mostly in moist waste places. The fruits yield a dye.

Croton argyratus

Shrubs or small trees found in evergreen and deciduous forests of peninsular India. The bark yields a lac which can be used in making varnish.

Mallotus philippensis

The Kamala tree, up to 15 m tall, common in evergren and deciduous forests. The tree has long been valued as a source of dyeing material, called Kamala Powder, for dyeing silk and wool. The colouring matter is persent in the red granular indumentum covering the ripe capsules.

Food plants

Manihot esculenta

The Tapioca plant, also called Cassava plant, native of Tropical America, now cultivated in many parts of tropical Asia and Africa, for its edible tuberous roots. In India it is widely cultivated in Kerala, where it forms a staple food for many poor families. The tubers are exploited commercially to make starch, sago and flour. It is also being cultivated in Tamil Nadu, Andman Islands and North-east India.

Fruit trees

Antidesma acidum*, *A. acuminatum* and *A. ghaesembilla

Fruits are edible.

Baccaurea courtallensis

Trees up to 15 m tall in evergreen forests of southern Western Ghats. The fruits are edible.

Baccaurea ramiflora

Evergreen forest trees of North east India and Andamans, sometimes cultivated. The fruits are edible and has a pleasant acidic taste.

Drypetes andamanica

Trees up to 15 m high, growing in semievergreen or secondary forests of South Andaman Islands. The fruits are edible.

Drypetes assamica

Shrubs or trees up to 15 m high, growing in eastern Himalaya, Assam and Andhra Pradesh. The fruits are edible.

Drypetes bhattacharyae

Shrubs or trees, up to 20 m high, growing in littoral and inland evergreen forests of Andaman Islands. The fruits are sweet and edible.

Phyllanthus acidus

A small tree, native of Tropical America, called Star Gooseberry, is widely cultivated in tropical countries of Asia and Africa. Its drupaceous yellowish fruits, resembling Gooseberry (*P. emblica*) but smaller, are eaten fresh, cooked or as perserves and pickles.

Phyllanthus emblica

This indigenous tree, usually found in tropical deciduous or semideciduous forests and also often in cultivation, is called the Gooseberry tree. The drupaceous fruits are rich source of Vitamin C and is eaten fresh or usually used in pickles, preserves and also used as a component of various Ayurvedic tonics and hair oils.

Hydrocarbon source

Euphorbia lathyris

The plant is cultivated in China, Japan and Russia for its oil-yielding seeds. The milky latex contains high percentage of hydrocarbons and is called the fuel-supplying plant (Calvin, 1987). There is only one record of its occurrence in India, as a weed in cultivated fields in Darjeeeling District of West Bengal at 1500 2500 m altitude (Binojkumar & Balakrishnan 1997).

Euphorbia tirucalli

A tropical African plant, often cultivated as hedge plant in India. A promising source of hydrocarbons for fuel. The charcoal is used in fireworks.

Oil-yielding plants:

Aleurites moluccana

Native of Malesia, often planted in tea gardens of Assam, West Bengal and South India, sometimes seen as naturally regenerating. The oil from the seeds is used for manufacture of paints and varnishes.

Jatropha curcas

A shrub, native of Tropical America, now widely cultivated as hedge plant in tropical Asia and Africa. In India it is common along coastal areas. The seeds yield an oil which is of commercial use as a lubricant and also used in candle making. The drupaceous fruits are highly poisonous, though the seed oil is often used as laxative in mild doses.

Mallotus philippensis

Oil from seeds is used as a substitute for Tung Oil (*Vernicia fordii*).

Ricinus communis

The Castor oil plant, a shrub native of Tropical America, now widely cultivated in Asia and Africa for its seeds which yields the castor oil of medicinal use and also as an illuminant. In India it is widely cultivated and also seen as an escape.

Sapium sebiferum

The Chinese Tallow tree, native of China, found naturalised in Bihar and often in cultivation in other parts of India. The white wax found around the seeds form the source of the vegetable tallow and also used for candles. The leaves are sometimes used to make a black dye

Vernicia cordata

Native of Japan, introduced into many countries in South east Asia; cultivated in Sikkim for the seed oil.

Vernicia fordii

Native of Japan, China and Indo-China, often cultivated in tea and coffee gardens of Assam, West Bengal and Karnataka. The oil from the seeds called *Tung Oil* is used for preparation of paints and varnishes.

Vernicia montana

Native of Japan, South China and Indo-China; usually cultivated and often naturalised in Assam, Arunachal Pradesh, Sikkim, West Bengal, Karnataka and Tamil Nadu. The seeds yield an oil used in preparation of paints and varnishes.

Ornamental plants

Acalypha hispida

Native of Bismarck Archepelago, now cultivated in many tropical countries as ornamental garden plant for its attractive female inflorescenes with dense mat of crimson styles.

Acalypha wilkesiana

Widely cultivated in tropical gardens around the World, for its attractive brightly coloured variegated leaves and catkin-like crimson red inflorescences. Probably a native of Fiji Islands. There are several cultivars of this plant grown in gardens.

Codiaeum vareigatum

Widely cultivated in tropical gardens around the World, for its ornamental, variously coloured and shaped foliage. Native country uncertain.

Euphorbia cotinoides

Shrubs or small trees, native of America, introduced into several tropical Asian countries as garden plant for its attractive pinkish young leaves and pinkish green mature leaves (Binojkumar & Balakrishnan, 1991).

Euphorbia cyathophora

Native of tropical America, introduced into many tropicial countries of Asia and Africa as an attractive garden plant. Herbs or shrubs with the upper floral leaves red or reddish at base or up to middle.

Euphorbia leucocephala

A shrub native of Guatemala, introduced into India as an ornamental garden plant for its attractive white floral leaves (Binojkumar & Balakrishnan, 1992).

Euphorbia mauritanica

Native of tropical Africa, introduced into many tropical countries of Asia and America. Bushy shrubs or small trees, with erect, branched, slender, cylindrical green stems, small linear-oblong leaves and small yellow flowers. Can be easily propagated by stem cuttings (Binojkumar & Balakrishnan, 1993).

Euphorbia milii

Native of Madagascar, introduced into Asian gardens and grows well at 1200 to 2500 m altitude. Bushy spiny shrubs with pinkish red involucre.

Euphorbia pulcherrima

Shrubs with conspicuous floral leaves coloured bright red, yellow or pale yellow. Native of Mexico, introduced and cultivated as attractive garden plant in many tropical countries of Asia and Africa.

Euphorbia tirucalli

Often cultivated as an ornamental hedge plant.

Pedilanthes tithymaloides

A fleshy shrub native of Tropical America, with red or orange flowers and often mildly variegated leaves, is often found in gardens as hedge plant.

Phyllanthus arbuscula

A shrub, native of West Indies, with flattened branches and coloured calyx (scarlet, pink, white or greenish), often found in gardens.

Synadenium grantii

Often cultivated as an ornamental hedge plant.

Rubber plants

Hevea brasiliensis

A large tree, native of South America, cultivated in many tropical countries of Asia and Africa, for its valuable latex which forms the rubber of commercial use. In India large plantations are to be found in Kerala, and recently started in Andaman Islands, Manipur and Tripura.

Manihot glaziovii

Native of Brazil, introduced and cultivated in Kerala, Tamil Nadu and Andamans. Now though the cultivation has been discontinued, the trees are seen growing in wild populations. The bark produces latex which can be used as rubber of inferior quality.

Timber trees

Bischofia javanica

A large deciduous tree with moderately hard wood useful for planking purposes.

Bridelia retusa

A small tree common in deciduous forests of central and peninsular India. The wood is durable and useful having grey to olive-brown colour with pleasing silver grains.

Givotia rottleriformis

A moderate-sized tree common in deciduous and semievergreen forests of Deccan and Western Ghats. The wood is very light, soft, white and used for making carvings, toys, lacquered articles, etc..

Trewia nudiflora

Tree, up to 15 m tall, found in deciduous forests. Wood soft, useful for carving, planking, packing cases and plywood purposes.

Medicinal Plants

The list given below is not exhaustive as only the important and recently known ones are listed. The latex of many species are used externally for skin afflictions and warts. However, some people may be allergic to the latex, and test application is advisable.

Acalypha indica

Used in various Ayurvedic medicines.

Croton bonplandianum

Herbaceous weed common throughout the country. The plant is used as antiseptic and styptic. The plant contain antibacterial alkaloid sparsiflorine, which has been reported to be inhibitory (*in vitro*) to *Vibrio coma, Escherichia coli* and *Salmonella typhosa* (Acharya *et al.*, 1964, Ananthakrishnan *et al.*, 1941, Chatterjee *et al.*, 1965).

Croton roxburghii

Shrubs or small tres, common in deciduous forests from sub Himalayan regions to peninsular India. Called in Sanskrit as *Nagadanti*, it is used in various Ayurvedic preparations. The bark is particularly useful in reducing chronic liver enlargements and intermittent fever.

Croton tiglium

The oil from the seeds, popularly known as 'Croton oil' is used in Ayurvedic medicines. It is a powerful laxative, applied externally in rheumatism and various skin afflictions.

Excoecaria acerifolia

Leaves applied externally in rheumatism (Chakrabarty & Gangopadhyay, 1994).

Excoecaria agallocha

Latex applied to obstinate ulcers and also used externally in rheumatism, leprosy and paralysis. Decoction of leaves is given in epilepsy (Chakrabarty & Gangopadhyay, 1994).

Euphorbia antiquorum

Latex applied to warts and cutaneous infections (Mishra & Sahu, 1984).

Euphorbia articulata

Latex used as an abortifacient and emmenagogue (Ambasta, 1986).

Euphorbia barnhartii

Juice of heated leaves applied for ear-ache (Mishra & Sahu, 1984). Latex applied for muscle pain, wounds and ulcers (Rama Rao, 1988).

Euphorbia caducifolia

Latex used as a cure for coughs, applied to blisters and wounds (Shekhawat & Anand, 1984). Latex applied to injuries and fractures (Mayuranathan, 1929).

Euphorbia cattimandoo

Latex used as vesicant (Drury, 1873).

Euphorbia cornigera

Leaves and seeds crushed and boiled in water and given with milk in case of food poisoning (Paliwal & Badoni, 1990).

Euphorbia corrigioloides

Latex applied on scabies (Binojkumar & Balakrishnan, 1996).

Euphorbia cristata

Tender leaves made into a paste and applied on fracture (Binojkumar & Balakrishnan, 1996).

Euphorbia donii

Juice extract of whole plant used in fistular sores (Ambasta, 1986).

Euphorbia dracunculoides

Paste of fruits applied on warts (Mishra & Sahu, 1984). Paste of roots applied on scorpion sting (Shukla *et al.*, 1992).

Euphorbia epiphylloides

Stem warmed and wrapped around areas with rheumatic pain (Saini & Singh, 1990).

Euphorbia fusiformis var. *fusiformis*

Extract of rootstock applied on breast for desolidifying and increasing lactation (Ravishankar, 1990).

Euphorbia fusiformis var. *khandallensis*

Latex used for eye trouble in buffalloes (Santapau, 1967).

Euphorbia granulata

Latex used as an antidote to scorpion sting (Shekhawat & Anand, 1984).

Euphorbia helioscopia

Whole plant made into a paste and applied to wounds (Kumar & Naqshi, 1990).

Euphorbia heterophylla

Leaves and latex applied against skin diseases (Saini & Singh, 1990).

Euphorbia heyneana

Branches and leaves made into a paste with pepper and applied on forehead to relieve headache (Binojkumar & Balakrishnan, 1996).

Euphorbia hirta

Latex used to remove warts (Mishra & Sahu, 1984). Whole plant used for asthma in Bastar district of Madhya Pradesh (Jain, 1965).

Euphorbiia hypericifolia

Infusion of whole plant used as an astringent in diarrhoea, dysentery and leucorrhoea (Ambasta, 1986).

Euphorbia indica Lamk.

Plant made into a paste with pepper leaves and applied on forehead to reduce headache (Binojkumar & Balakrishnan, 1996).

Euphorbia katrajensis

Latex used as antidote to snake poison (Binojkumar & Balakrishnan, 1996).

Euphorbia khasyana

Latex applied for toothache (Binojkumar & Balakrishnan, 1996).

Euphorbia lactea

Stems after removing the spines made into paste and applied on forehead to relieve headache (Saini & Singh, 1990).

Euphorbia lathyris

Leaves used as carminative. Seeds used in dropsy and for intoxicating fish (Ambasta, 1986).

Euphorbia mauritanica (as *E. antisyphilitica* non Zucc.)

Latex used for skin diseases (Saini & Singh, 1990).

Euphorbia nana

Latex used in rheumatism and gout by Tharus in Uttar Pradesh (Binojkumar & Balakrishnan, 1996).

Euphorbia neriifolia

Latex used to remove warts and cutaneous eruptions (Mishra & Sahu, 1984).

Euphorbia nivulia

The paste made of stem bark powdered and mixed with goat milk and jaggery is plastered over bone fracture (Rama Rao, 1988). Latex applied on mumps (Ravishankar, 1990). Latex is also applied on wounds in cattle (Jain, 1965).

Euphorbia perbracteata

Whole plant used as a fish poison (Ravishankar, 1990).

Euphorbia prolifera

Tender leaves made into a paste and swallowed for abortion and antifertility (Binojkumar & Balakrishnan, 1996).

Euphorbia prostrata

A paste of whole plant applied on mumps to reduce the swelling (Binojkumar & Balakrishnan, 1996). Plant used as vegetable promotes lactation in women (Jain, 1965).

Euphorbia pulcherrima

Latex applied on wounds (Krishna & Singh, 1987).

Euphorbia rosea

Leaves and seeds used as vermifuge (Ambasta, 1988).

Euphorbia rothiana

Seeds used to remove warts (Mishra & Sahu, 1984).

Euphorbia royleana

Latex applied on cuts, wounds and burns (S.P. Jain, 1984).

Euphorbia thomsoniana

Rootstock crushed and used as hair wash; boiled and given as purgative (Caius, 1938).

Euphorbia thymifolia

Whole plant made into a paste and applied on joint pains (Binojkumar & Balakrishnan, 1996). Decoction of whole plant used to cure dysentry (Shukla *et al.*, 1992).

Euphorbia tibetica

Whole plant given to cattle as nutritious food and latex used in nausea (Rawat & Pangtey, 1987).

Euphorbia tirucalli

Latex applied on warts, rheumatism and for tooth ache (Mishra & Sahu, 1984).

Euphorbia tortilis

Latex applied for pains in rheumatism and skin diseases (Binojkumar & Balakrishnan, 1996).

Euphorbia santapaui

Latex applied for skin diseases and scabies (Binojkumar & Balakrishnan, 1996).

Euphorbia vajravelui

Latex applied on domestic animals against falling of hairs (Binojkumar & Balakrishnan, 1996).

Euphorbia wallichii

Decoction of leaves used against constipation (Paliwal & Badoni, 1990).

Jatropha curcas

Seeds are medicinal and the juice from twigs is applied to sores. Oil from seeds is purgative.

Phyllanthus fraternus

A weed found in wastelands, paddy fields and other wet places throughout India. An excellent liver tonic, used in Ayurveda for treating jaundice and genito-urinary infections.

Macaranga indica

The milky latex is used to help healing of wounds by tribals in Sikkim and Darjeeling.

Putranjiva roxburghii

Decoction of leaves and fruits given orally for cold, fever and in rheumatism (Chakrabarty *et al.*, 1997).

Ricinus communis

Castor oil extracted from seeds is used as purgative in Ayurveda and also to help growth of healthy hair. The seeds are poisonous.

ENDANGERED TAXA

Among the endemics, there are several species which are rare, show very restricted distribution, often confined to one or a few adjacent localities and are facing several threats to their very existence. Some of them have not been relocated for the last 100 years and may have already become extinct or are on the verge of extinction. These species are considered as endangered and their extinction would be a irreparable loss to humanity. Therefore, special efforts should be undertaken to protect and conserve them *in situ* as well as *ex situ*, to preserve them for posterity. Among them, the critically endangered ones are given in Table VIII.

Table VIII
Endangered taxa and their distribution

Name	Distribution
Acalypha dalzellii	Maharashtra
Antidesma oblongatum	Meghalaya
Antidesma wattii	Meghalaya
Aporusa bourdillonii	Kerala

Name	Distribution
Briedelia nicobarica	Nicobar Is. (Car Nicobar)
Claoxylon wightii var. *angustatum*	Tamil Nadu (Tirunelveli district)
Claoxylon wightii var. *glabratum*	Tamil Nadu (Coimbatore district)
Claoxylon wightii var. *hirsutum*	Tamil Nadu (Tirunelveli district)
Claoxylon wightii var. *wightii*	Tamil Nadu (Tirunelveli district)
Cleidion javanicum var. *alongense*	Arunachal Pradesh.
Cleidion javanicum var. *longipedicellatum*	Sikkim
Cleistanthus balakrishnanii	Great Nicobar Is.
Cleistanthus travancorensis	Kerala.
Cnesmone javanica var. *glabriuscula*	South Andaman Is.
Croton lawianus	Karnataka (Chickmagalur distr., Bababudan hills) not located since the type collection during early part of the 19th century.
Dalechampia stenoloba	Karnataka (Chickmagalur district)
Dimorphocalyx balakrishnanii	South Andaman Is.
Dimorphocalyx beddomei	Tamil Nadu and Kerala (Southern most ends of Western Ghats).
Dimorphocalyx kurnoolensis	Andhra Pradesh (Kurnool district)
Drypetes andamanica	South Andaman Is.
Drypetes ellisii	Andaman Is. (Mount Harriet).
Drypetes jaintensis	Meghalaya.
Drypetes leiocarpa	Nicobar Is. (Kamorta Is.), not collected since the type in 1875.
Drypetes malabarica	Tamil Nadu (Tirunelveli district).
Drypetes porteri	Tamil Nadu (Tirunelveli district).
Euphorbia balakrishnanii	Tamil Nadu (Tirunelveli district).
Euphorbia cattimandu	Andhra Pradesh.
Euphorbia concanensis	Maharashtra (Sindhudrug district).

Name	Distribution
Euphorbia epiphylloides	North Andaman and Car Nicobar Is. Rare.
Euphorbia heyneana var. *nilagirica*	Tamil Nadu (Nilgiri district).
Euphorbia jacquemontii	Jammu & Kashmir.
Euphorbia jodhpurensis	Rajasthan.
Euphorbia katrajensis	Maharashtra (Pune district, Katraj hills).
Euphorbia laciniata	Extremely rare, though found in a few scattered localities in Mahararashtra, Karnataka and Tamil Nadu.
Euphorbia longistyla	Andhra Pradesh (Anantapur, Cuddapah and Kurnool district).
Euphorbia peltata	Andhra Pradesh (Coromandal coast) - not collected since the original description by Roxburgh in 1832.
Euphorbia santapaui	Tamil Nadu and Kerala (Southernmost Western Ghats).
Euphorbia senguptae	Andhra Pradesh (Anantapur, Cuddapah and Kurnool district).
Euphorbia vajravelui	Tamil Nadu and Kerala (Southernmost Western Ghats).
Glochidion andamanicum	Andaman Is., collected only once in 1899 by Prain, after the type collection by Kurz in 1867.
Glochidion karnaticum	Karnataka (N. Kanara District)
Glochidion khasicum var. *bilobulatum*	N. Andaman Is. (Saddle Peak).
Glochidion subsessile	Andaman Is.
Glochidion zeylanicum var. *arunachalense*	Arunachal Pradesh.
Jatropha maheshwarii	Tamil Nadu (Kanniyakumari and Tirunelveli district).

Name	Distribution
Jatropha nana	Maharashtra.
Leptopus emicans	Arunachal Pradesh.
Macaranga balakrishnanii	Sikkim and North Bengal.
Macaranga nicobarica	Nicobar Islands (Katchal and Great Nicobar).
Meinickia calycina	Tamil Nadu (Anamalai hills).
Meinickia macropus	Arunachal Pradesh (Mishmi hills).
Phyllanthus anamalayanus	Tamil Nadu (Anamalai hills).
Phyllanthus andamanicus	N. Andaman Is. (Saddle Peak).
Phyllanthus brevipes	Arunachal Pradesh.
Phyllanthus fimbriatus	Tamil Nadu (Nilgiri hills).
Phyllanthus kozhikodianus	Kerala (Kozhikode district).
Phyllanthus megacarpus	Kerala (Wyanad district) and Tamil Nadu (Nilgiri distr.).
Phyllanthus pendulus	West Bengal plains. Very rare, not collected since Roxburgh described it in 1832.
Phyllanthus sanjappae	N. Andaman Is. (Saddle Peak).
Phyllanthus singampattianus	Tamil Nadu (Tirunelveli district).
Phyllanthus talbotti	Karnataka.
Sauropus bishnupadae	North Bengal and Sikkiim.
Sphyranthera airyshawii	Andaman Is.
Sphyranthera lutescens	Andaman Is. (very rare) and Great Nicobar Is. (seen only in a few scattered localities).
Tragia bicolor	Tamil Nadu (Nilgiri hills).
Trigonostemon viridissimus var. *confertifolius*	N. Andaman Is. (Saddle Peak).

CONSERVATION STRATEGIES

The increased awareness on the need for conservation of India's rich biodiversity during the last two decades has resulted in the establishment of an elaborate protected area network (PAN), including 12 Biosphere Reserves in the country from Himalaya and North-east India to Western Ghats and Nicobar Islands. These have, to a certain extent, conserved and protected several rare and endemic species of plants, but there are many more which need to be protected. As far as the family Euphorbiaceae is concerned, there are two areas where the endemics are concentrated. They are the Andaman & Nicobar Islands and Peninsular India (see Table V). Apart from Euphorbiaceae there are several other families of flowering plants which also show great diversity in these two areas. However, presently there are only two Biosphere Reserves, one each in these two areas, the Great Nicobar Island Biosphere Reserve at the southernmost end of Andaman & Nicobar Islands and the Nilgiri Biosphere Reserve at the northernmost end of Western Ghats including parts of Tamil Nadu, Kerala and Karnataka. These two are found to be inadequate. The Andaman & Nicobar group of Islands stretch in North-South direction for a length of about 900 km from Landfall Island in North Andamans to Indira Gandhi Point in Great Nicobar Island and the consequent gradual change in the flora in that direction resulted in the flora of North Andaman Island being totally different from that of Great Nicobar Island. Similarly the flora of Western Ghats from Gujarat through Maharashtra, Karnataka, Kerala and Tamil Nadu stretching in North-South direction for a length of about 1600 Km from Tapti Valley in Gujarat to Cape Kanniyakumari in Tamil Nadu also continuously change and the elements, particularly the endemics found in the Gujarat or Maharashtra sections are totally different from those found in Kerala and Tamil Nadu. Therefore, in order to conserve and protect the maximum number of endemics and rare plants it is suggested that the proposals pending with the Ministry of Environment and Forests, Government of India, for the creation of two Biosphere Reserves: (i) North Andaman Island Biospere Reserve (including Saddle Peak), and (ii) Agastyamalai Hills Biosphere Reserve in Tirunelveli District of Tamil Nadu and Thiruvananthapuram District of Kerala at the southernmost end of Western Ghats, should be immediately taken up for implementation. This would result in covering a much larger number of rare and threatened plants into the *in situ* conservation net.

REFERENCES

Acharya, B.K., M.L. Modi and S.N. Sinha 1964. The antibacterial activity (in vitro) of the alkaloids of *Croton sparsiflorus* Morong on some pathogenic organisms. *J. Indian Medic. Assoc.* **43:** 592-595.

Ahmedullah, M. and M.P. Nayar. 1987. *Endemic plants of Indian region, Vol. I, Peninsular India.* BSI, Calcutta.

Airy-Shaw, H.K. 1965. Diagnoses of new families, new names, etc. for the seventh edition of Willis's 'Dictionary'. *Kew Bull.* **18:** 249-272.

Airy-Shaw, H.K. 1966. *Willis' Dictionary of Flowering Plants, Addenda.* Cambridge University Press, Cambridge.

Ambasta, S.P. 1986. *Useful plants of India.* C.S.I.R., New Delhi.

Ananthakrishnan, S.V., S. Aravamuthachari and V.S. Govindarajan 1941. A study of the constituents of the seed of *Croton sparsiflorus* Morong. II. Chemical examination of the components. *Proc. Indian Acad. Sci.* Sect. A. **14:** 616-639.

Balakrishnan, N.P. 1998. Endemism in the family Euphorbiaceae in India. In: Mathew, Philip and M. Sivadasan (eds). *Diversity and Taxonomy of Tropical Flowering Plants.* Mentor Books, Calicut.

Bentham, G. 1878. Notes on Euphorbiaceae. *J. Linn. Soc. London* **17:** 185-267.

Binojkumar, M.S. and N.P. Balakrishnan 1992. *Euphorbia leucocephala* Lotsy - A new record for India. *Indian J. For.* **15:** 181-182.

Binojkumar, M.S. and N.P. Balakrishnan 1996. Ethnobotanical studies of the genus *Euphorbia* L. (Euphorbiaceae). *J. Econ. Taxon. Bot., Addl. ser.* **12:** 46-49.

Carter, S. and A. Radcliffe-Smith 1988. Euphorbiaceae. *Flora of Tropical Africa.* Part 2, pp. 409 597.

Chakrabarty, T. and N.P. Balakrishnan 1992. The family Euphorbiaceae in Andaman & Nicobar Islands. *J. Econ. Taxon. Bot.*, Addl. ser. **9:** 1-122.

Chakrabarty, T. and M. Gangopadhya 1994. A revision of *Excoecaria* L. (Euphorbiaceae) for Indian subcontinent. *J. Econ. Taxon. Bot.* **18:** 193-210.

Chakrabarty, T., M. Gangopadhyay and N.P. Balakrishnan. 1997. The genus *Drypetes* (Euphorbiaceae) in the Indian subcontinent. *J. Econ. Taxon. Bot.* **21:** 251-280.

Chatterjee, A., P.L. Majumdar, R. Mukherjee, S.K. Saha and S.K. Talaatra 1965. Structure of sparsiflorine, an alkaloid of *Croton sparsiflorus* Morong. *Tetrahedron Letters* **1965:** 1539-1544.

Cronquist, A. 1981. *An Integrated system of Classification of Flowering Plants.* Columbia Univ. Press, New York.

Drury, H. 1873. *The useful plants of India.* W.H. Allen & Co., London.

Ghazanfar, S.A. 1998. The tropical vegetation and floristic diversity of the Arabian Peninsula. In: Mathew, Phiilip and M. Sivadasan (eds.) *Diversity and Taxonomy of Tropical Flowering Plants.* Mentor Books, Calicut.

Hooker, J.D. 1887. *The Flora of British India.* **5:** 241-462. L. Reeve & Co., London.

Hurusawa, I. 1954. Eine nochmalige Durchsicht des herkommelichen sytems der Euphorbiaceae in weiteren Sinne. *J. Fac. Sci. Univ. Tokyo,* Sect. 3. Botany **6:** 209-342.

Jain, S.K. 1965. Medicinal plant-lore of the tribals of Bastar. *Econ. Bot.* **19:** 236-250.

Jain, S.P. 1984. Ethnobotany of Morni & Kaleswar (district Ambala, Haryana). *J. Econ. Taxon. Bot.* **5:** 809-813.

Krishna, B. & S. Singh 1987. Ethnobotanical observations in Sikkim. *J. Econ. Taxon. Bot.* **9:** 1-7.

Kumar, G.M. and A.R. Naqshi 1990. Ethnobotany of Jammu II: Banihal. *J. Econ. Taxon. Bot.* **14:** 67-74.

Leonard, J. and M. Mosango 1985. Hymenocardiaceae. *Flore d'Afrique Centrale*: Spermatophytes.

Mayuranathan, P.V. 1929. The flowering plants of Madras City and its immediate neighbourhood. *Govt. Museum, Madras Bull. (n. s.)* **2:** 1-345.

Meeuse, A.D.J. 1990. *The Euphorbiaceae auct. plur. An unnatural taxon.* Eburon, Delft.

Mishra, D.P. and T.R. Sahu 1984. Euphorbiaceous plants in medicine by the tribals of Madhya Pradesh, India. *J. Econ. Taxon. Bot.* **5:** 791 793.

Paliwal, G.S. and A.K. Badoni 1990. The ethnobotany of the hill tribes of Uttar Kashi. *J. Econ. Taxon. Bot.* **14:** 421-442.

Radcliffe-Smith, A. 1987. Segregate families from the Euphorbiaceae. *Bot. J. Linn. Soc.* **94:** 47-66.

Ramarao, N. 1988. *The ethnobotany of Eastern Ghats in Andhra Pradesh.* Ph.D. Thesis, Bharatiar University, Coimbatore (unpublished).

Ravisankar, T. 1990. *Ethnobotanical studies of Adilabad and Karimnagar districts of Andhra Pradesh, India.* Ph.D. Thesis, Bharatiar University, Coimbatore (unpublished).

Rawat, G.S. and Y.P.S. Pangtey 1987. A contibution to the ethnobotany of Alpine regions of Kumaon. *J. Econ. Taxon. Bot,* **11:** 139-145.

Saini, D.C. and S.K. Singh 1990. Additions to the flora of Upper Gangetic Plain and their ethnobotanical studies. *J. Econ. Taxon. Bot.* **14:** 83-104.

Santapau, H. 1967. Euphorbiaceae. In: The Flora of Khandala on the Western Ghats of India (ed.3). *Rec. Bot. Surv. India* **16**(1): 240-243.

Shekawat, G.S. and Sunil Anand 1984. An ethnobotanical profile of Indian desert. *J. Econ. Taxon. Bot.* **5:** 591-598.

Shukla, G.P., V. Mudgal and K.K. Khanna 1992. Notes on medicinal uses of plants known amongst rural folk-lore of Pratapgarh & Sultanpur districts of Uttar Pradesh. *J. Econ. Taxon. Bot., Addl. ser.* **10:** 221.

Takhtajan, A.L. 1980. Outline of the classification of flowering plants (Magnoliophyta). *Bot. Rev.* **46:** 225-359.

Van Welzen, P.C. 1997. *Malesian Euphorbiaceae Newsletter*, No. **6:** 1-31. Leiden.

Webster, G.L. 1987. The saga of the spurges: A review of classification and relationships of the Euphorbiales. *Bot. J. Linn. Soc.* **94:** 3-46.

Webster, G.L. 1994. Systematics of the Euphorbiaceae. *Ann. Missouri Bot. Gard.* **81:** 1-144.

ACANTHACEAE

J.L. Ellis

The Acanthaceae - a pantropial, cosmopolitan family comprising about 240 genera with about 2200 species, including infraspecific taxa are distributed in the tropical belt mainly in Africa, Malesia extending up to northern Australia, Brazil and Central America including Mexico, occurring up to 1800 m altitude. Many have found their way into the gardens for their beautiful flowers. In India there are several genera like, *Barleria, Thunbergia, Meyenia, Strobilanthes* (*sensu lato*), *Asystasia*, and several others which have beautiful flowers. In general, the family occurs in drier localities. The physiological draught conditions that are prevalent in rolling downs and in between in the stunted evergreen montane forests that are a common feature in the upper reaches of the Western Ghats of the Peninsular India, have proven to be conducive for the gregarious nature of genera, making a treasure house of variegated colours and economically viable plants for honey. Interestingly, there are marsh-dwellers all along the riverine belt, and back-waters of the intrusive seawater that is a frequent occurrence in India, exemplified by *Hygrophila* spp., *Acanthus ilicifolius, Cardanthera* spp., etc. The xerophytic habit is very much evident by the spiny nature of the plants. Etymologically, therefore, the name of the family is derived from the term *acantho* meaning thorn or spine bearing plants, though admittedly there are quite a few genera without any.

The classification of plants under the family Acanthaceae, ridden with the various problems of delimitation of several of the genera, has been a deterrent for a proper understanding of the family, much less of the genera. Examples may be cited of *Strobilanthes* and *Justicia*, among others, which have been split by some, initiated as it were by Nees Esenbeck (1832, 1847), followed by Ridley (1925), Bremekamp (1965), Santapau (1967), Ellis (1988, 1990), among others. From among the traditional followers who have been swayed by a catholic outlook, mention may be made of T. Anderson (1867), C.B. Clarke (1885), Lindau (1896), T. Cooke (1906), Gamble (1925). There is still no consensus among workers with regard to many genera. Dealing with Columbian Acanthaceae, Leonard (1958) has given a broad concept of the genus *Justicia*. From the present understanding of the family, at least from those of India, apparently it seems best to treat them on individualistic circumscriptional merit. Examples may be cited of *Strobilanthes* (*Curvia, Nilgirianthus, Thelepapale,* etc.), *Justicia (Adhatoda, Gendarusa, Rhaphidospora, Rostellularia,* etc.).

The Acanthaceae are characterised by the usual presence of cystoliths all over the plant, ontology of bracts and bracteoles, generally of bilabiate corollas, bilocular ovary, bivalvate, elastically dehiscing capsular fruits, with usually curved retinaculae supporting the seeds. These ejaculators, however, are absent in *Isonioideae, Dendancioideae*, and *Thunbergioideae.* In several genera the seeds are hygroscopic, covered by elastic hairs becoming prominent when wetted.

The members of the family Acanthaceae are generally herbs, shrubs, and rarely trees. Some species of *Strobilanthes* have treelet appearance by their robust habit, some becoming supine by the lack of supporting structure. The open rolling downs render them short and stunted. The climbers include *Thunbergia, Meyenia*, etc.

It is remarkable that the family Acanthaceae has almost uniform appearance giving it a unique character with gamopetalous, pentamerous flowers except for the number of stamens and bicarpellate ovary. The calyx number is 4 in some genera, whereas numerous in *Thunbergia* and *Meyenia.* Again the 5-lobed nature is 2-lipped in several plants, and in some, like *Acanthus, Blepharis*, several species of *Justicia* (*sensu lato*), and others the upper lip is very much suppressed if not absent. The presence of spurred nature of the lower cell of the anther lobes is an important character considered in the classification of the family. The orientation of the sculpturing of the pollen grains is rather constant in many genera.

The fruits are hygroscopic, and this character is very pronounced in several of the genera, like *Barleria, Ruellia,* and others. The seeds are generally echinate, often flattened. This character is of some importance in differentiating genera, like *Andrographis, Gendarussa, Adhatoda, Justicia, Rhaphidospora,* etc. In *Rhaphiodospora glabra* the seeds are villous, obscuring the underlying sculpturing of them.

DIVERSITY AND DISTRIBUTION

C.B. Clarke's incisive treatment of the family in J.D. Hooker's the *Flora of the British India* (1885) though taken in a catholic sense including

Myanmar and Sri Lanka, has 45 genera and about 519 species and varieties. Haines (1906) treat about 40 genera and 100 species. Cooke (1906) dealt with 36 genera and 113 species and 12 varieties for the midwest of the peninsular India. Santapau (1952) working on the Acanthaceae of Bombay treated 42 genera and 130 species. Gamble (1925) accounts for 38 genera and 197 species with 17 varieties from then the Presidency of Madras. Lakshminarasimhan and Sharma (1991) have treated 20 genera and 41 species from the Nasik District of Maharashtra. The works on the Andhra Pradesh in the peninsular India more or less follow the same pattern with about 20 genera and 35 species (Rao & Sreeramulu, 1986) from Srikakulam District, 20 genera and 30 species (Rao, *et al.*, 1986) from West Godavari District, and Ellis (1992) has recorded 19 genera and 35 species from erstwhile Kurnool District. This trend in the number of taxa is reflected even in the plains of North India (Haines, 1906, Kanjilal *et al.* 1939). The islands of Andaman & Nicobar are still in a state of uncertainty because of lack of facilities to assess the ground truth. In a recent analysis of flowering plants of India, Karthikeyan (2000) recorded 500 species within the family, from the present political boundary of India, belonging to 92 genera. He (Karthikeyan, 2000) also recorded 84 varieties and subvarieties in the family. Many plants of secondary forest formation are the outcome of the disturbances in the primary vegetation. Of interest is *Strobilanthes glandulosus* which is a herb under the shade in the thick forests especially in the gradience. The wet condition encourages the plant to thrive well. *Peristrophe bicalyculata* is very common in disturbed areas.

Economically, some of the members of *Andrographis*, like *A. paniculata*, *A. stenophylla*, etc. are medicinally important. *Justicia adhatoda* makes the famous cough syrup, though the Astavidyas of Kerala are of the opinion that it is *Justicia beddomei* which is more efficacious. *Andrographis nallamalayana* from Andhra Pradesh is said to be used in colouring *Areca catechu* the betle nut. The gregarious periodic flowering encourages honey industry classification.

ENDEMISM

Acanthaceae has 17 endemic genera, which together with family Poaceae, is the highest number for the country, while the genera. *Nilgirianthus* and *Pteracanthus*, with 20 species each, have the maximum number of endemic species in India (Ahmedullah, 2000). Of the endemic genera, while *Indoneesiella* occurs throughout the country, genera like *Aechmanthera* (with 3 species), *Listerobanthes* (1), *Pseudaechmanthera* (1), *Pteracanthus* (20), *Sympagis* (5), *Tarphoclamys* (1), *Triaenanthus* (1) are confined to the Himalayan region, including North-eastern state. Whereas, genera like *Carvia* (1), *Gantelbua* (1), *Kanjarum* (1), *Nilgirianthus* (20), *Phlebophyllum* (8), *Pleocaulus* (3), *Santapaua* (1), *Taeniandra* (1), *Xenacanthus* (3) are confined to peninsular India.

Neuracanthus neesianus, known to occur in North Arcot district of Tamil Nadu, could not be collected for a long time now and is feared to have become extinct (Henry & Janarthanam, 1988), while species, like *Barleria gibsonioides*, *Dicliptera abuensis*, *D. ghatica*, *Hypoestis andamanensis*, *H. lanata*, *Lepidagathis barberi*, *L. diffusa*, *Mackenziea caudata*, *Nilgirianthus circarensis*, *Phlebophyllum jeyporense*, *Santapaua madurensis*, *Strobilanthes dupenii*, *S. hallbergii*, etc. are threatened because of various biotic pressures, (Nayar & Sastry, 1987, 1988, 1990).

REFERENCES

Anderson, T. 1867. An enumeration of the Indian species of Acanthacae. *Journ. Linn. Soc.* **9** : 425-456.

Clarke, C.B. 1885. Acanthaceae. In: J.D. Hooker, *The Flora of British India.* **4** : 339-417.

Cooke, T. 1904. Acanthaceae. In: *The Flora of the Presidency of Bombay.* pp. 339-417.

Ellis, J.L. 1992. *Flora of Nallamalais.* **2** : 297-318. Calcutta.

Haines, H.H. 1906. *The Botany of Bihar and Orissa.* **2** : 694-737. (reprinted ed. 1961).

Henry, A.N. and M.K. Janarthanam 1988. *Neuracanthus neesianus* (Wight ex T. Anders.) Clarke (Acanthaceae). In: Nayar, M.P. and A.R.K. Sastry (eds.) *Red Data Book of Indian Plants.* **2** : 4. BSI, Calcutta.

Kanjilal, U.N., A.Das, P.C. Kanjilal and R.N. De 1939. *Flora of Assam.* **3** : 408-456.

Karthikeyan, S. 2000. A statistical analysis of flowering plants of India. In: Singh, N.P., D.K. Singh, P.K. Hajra and B.D. Sharma (eds.) *Flora of India Introductory Volume* Part II: 201-217. BSI, New Delhi.

Leonard, E.C. The Acanthaceae of Columbia. *Contr. U.S. Nat. Herb.* **31** : 487-698, 1958.

Linnaeus, C. 1753. *Species Plantarum.* London.

Lindau, G. 1895. In A. Engler and H. Prantl, *Die Naturlichen Pflanzenfamilien.* IV Tiel 3. Ab. b:274-354.

Nayar, M.P. and A.R.K. Sastry (eds.), 1987-90. *Red Data Book of Indian Plants.* Vols. 1-3. BSI, Calcutta.

Nees, von Esenbeck 1832. Acanthaceae Indiae Orientalis. In: N. Wallich, *Plantarum Asiaticae Rariore* **3** : 70-117.

Nees, von Esenbeck 1847. In: A.P. de Candolle, *Prodromus systematis naturalis regni vegetabilis.*

Prain, D. 1903. *Bengal Plants* **2** : 590-611. (reprinted ed. 1963).

Rao, R.S. and S.H. Sreeramulu, 1986. *The Flora of Srikaklam district, Andra Pradesh, India.* Meerut.

Rao, R.S., P. Venkanna and T.A. Reddy, 1986. *Flora of West Godavary district, Andhra Pradesh, India.* Meerut.

Ridley, H.N. 1923. *Flora of the Malay Peninsula* **2** : 554-610.

Santapau, H. 1952. The Acanthaceae of Bombay. *Univ. Bombay Bot. Mem.* **2** : 1-104, 1952.

SCROPHULARIACEAE

Moonmoon Munshi
Soumen Gantait
M.S. Mondal

Scrophulariaceae, the 'Foxglove' family is one of the cosmopolitan families occupying eighth position amongst the first ten largest dicotyledonous families in the world. In India, it is the ninth largest family.

The family was first described by Jussieu (1789) in *Genera Plantarum*. The family comprises about 222 genera and 4500 species mostly herbs, few shrubs and lianes, spreading across all the continents of the world. Some of the largest genera are *Pedicularis* (600 spp.), followed by *Verbascum* (250 spp.), *Linaria* (150 spp.), *Mimulus* (150 spp.) and *Veronica* (150 spp.).

Bentham (1835, 1846) comprehensively studied the family. In India preliminary work was done by Hooker (1884) for "Flora of British India" He described 57 genera and 227 species. Other workers subsequently studied the family and analysed more taxa. Thus more and more combinations, records and name changes have come up a new. Due to restructuring and modification in the political boundary of Indian subcontinent quite a few species recorded by Hooker (*l.c.*) are at present outside the territory of the Indian Republic. Considering all these facts and factors, the authors infer that there are 66 genera and 387 species(Table I) out of which 7 genera, viz. *Calceolaria*, *Capraria*, *Digitalis*, *Maurandya*, *Mecardonia*, *Movrera* and *Penstemon* are introduced and widely cultivated in India. There are also some disputed genera, such as *Falconeria* and *Oreosolen*. *Falconeria* with its single species has been placed by Pennell (1943) under the genus *Wulfenia* as *W. himalaica*. Later, Hong (1990) changed the status of the genus *Falconeria* being a later homonym to *Kashmiria* and named the species *Kashmiria himalaica*. Similarly, *Lathraea*, initially placed under Scrophulariaceae by Hooker (*l.c.*) has been transferred to the family Orobanchaceae. The family has a number of economically important plants though basically it is known as a weed family.

DIVERSITY

In the present state of our knowledge the family Scrophulariaceae is represented in India by 66 genera and 387 species. *Pedicularis*, with about 105 species known to be occurring in the country, is the largest genus followed by *Veronica* (35 species), *Euphrasia* and *Linderina* (25 species each) and *Limnophila* (20 species), (Table I). On the other hand 30 genera are represented by single species only. Some of them are *Wightia, Brandisia, Sutera, Lancea, Scoparia, Melampyrum, Kashmiria, Hemiphragma* etc. Status of the genera for number of species available in India are shown in Table II.

Table I
Status of the Indian Genera of Scrophulariaceae in India with number of species/subspecies and varieties.

Name of the genus	No. of species	No. of subsps. and varieties
Adenosma	4	
Alectra	1	1
Angelonia	3	
Anticharis	1	
Antirrhinum	2	
Artenema	2	
Bacopa	3	
Bartsia	3	
Brandisia	1	
Buchnera	3	
Bythophyton	1	
Calceolaria	2	
Calorhabdos	1	
Campylanthus	2	
Capraria	1	
Celsia	1	
Centranthera	7	1
Chaenorrhinum	1	

Name of the genus	No. of species	No. of subsps. and varieties
Curanga	1	
Digitalis	2	
Dopatrium Hamil.	3	
Ellisiophyllum	1	
Euphrasia	25	
Glossostigma	1	
Gratiola	1	
Hemiphragma	1	
Kichxia	3	
Kashmiria	1	
Lancia	1	
Leptorhabdos	2	
Limnophila	20	3
Limosella	1	
Linaria	1	1
Lindenbergia	8	
Lindernia	25	2
Maurandya	3	
Mazus	4	
Mecardonia	1	
Melampyram	1	
Melasma	2	
Microrgeria	1	
Microcarpaea	1	
Mimulus	3	1
Movrera	1	
Neopicrorhiza	1	
Odontites	1	
Oreosolen	3	
Pedicularis	105	

Name of the genus	No. of species	No. of subsps. and varieties
Penstemon	4	
Peplidium	1	
Phtheirospermum	3	
Picrorhiza	1	
Ramphicarpa	1	
Rhodochiton	1	
Rusellia	3	
Schweinfurthia	1	
Scoparia	1	
Scrophularia	13	1
Sopubia	3	
Stemodia	2	
Striga	7	2
Sutera	1	
Torenia	12	3
Verbascum	4	1
Veronica	35	15
Wightia	1	
Wulfenia	1	

Table II
Status of the Genera of Scrophulariaceae in India

Genera having 1 Species	=	30
Genera having 2-5 Species	=	24
Genera having 6-10 Species	=	3
Genera having 11-15 Species	=	2
Genera having 16-20 Species	=	1
Genera having 21-30 Species	=	2
Genera having 31-50 Species	=	1
Genera having 51-100 Species	=	-
Genera having 100 or more Species	=	1

ECONOMIC IMPORTANCE

The drug plant *Digitalis purpurea*. (Common Foxglove) may be referred to in this context. The drug digitalin of the plant is good for heart ailments. *Antirrhinum majus* the common Figwort, is another striking plant familiar for its medicinal and horticultural uses, which led the family being known as Figwort family. The family has a number of economially important plants that have horticultural, medicinal and ethno-botanial uses. A summary for the same has been shown in Table III. Besides there are garden ornamentals, such as *Veronica*, *Antirrhinum* and *Kashmiria* etc.

A large number of genera, like *Antirrhinum*, *Calceolaria*, *Cymbalaria*, *Digitalia*, *Kashmiria*, *Mimulus*, *Paulownia*, *Penstemon*, *Russelia*, *Torenia*, *Veronica* are widely cultivated in India for ornamental purpose.

It is apparent that the family Scrophulariaceae has a greater range of botanical interest in the field of medicinal, ethnobotanical and other uses, distribution pattern including endemism, rarity and phenological plasticity. Revision of the family would reveal more information about the family in India.

ENDEMISM AND THREAT

Though the family is of cosmopolitan distribution, it contains a number of endemic genera and species, subspecies and varieties indigenous to the country. *Picrorhiza*, *Kashmiria*, and *Bonnayodes* are such endemic genera, the former two being confined to North-West Himalaya and the last one to the South India (Ahmedullah, 2000). The degree of endemism is largest in North-West Himalaya. Some of the endemic taxa are enumerated in Table IV. *Pedicularis* includes largest number of endemic species. There are also certain rare and threatened species. Scrophulariaceae includes in its fold a very important medicinal plant, *Picrorhiza kurrooa*. An IUCN report reveal that 10-24 tonnes of root is being exported per year from the range countries. Such uninterrupted human act of destruction has gradually made this vulnerable species rare and endangered. The plant has recently been included in Appendix II of CITES to restrict its indiscriminate exploitation. The family has many endemic species in India. There are also a number of rare and threatened species in the family. *Campylanthus ramosissimus* and *Picrorhiza kurrooa* have

Table III
Some medicinally important plant species of *Scrophulariaceae*

Name of the species	Diseases used for	Parts used
Alectra paracitica* var. *chitrakutensis	Leprosy and rheumatism	Whole plant
Antirrhinum majus	Typhoid fever	Fruits, leaves, stems
Artenema sesamoides	Rheumatism, syphilis, ophthalmia	Root
Bacopa monnieri	Blood purification, cough, eczema, fever, headache, fish poisoning.	Whole plant
Celsia coromandeliana	Chronic dysentery, sedative.	Leaves
Centranthera indica	Fever and sores eye	Whole plant
Curanga amara	Febrifuge	Whole plant
Digitalis lanata	Cardiac stimulant	Leaves
Digitalis purpurea	Cardiac stimulant	Leaves
Euphrasia himalaica	Diseases of eye	Leaves
Euphrasia officinalis	Astringent	Leaves
Euphrasia platyphylla	Eye disease	Whole plant
Kickxia ramosissima	Diabetes	Whole plant
Limnophila aromatica	Feverr and antiseptic	Juice of plant
Limnophila indica	Skin eruption and dysentery	Leaves
Limnophila rugosa	Diuretic, stomachic and digestive	Leaves

Name of the species	Diseases used for	Parts used
Limnophila sessilifera	Gastric complaint.	Whole plant
Lindenbergia indica	Bronchitis and skin eruption	Leaves
Lindernia anagallis	Headache	Leaves
Lindernia antipoda	Cholera, cough, ring worm, small pox, snake bite	Leaves
Lindernia crustacea	Dysentery and ring worm.	Leaves
Lindernia oppositifolia	Fever	Leaves
Lindernia ruelloides	Urine complaint and skin disease.	Leaves
Pedicularis pectinata	Body ache and sedative.	Whole plant
Pedicularis pycnantha	Toxic	Whole plant
Pedicularis pyramidata	Headache	Whole plant
Picrorhiza kurrooa	Stomach disease, fever, jaundice, anaemia.	Root and rhizome
Schweinfurthia sphaerocarpa	Tonic, diuretic, typhoid.	Stem, leaves
Scoparia dulcis	Antienactic, in body pain and body swelling	Leaves, root, fruits
Scrophularia variegata	Eye disease	Leaves
Stemodia viscosa	Demulcent	Dried plant
Striga lutea	Blood diseases	Whole plant
Torenia asiatica	Gonorrhoea	Leaves
Verbascum thapsus	Asthma, cough, fish poison,	Whole plant
Veronica baccabunga	Antiscorbutic, diuretic, ulcers, burns, swollen piles.	Whole plant

been included in the Red Data Book of Indian Plants (Nayar & Sastry, 1987-90). Based on recent population study another five species have been included in the forthcoming issue of Red Data Book of plants in India. *Melasma thomsoni*, *Adenosma malabaricum* and *Picrorhiza kurrooa* are three such species threatened due to over exploitation for their medicinal property. A list of the rare and threatened plants of the family have been given in Table V.

Table IV
Species endemic in India and their distribution

Name of the Taxon	Distribution
Adenosma malabaricum	Southern Western Ghats region of Kerala.
Campylanthus ramosissimus	South-east Kutch
Euphrasia himalayica	Kashmir to Arunachal Pradesh.
Hemiphragma heterophyllum	Eastern Himalaya.
Lagotis cashmeriana	Kashmir to Himachal Pradesh.
Lagotis kunwurensis	Kashmir to Kumaun
Lagotis pharica	Eastern Himalaya.
Limnophila glandulifera	Southern Western Ghats (Travancore hills).
Lindenbergia titensis	Madarihat (Jalpaiguri, West Bengal).
Lindernia calemeriana	Tamil Nadu (Point Calemere).
Lindernia minima	Tamil Nadu (Chengalpattu, Tirunelvelli)
Mazus dentatus	Kumaun to Arunachal Pradesh.
Melasma thomsoni	Orissa
Pedicularis bicornuta	Kashmir to Garhwal
Pedicularis bifida	Himachal Pradesh-Arunachal Pradesh.
Pedicularis punctata	Kashmir
Pedicularis zeylanica	Tamil Nadu
Phtheirospermum glandulosum	Garhwal Himalaya

Name of the Taxon	Distribution
Picrorhiza kurrooa	Kashmir to Garhwal
Ramphicarpa longiflora	Western Ghats
Scrophularia elatier	Garhwal to Arunachal Pradesh.
Torenia hirsuta Willd.	Southern Western Ghats.
Veronica lanuginosa	Sikkim

Table V
Rare and threatened plants

Name of the Plant	Distribution
Adenosma malabaricum	Southern Western Ghat region of Kerala.
Campylanthus ramosissimus	South-east Kutch
Limnophila glandulifera	Travancore hills
Lindenbergia titensis	Madarihat forest range, (Jalpaiguri, West Bengal)
Lindernia calemeriana	(Tamil Nadu) Point Calemere
Melasma thomsoni	Kalahandi (Orissa)
Picrorhiza kurrooa	Kashmir - Kumaun

REFERENCES

Ahmedullah, M. 2000. Endemism in the Indian flora : In: Singh, N.P., D.K. Singh, P.K. Hajra, and B.D. Sharma (eds.) *Flora of India Introductory Volume,* Part II. pp. 246-265. BSI, Calcutta.

Bentham, G. 1835. *Scrophulariaceae Indicae.* London.

Bentham, G. 1846. Scrophulariaceae. In: A.P. de Candolle, *Prodromus Systematis naturalis regni vegetablis* **10:** 303-317.

Hong, D. 1980. *Kashmiria* (Scrophulariaceae, Veroniceae), a new name for *Falconeria* Hook. fil. from the Western Himalayas. *Bot. Notiser* **133:** 565-567.

Hooker, J.D. 1884. Scrophulariaceae. In *The Flora of British India.* **4:** 246-289. London.

Jusssieu, A.L. de 1789. *Genera Plantarum.* Paris.

Nayar, M.P. and A.R.K. Sastry (eds.) 1987-90. *Red Data Book of Indian Plants.* Vols. 1-3. BSI, Calcutta.

Pennel, F.W. 1943. The Scrophulariaceae of the Western Himalayas. *Acad. Nat. Sci. Philad. Monogr.* **5:** 1-163.

Verbascum thapsus

Pedicularis sp. in Valley of Flowers

Euphrasia himalayica

APIACEAE

P. K. Mukherjee

Umbelliferae or Apiaceae is probably the first family of flowering plants to achieve general recognition. Dalechamps (1586) is credited with establishment of the family although grouping together the umbelliferous plants with precise definition was made by Theophrastus quite early in the development of taxonomy (Constance, 1971). Even prior to Theophrastus, plants referable to Umbelliferae were treated in ancient Chinese and Sanskrit literatures of second and third Century B.C., but it is presently difficult to assign their identities with certainties. The history of taxonomy of umbelliferae has been dealt with by Constance (1971) and according to him the term Umbelliferae was first used by Dodoens (1583) and curiously a systematic study of the family was made as early as in 1672 by Morison. The group name has its origin from the typical umbellate inflorescence and was called "Umbellatae" by Tournefort (1694). Alternative family name as Apiaceae was proposed by Lindley (1836) and Ammiaceae by Britton and Brown (1896-98), the first of which is presently accepted by the ICBN.

Almost every author, except Hutchinson (1959, 1969), dealing with Angiosperm classificaiton, has preferred to consider Araliaceae and Apiaceae as closely related. Recognition of the two as separate families was first altered by Adanson (1763) who combined them in a single family Araliaceae. The same belief was held subsequently by Bauman (1946) and Thorne (1968, 1983). Others who combined the two in a single family but as Umbelliferae were Reichenbach (1828), Baillon (1867) and Calestani (1905). Thorne (1992) revised his opinion to consider Araliaceae as a separate family but Umbelliferae was splitted into two families Hydrocotylaceae and Apiaceae. The separation of Hydrocotylaceae was proposed earlier by Hylander (1945). To an extreme as many as four families - Angelicaceae, Smyrniaceae, Coriandraceae and Umbellaceae were named by Burnett (1835). The other family names, splitted up ones, have been summarised by Pimenov and Constance (1985) but all of them are invalid.

STATE OF ART

Apart from the dominant feature of the umbellate inflorescence, the Umbelliferae possess a typical specialised fruit, a schizocarp consisting of two, one-seeded mericarps developing from a bicarpellate inferior ovary. The fruits show a very wide range of variation as to their general form, degree and plane of compression, development of ridges, ribs or wings, stylopodium, carpophore and their surface outgrowths. As a result, fruit characters have been used quite extensively in the classification of the family at all levels down to the subspecies.

In the first systematic study of the family by Morison (1672), 165 species under 9 genera were recognised on the basis of "Seed" characters, although the distinciton between seeds and fruits was little recognised at that time, otherwise seeds would not have been considered naked by de Jussieu (1789). Mainly the characters of the fruits gained prominence since the time of La Gasca (1821, 1826) except perhaps by Linnaeus (1753) who stressed on involucral characters. La Gasca was followed by Cusson (1782), Sprengel (1813, 1820, 1825-28); Hoffmann (1814, 1816); Koch (1824); de Candolle (1830); Endlicher (1836-40); Bentham (1867); Drude (1898) and Koso-Poljansky (1916). Concomitant with the use of fruits, there were detailed studies on fruits with the aim to explore taxonomically useful characters. The form of endosperm (Koch, 1824; de Candolle, 1830); pericarp (Rompel, 1895); secretory structures (Hoffmann, 1814, 1816; Bentham, 1867; Moynier de Villepoix, 1878); carpophore (Hoffmann, 1814, 1816); presence/absence of secondary ribs (Bentham, 1867) as also plane and degree of compression, nature of ribs, all were used by Drude (1898) for the classification of the family into three subfamilies: Hydrocotyloideae, Saniculoideae and Apioideae. There is a general concensus among the umbellifer specialists for the acceptane of Drude's classification of subfamilies, though reservations have been expressed for his classification particularly at lower levels (Theoblad, 1971; Pimenov & Leonov, 1993). Other notable classifications of the family include those of Koso-Poljansky (1916) and Cerceau-Larrival (1962).

Genetic boundaries in this family "are often vague, arbitrary and constantly fluctuating" (Constance, 1984). Besides, being dependent on the philosophical traditions of the generic concept, a wider or a narrower one (Dawson & Webb, 1978) and the situation had altered little from the time of Royle (1839) when he expressed the same difficulty. According to Walters (1961) many of the umbellifer genera owe their names from common names prevalent in Europe even prior to Linnaeus and he speculated that "a New Zealand Linnaeus might have treated the family as a single genus, or a few genera in the Araliaceae". Probably, reticulate relationships and convergence create such problems (Hedge & Lamond, 1987; Pimenov & Leonov, 1993). Inadequacies in source materials as have been noted by Heywood (1978), Mukherjee (1983), and Hedge and Lamond (1987) may be another limiting factor. The characters of importance, as listed by Hedge and Lamond (1987) are unequally present or noted or often neglected.

Fortunately, Umbelliferae is one of the few plant families remaining under constant attention of taxonomists. Two successive International Symposia (Reading, 1970 - Heywood, 1971; and Perpignan, 1977 - Cawet-Marc & Carbonnier, 1978) bear testimony to this. Carpology still remains the central one, being studied for detailed anatomy (Bradley & Fell, 1966; Pimenov, 1975, 1976; Sandina, 1957; Tichomirov & Galakova, 1965; Tichomirov & Tretyakova, 1967; Tseng, 1967; Kowal & Wojterska, 1973, 1975; etc.), development pattern (Theobald, 1971), surface ornamentation under SEM (Heywood, 1968, 1971, 1973; Heywood & Dakshini, 1971; Rivas *et al.*, 1978; Ray *et al.*, 1987), secretary structures (Kapoor & Kaul, 1967; Ray, 1985) and carpophore (Jackson, 1933). Vegetative organs have also recived attention for seedling morphology (Cerceau-Larrival, 1962), morphology of bracts and bracteoles (Okeke, 1978), inflorescence (Froebe, 1971), stomata (Guyot, 1971), micromorphology of leaf and involucres including surface ornamentation (Chakrabarty, 1989; Charabarty & Mukherjee, 1986), petiole ornamentation (Chakrabarty, 1989; Chakrabarty & Mukherjee, 1986), petiole morphology (Pimenov *et al.*, 1982) besides pollens (Cerceau-Larrival, 1962) and petal morphology (Reduron, 1978). Cytological and photochemical data are also there. Heywood (1978). Cytological and photochemical data are also there. Heywood (1978) saw "..... a chance to make substantial advances in the classification of Umbelliferae using a multivariate approach" but for Pimenov and Constance (1985) the construction of a modern "system" for this cosmopolitan family remains a task for the remote future. Pimenov and Leonov (1993) presented a compilation of a World list of genera as a step towards this end. The optimism may be there as presently an insignificant number of disputes exist at the specific level. In addition, a number of treatise dealing with Umbelliferae have been published from different countries during the last few decades, notable amongst which are Hiroe and Constance (1958) from Japan, Kitamura (1960) and Rechinger f. and Reidl (1963) from Afghanistan, Tardieu-Blot (1967) from Vietnam, Nasir (1972) from Pakistan, Cannon (1978) from Nepal and Zambesia, Shan and Shen (1979, 1985) from China, Krahulik and Theobald 91981) from Sri Lanka, Adylov

(183) from middle Asia, Cannon and Martins (1981) from Mozambique; Hedge, Lamond and Rechinger, f. (1987) from Iran; Hedge and Lamond (1992) from Thailand and Mukherjee and Constance (1993) from India.

The first umbellifer to be recorded from India (Malabar) was *Centella asiatica* under the name "Codogam" or "Kutakan" by van Rheede (1686). Roxburgh (1814) enumerated seven wild and six cultivated species from the plains of India. D.Don (1825) described fifteen species from Nepal Himalaya and most importantly, Wallich (1829) included sixty-six, chiefly Himalayan species in his "Catalogue", many of which were subsequently published formally by de Candolle (1830). Wight and Arnott (1834) reported twenty species from the peninsular mountains. Royle's collection of ninety species from the north-western Himalaya included several new taxa that were published by Lindley (1835). Several new taxa were added by Edgeworth (1846, 1851) and Dalzell (1861). A comprehensive account was prepared by Clarke (1879) that dealt with 188 species under 39 genera. Further additions to taxa were made by Clarke (1886, 1889), Gamble (1919), Haines (1922), Wolff (1910-1930), Mukherjee (1969-1972), Mukherjee and Constance (1974), Farille *et al.* (1984, 1985) and Pimenov *et al.* (1991). A revision of Indian Umbelliferae (area includes India, Bangladesh, Nepal and Bhutan) by Mukherjee and Constance (1993) presented an account of 68 genera and about 240 species. This work was primarily based on morphogeological approach - "solid alpha-taxonomy at its best" (Nicolson, 1995).

MORPHOLOGICAL VARIATIONS

The generalised distribution pattern of the Umbelliferae shows the temperate requirement of the family and the species which are found in the tropics, are, except for a few weedy ones, confined to the mountains.

The whole of continental India lies North of equator and more than half of its area is North of the tropic of Cancer. By its position, the climate is more generally tropical. The mountains, however, when above 1250-2000 m, everywhere present more or less a temperate vegetation, which becomes wholly temperate at higher elevations and which passes into alpine flora over a large extent of still loftier mountains.

Umbellifers in genral love to occupy open spaces as edge species in sun, inspite of differences of habitats from marshy to forest floors, slopes and ledges, screes and even as epiphytes on moss laden branches. Consequently they offer various life forms and growth forms apart from varying infloresence, flower and fruit forms.

The plants of wet or marshy places are procumbent or repent to ascending, sometimes with fistular stems rooting at nodes and fruits with corky ribs which may be adaptive for dispersal through water, e.g. *Centella, Hydrocotyle, Vanasushava, Oenanthe, Selinum vaginatum, Berula, Cicuta, Cnidium moonieri.* Plants growing on forest edges are tall plants reaching up to a height of 2 m or more with fistular stems (*Heracleum, Angelica, Peucedanum*), but they are not markedly fistular. They represent annuals, coming under therophytic life forms. Acaulescent or ascending forms are prevalent on alpine heights (e.g. *Corta, Cortiella, Kedarnatha, Keraymonia, Trachydium*) with usually very long tap roots. Tap roots are the general nature, giving way to tuberous ones for taxa growing on mossy rocks, branches or ledges at this height or at slightly lower elevations, representing geophytic or hemicryptophytic life forms (*Acronema, Sinocarum, Tongoloa, Bunium, Neoconopodium, Chaerophyllum* some species, *Scaligeria*). Curiously, many of them germinate to produce monocotyledonous seedlings (*Acronema, Sinocarum, Tongoloa, Bunium*). In *Daucus*, the root becomes fleshy, fusiform, which being edible is widely cultivated.

Leaves are alternate, exstipulate, (except *Hydrocotyle*) mono-, di- or trimorphic. They are simple, variously lobed (*Hydrocotyle, Centella,* some species of *Eryngium*) or entire (*Bupleurum*). When di- or trimorphic, basal leaves may be simple and lobed or dentate or serrated (*Pimpinella, Trachyspermum, Apium, Sanicula*). All leaves are pedately 5-7 foliolate in *Vanasushava*. The cauline leaves may be dimorphic, varying according to their position on the stem. Compound leaves are more common, may be imparipinnate or ternate or ternately deocmound. Taxa with imparipinnate leaves have the ultimate segments broader, 3-11 in number (e.g. *Seseli*), but more compound leaves may have linear segments (*Foeniculum, Anethum, Vicatia, Cnidium*, etc.), elliptic or ovate or oblong but usually larger (*Heracleum, Ferula, Peucedanum*, etc.). Leaves are greatly reduced to phyllodes in *Oenanthe hookeri*. Quite often leaf divisions are so great that no description can vividly describe them. Leaves are petiolate for most, though sessile and amplexicaule ones are not rare (species of *Bupleurum, Eryngium*). In texture most taxa have membranous leaves except perhaps in some *Eryngium*, which are spiny at margins and above along with species in *Pycnocycla*. Except perhaps *Bupleurum*, all others have leaf margins variously dentate, crenate, serrate or variations thereof. In tomentum, taxa which are not glabrous may have it hairy (pilose to villous), papillate or with glochidiate hairs.

Exceptions to umbellate inflorescence occur in *Centella* (cyme) and *Eryngium* (capitate). Flowering sequence in an umbel is centripetal, terminal umbels bloom first, followed by lowr ones and laterals. Simple umbels characterise *Hydrocotyle* and *Sanicula* and those apparent simple umbels in *Trachydium roylei, Cortia* and *Cortiella* are essentially compound. *Sanicula* possesses 3 flowers at each umbel, but to about 30 may be found in *Hydrocotyle*. Taxa with compound umbels may have varying numbers of rays and pedicels, uniform or not, ascending and spreading but rarely compact and convexed. In *Pternopetalum* the pedicels, only few (+3) in number, are so unequal that some of the flowers are almost sessile. In *Pycnocycla,* pedicels of barren flowers become greatly inflated on maturity and surround a solitary sessile fruit. In *Ferula*, one or few of the rays may proliferate to bear a compound umbel the top. Proliferated umbels may also arise from extra-axillary position. Umbels are usually axillary, but in *Oenanthe* they may be leaf opposed.

Bracts and bracteoles may be both absent (*Anethum, Apium, Aegopodium,* some *Pimpinella,* etc.) or present. Bracteoles if present may be caducous or persistent and then may be deflexed or reflexed, may be equal to or longer than pedicels. They vary in number, shape, texture, division. Bracteoles usually may be longer than pedicels and lobed in *Daucus, Ammi, Cortia, Selinum, Eryngium, Cuminum, Aulacospermum, Pleurospermum, Schulzia,* etc., and white margined in some of them. They are few and unilateral in *Pinda, Polyzygus*.

Flowers in an umbel may be monomorphic, all fertile or polygamous. In later case male flowers are central surrounded by females or hermaphrodies. Unisexuality is most conspicuous in an umbel in *Pycnocycla*. Calyx teeth range from obsolete to prominent, caducous or persistent on the fruit. Petals may be all equal or unequal, when some of them may be radiant and lobed. In *Acronema* the petals are long-caudate to linear, but they are spathulate and unequal in *Sinocarum* and *Tongola*. Otherwise petals in majority of the taxa ovate are acuminate with an inflexed apex. But in zygomorphic flowers, petals are similar in shape though in three sizes, with an inflexed or sometimes emarginate apex.

Various petal forms are possible (c.f. Reduron, 1977) but have not been studied in detail for Indian taxa, nor are their colours. Same can be said of protandry or protogyn. The shape of the stylopodium on mature fruits is sometimes important for delimitation of taxa. These may be flat or obsolete (*Acronema*), bulbous (*Ciclospermum*), conical (*Daucus, Anthriscus*), but may differ in the same genus as well (*Chaerophyllum villosum* and *C. reflexum*).

Fruits provide the most diagnostic characters to determine the genus and even the species. They vary in shape, size, plane and degree of compression, formation of ribs and wings, number of oil canals (vittae), nature of commissure face, carpophore and indumentum. Different developmental patterns may lead to same form of fruits though these can be differentiated by anatomy. Fruits may be terete with the mericarps so or the latter flattened at different planes. The fruits are dorsally compressed with the mericarps so in the Peucedaneae and Tordylieae, terete with mericarps flattened in Angeliceae; hairy in Scandiceae; with prickles in Caucalideae; commissure face sulcate in Smyrnieae; with secondary ribs in *Centella, Chamaesium* and *Coriandrum*; mericarps terete in most of Apieae; with persistent calyx as corona in *Oenanthe, Berula, Selinum* etc.; ribs equally obsolete or ridged or winged in Apieae or spongy or corrugated in *Prangos, Pleurospermum, Aulacospermum* or corky and thickened in *Seseli, Oenanthe, Cnidium, Berula, Sium*. Ribs may be unequally winged when in most cases the marginal rib is wigned or all winged (*Peucedanum, Angelica, Heracleum, Ferula, Selinum, Cortia, Cortiella* etc.). The number of vittae in each vallecula, seems to be a very dependable character. Vittae may be totally absent (*Hydrocotyle, Centella, Osmorhiza, Conium, Selinum vaginatum*). These may be clavate in *Heracleum*, mono-, or polymorphic, simple or branched, septate or aseptate, tapering at one or both ends, which character can only be seen in L.S. or macerated samples. Carpophores likewise may be absent (*Hydrocotyle, Centella, Sanicula, Eryngium*), or if present, as one solid structure, apically bifid or bifid to half length or completely bipartite.

DIVERSITY

According to recent estimates there are 455 genera and 3600-3751 species (Pimenov & Leonov, 1993) or 446 genera and 3540 species (Mabberley, 1997) of Apiaceae in the world. According to Pimenov and

Leonov (1993), there are 42 genera and 469-490 species belonging to subfamily Hydrocotyloideae, 9 genera and 304-325 species to Saniculoideae and the remaining 404 genera and 2827-2935 species to Apioideae. The total number of genera (correct and synonyms) is 1006. The numbers are approximate. There are 186 monotypic, 76 bitypic and 44 tritypic genera. Besides, 27 genera have four species each, 15 genera have 5 species each, 11 genera of 6 species each, 12 genera have 7 species, 7 genera have 8 species each, and 5 genera of 9 species each. The largest genus is *Eryngium* with 230-250 species followed by *Bupleurum* (180-190 species), *Ferula* (170 species), *Pimpinella* (*ca* 150 species), *Hydrocotyle* (120-130 species), *Angelica* (110 species), *Seseli* (100 species), *Lomatium* (74 species), *Azorella* (65-75 species), *Heracleum* (65 species), *Arracacia* (55 species), *Trachymene* (45 species), *Ferulago* (45 species), *Bunium* (45-50 species). The genera, like *Peucedanum* (100-120 species) and *Ligusticum* (40-50 species) are somewhat artificial.

Recently Karthikeyan (2000) reported 72 genera, 288 species, one subspecies, 32 varieties/subvarieties and two forma under Apiaceae in India. However, in the present paper only 70 genera and 249 species, belonging to 11 tribes, and three subfamilies of Apiaceae are recognised from India (including Bangladesh, Bhutan, Nepal and Sri Lanka). There are 2 genera, 7 species in Hydrocotyloideae, 2 genera, 5 species in Saniculoideae and the rest 66 genrea and 237 species in Apioideae. The largest genus is *Bupleurum*, which is represented by 27 species, followed by *Pimpinella* with 24, *Heracleum* with 20 and *Pleurospermum* with 19. The only other genus with more than 10 speices is *Acronema* with 11 species. Besides, *Selinum* as 8 species, *Peucedanum* 7, *Hydrocotyle* and *Angelica* 6 species each, followed by 5 speices each in *Chaerophyllum*, *Physospermopsis*, *Seseli* and *Trachyspermum*. Genera represented by only one species are: *Centella*, *Sanicula*, *Pycnocycla*, **Neoconopodium*, *Osmorhiza*, *Scandix*, *Turgenia*, *Aulacospermum*, *Conium*, **Pleurospermopsis*, *Prangos*, *Berula*, *Ciclospermum*, *Cicuta*, *Cnidium*, *Cortiella*, **Karnataka*, **Kedarnatha*, *Psammogeton*, *Sium*, *Pinda*, **Polyzygus*, *Semenovia*, **Tordyliopsis*, **Vanasushava* and *Zosima*. Table I shows the phytogeographical relationship of the genera of Indian umbellifers, while Table II provides a conspectus of unbellifers in India, Bangladesh, Bhutan, Nepal and Sri Lanka.

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*Monotypic genra

Table I

Distribution of Genera of Indian umbellifers

Genera	No. of species		Species endemic to India	World distribution												
	World	India		India	China	S.E. Asia	Mediterranean	Europe	Russia	S.W. Asia	Australia	S.America	N. America	E. Asia, incl. Japan	Africa	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Acronema	25	11	5	+	+	+		·					-	·		
Aegopodium	7	3	·	+	+		+	+	+	+	−	+		−		
Ammi		3-4	2	+	−	−	−	+		−	−		−	+	+	cultivated
Anethum	2	1	−	+	−	−	+	+		+	−	−				cultivated
Angelica	110	6	3	+	+	−	+	+	−	+	··	-	+	+	-	
Anthriscus	10-12	2		+	−	-	+	+	+	+			+	+	+	adventive
Apium	25	1	−	+	+	+	+	+	+	+	+	+	−	+	−	cultivated
Aulacospermum	12	1	−	+	+	−		−	+	+						
Berula	2	1		+	+	−	+	+	+	+	−		+	+		
Bunium	45–50	3	1	−	+	+	+	+	+	−	·				+	
Bupleurum	180–190	32	10	+	+	+	+	+	+	+			+	+	−	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Carum	30	2+(1)?	1(+1)?	+	+	+	+	+	+	+	–	–	+		+	
Centella	40	1	–	+	+	+	+	+	+	+	+	+	+	+	+	mostly tropical
Chaerophyllum	35	5	3	+	+	+	+	+	+	+	–	–	+	+	+	
Chmaesium	5	4	2	+	+		·			–	·	+	+	+	+	
Cyclospermum	3	1		+	+	+	+	+	+	+	+	+	+	+		
Cicuta	8	1		+	+	+	+	+	+	+	+		+	+		
Cnidium	4–5	1	–	+	+	+	+	+	+	+			+	+	+	
Conium	6	1	–	+	+	+	+	+	+	+	+	+	+	+	+	
Coriandrum	2	1	–	+	–	–	–	+		·	–	+	+		+	cultivated
Cortia	2	2	1	+		–		–		·	–					
Cortiella	3	1		+	+	–		–	–	–			–			
Cuminum	4	1	..	+	·	·	·			+	–		+		+	cultivated
Daucus	22	1	–	+	–		+	+	+	+	+	+	+		+	cultivated
Elaeosticta	24	1	–	+	+		+	+	+					--		
Eriocycla	7	4		+	+			–		+			–	..		
Eryngium	230–250	4		+	+		+	+	+		–		·			Tropical, subtropical
Ferula	170	5	2	+	–	·	+	+	+	+					+	
Foeniculum	1	1	–	+	–	–	+	–	–	·	·		–	–	–	Cultivated

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Haplosphaera	1	2	–	+	–	–	–	–	–	–						
Heracleum	60–75	20(+)	12(+)	+	+	–	+	+	+	+		–	+	+	+	
Hydrocotyle	130	6	2	+	+	+	+	+	+	+	+	+	–	+	+	
Karnataka	1	1	1	+												Endemic
Kedarnatha	1	1	1	+						–						Endemic
Keraymonia	3	3	1	+				–								Ony Nepal Himalaya
Lalldhwojia	2	2	2	+	–		–			–				–		Endemic
Ligusticum	40–50	4	1	+	+	+	+	+	+	+			+	+		Treated in the broad sense
Meeboldia	1	1	1	+	–		–		–							Endemic
Neoconopodium	1	1	–	+		–	–	–	–	+						
Oenanthe	40	3	1	+	+	+	+	+	+	+	+		+	+	+	Marsh plant
Osmorhiza	10	1		+	+	+	–	–	–	–		+	+	+	+	
Pastinaca	14	1		+		+	+	+	+	–	+		+	–	–	cultivated
Peucedanum	100–200	7	5	+	+	+	+	+	+	+			+	+	+	May be an artificial assemblage; 2 Indian species not properly described.
Physospermopsis	10–12	5	2	+	+	–					–					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Pimpinella	150	23(+2)	16(+2)	+	+	+	+	+	+	+			+	+	+	May be an artificial assemblage; 2 Indian species not properly described.
Pinda	1	1	1	+	+		+									Endemic
Pleurospermopsis	1	1	1	+		+										Endemic
Pleurospermum	40–50	19	7	+	+		+	+	+					+		The concept followed is conservative.
Polyzygus	1	1	1	+		+										Endemic
Prangos	38	1		+	+		+	+		+					+	
Psammogeton	7	1		+	+	+										
Pternopetalum	27	4	2	+	+	+								+		
Pycnocycla	12	1		+						+					+	
Sanicula	39	1		+	+	+	+	+	+	+	+	+	+	+	+	
Scandix	15	1		+	?		+	+	+							
Schulzia	4	3	2	+	+				+	+						
Selinum	10–12	8(+1)	5–6	+	+	+		+	+	+						*Oreocome stellіphora* provisionally included, though not formally transferred.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Semenovia	18	1	–	+	+	–	–	+	+	+		–				
Seseli	100–120	4	1	+	+	+	+	+	+	+	+	–	+	–	+	
Sinocarum	12–15	6(+2)	5(+2)	+	+			–							–	
Sium	14	1	–	+	+	+	+	+	+	+	+	+	+	+	+	Marsh plant
Tongoloa	8–10	2(+2)		+	+											
Tordyliopsis	1	1	1	+	–											Endemic
Torilis	15	4(+1?)		+	+	+	+	–	+	+			+		+	
Trachydium	2	2		+	+	–	–									
Trachyspermum	10–15	6	3	+	+	+	+				·					2 species cultivated
Turgenia	2	1		+		–		·		+			–			
Vanasushava	1	1	1	+	–	–	–							–		Endemic
Vicatia	4–6	4	–	+	+	–	·	·		+		–				
Zosima	4	1	–	+		–		–	–	+	–	–	–	–		

Table II
Conspectus of family Apiaceae in India, Bangladesh, Bhutan, Nepal and Sri Lanka

A. HYDROCOTYLOIDEAE

Hydrocotyleae -Hydrocotylinae

Centella asiatica
Hydrocotyle conferta
Hydrocotyle himalaica
Hydrocotyle hookeri
Hydrocotyle javanica
Hydrocotyle ramiflora
Hydrocotyle sibthorpioides

B. SANICULOIDEAE

Saniculeae

Eryngium billardieri
Eryngium coeruleum
Eryngium foetidum
Eryngium planum
Sanicula elata

C. APIOIDEAE

Echinophoreae

Pycnocycla glauca

Scandiceae

Authriscus caucalis
A. nemorosus
Chaerophyllum acuminatum
Chaerophyllum cachemiricum
Chaerophyllum cachemiricum var. *dissectum*
Chaerophyllum reflexum
Chaerophyllum orientale
Chaerophyllum villosum
Neoconopodium capnoides
Osmorhiza aristata
Scandix pecten-veneris

Caucalideae

Cuminum cyminum
Daucus carota
Torilis japonica
Torilis leptophylla
Torilis nodosa
Torilis stocksiana
Turgenia latifolia

Coriandreae

Coriandrum sativum

Smyrnieae

Aulacospermum stylosum
Conium maculatum
Keraymonia cortiformis
Keraymonia nipaulensis
Keraymonia triradiata
Meeboldia achilleifolia
Physospermopsis bhutanensis
Physospermopsis farillei
Physospermopsis kingdon-wardii
Physospermopsis obtusiuscula
Physospermopsis rubrinervis
Pleurospermopsis sikkimensis
Pleurospermum album
Pleurospermum. amabile
Pleurospermum angelicoides
Pleurospermum apiolens
Pleurospermum benthamii
Pleurospermum brunonis
Pleurospermum candollii
Pleurospermum corydalifolium
Pleurospermum densiflorum
Pleurospermum dentatum
Pleurospermum erosum
Pleurospermum hookeri

Pleurospermum lindleyanum
Pleurospermum. pilosum
Pleurospermum pumilum
Pleurospermum rotundatum
Pleurospermum stellatum
Pleurospermum wolffianum
Prangos pabularia
Tongoloa gracilis
Tongoloa loloensis
Trachydium roylei
Trachydium subnudum
Vicatia atrosanguinea
Vicatia coniifolia
Vicatia thibetica
Vicatia wolffiana

Apieae

Acronema bellum
Acronema. dyssimetriradiatum
Acronema handelii
Acronema hookeri
Acronema hookeri var. *graminifolium*
Acronema johrianum
Acronema muscicolum
Acronema nervosum
Acronema paniculatum
Acronema pseudotenerum
Acronema sichuanense
Acronema tenerum
Aegopodium henryi
Aegopodium kashmirica
Aegopodium podagraria
Ammi majus
Ammi visnaga
Apium graveolens
Berula erecta
Bunium bulbocastanum
Bunium nothum
Bunium persicum

Buplerum aitchisonii
Buplerum andhricum
Buplerum atroviolaceum
Buplerum canaliculatum
Buplerum candollei
Buplerum dalhousieanum
Buplerum distichophyllum
Buplerum falcatum
Buplerum falcatum var. *hoffmeisteri*
Buplerum falcatum var. *marginatum* f. *stenophyllum*
Buplerum hamiltonii
Buplerum imaicolum
Buplerum jucundum var. *cachemiricum*
Buplerum khasianum
Buplerum kurzii
Buplerum lanceolatum
Buplerum linearifolium
Buplerum longicaule var. *ramosum*
Buplerum maddenii
Buplerum mucronatum
Buplerum plantaginifolium
Buplerum rotundifolium
Buplerum rupestre
Buplerum sikkimense
Buplerum subuniflorum
Buplerum thomsonii
Buplerum virgatum
Buplerum wightii
Carum carvi Linn.
Carum diversifolium
Carum villosum
Chamaesium malleanum
Chamaesium noven-jugum
Chamaesium shrestaenum
Chamaesium viridiflorum
Ciclospermum leptospermum
Cicuta virosa
Cnidium monnieri
Cortia depressa

Cortia staintoniana
Cortiella hookeri
Elaeosticta aitchisonii
Elaeosticta meifolia
Eriocycla caespitosa
Eriocycla nuda
Eriocycla stewartii
Eriocycla thomsonii
Foeniculum vulgare
Haplosphaera himalayensis
Karnataka benthamii
Kedarnatha sanctuarii
Ligusticum afghanicum
Ligusticum albo-alatum
Ligusticum elatum
Ligusticum marginatum
Oenanthe fistulosa
Oenanthe hookeri
Oenanthe javanica
Oenanthe thomsonii
Pimpinella acuminata
Pimpinella adscendes
Pimpinella atropurpurea
Pimpinella bracteata
Pimpinella candolleana
Pimpinella diversifolia
Pimpinella diversifolia
Pimpinella evoluta
Pimpinella flaccida
Pimpinella hastata
Pimpinella heyneana
Pimpinella inundata
Pimpinella leschenaultii
Pimpinella nervosa
Pimpinella pimpinellisimulacrum
Pimpinella pulneyensis
Pimpinella sikkimensis
Pimpinella stracheyi
Pimpinella tibetanica

Pimpinella tirupatiensis
Pimpinella tomentosa
Pimpinella tongloensis
Pimpinella urceolata
Pimpinella wallichiana
Pimpinella wallichii
Psammogeton canescens subsp. *biternatum*
Pternopetalum radiatum
Pternopetalum senii
Pternopetalum tanakae
Pternopetalum vulgare
Schulzia dissecta
Schulzia garhwalica
Schulzia hameliana
Selinum candollii
Selinum cortioides
Selinum dissectum
Selinum elatum
Selinum papyraceum
Selinum striatum
Selinum vaginatum
Selinum wallichianum
Seseli buchtormense
Seseli cyclolobum
Seseli diffusum
Seseli mucronatum
Seseli trilobum
Sinocarpum acronemilium
Sinocarpum clarkeanum
Sinocarpum coloratum
Sinocarpum normanicum
Sinocarpum sikkimense
Sinocarpum wolffianum
Sium latijugum
Trachyspermum ammi
Trachyspermum anethifolium
Trachyspermum falconeri
Trachyspermum khasianum
Trachyspermum roxburghianum

Angeliceae

Angelica cyclocarpa
Angelica glauca
Angelica harae
Angelica nubigena
Angelica roylei
Angelica sikkimensis

Peucedaneae

Anethum graveolens
Ferula jaeschkeana
Ferula narthex
Ferula ovina
Ferula thomsonii
Ferula wolfii
Lalldhwojia cooperi
Lalldhwojia staintonii
Peucedanum anamallayense
Peucedanum dehradunense
Peucedanum dhana var. *dalzellii*
Peucedanum josephianum
Peucedanum nagpurense
Peucedanum nepalense
Peucedanum ramosissimum

Tordylieae

Heracleum aquilegifolium
Heracleum biternatum
Heracleum burmanicum
Heracleum cachemiricum
Heracleum candicans
Heracleum candolleanum
Heracleum canesens
Heracleum ceylanicum
Heracleum dalgadianum
Heracleum grande
Heracleum hookerianum

Heracleum jacquenontii
Heracleum lallii
Heracleum nepalense
Heracleum obtusifolium
Heracleum pinnatum
Heracleum rigens
Heracleum sprengeleanum
Heracleum sublineare
Heracleum wallichii
Pastinaca sativa
Pinda concanensis
Polyzygus tuberosus
Semenovia thomsonii
Tetrataenium himalayense
Tordyliopsis brunonis
Vanasushava pedata
Zosima absinthifolia

DISTRIBUTION/PHYTOGEOGRAPHY

According to Mukherjee and Constance (1993) the family is represented in India (including Bangaldesh, Bhutan and Nepal) by 68 genera and about 240 species. However, the current listing shows that in the same area there are 70 genera and about 260 species including 10 more yet to be described and 7 varieties/subspeics/forma. Of these, genera *Karnataka*, *Pinda*, *Polyzygus*, *Vanasushava*, *Kedarnatha*, *Keraymonia*, *Lalldhwojia*, *Meeboldia*, *Pleurospermopsis*, *Neoconopodium*, *Tordyliopsis* are endemic. The first five are monotypic taxa of peninsular India; *Kedarnatha* and *Meeboldia* are monotypic and from Garhwal-Kumaon (Uttaranchal) Himalaya; *Tordyliopsis* is a monotypic of wider range from Garhwal to Sikkim outer Himalaya; *Pleurospermopsis* represented by a single species from Sikkim Himalaya and the rest two are from Nepal to Bhutan Himalaya. The total number of endemic species to this region turns out to be about 38 per cent against the estimate of 25 per cent (Mukherjee & Constance 1993) but almost half of Chatterjee's (1939) estimate (72.8%). Estimates of endemic taxa are provisional and varying figures reflect the differences in taxonomic opinions.

Of the total species about two-thirds are Himalayan, about one-tenths are peninsular Indian, and one-twelths occur in East and North-east India. These areas represent the three principal foci of the family in the subcontinent. The rest are wide. The largest number is found in central and western Himalaya including Nepal (122), while eastern Himalaya, from Sikkim to Arunachal Pradesh, has 50, some 20 are common to both the regions.

The Himalaya provide a unique corridor for distribution of Umbellifers between eastern and western Asia and thus have the greatest diversity of the family. Some of the genera are common with Iran, Afghanistan, Pakistan from one end, Kirghiz or Altai mountains in another extreme to Myanmar, Sichuan, Yunnan, Thailand and Vietnam at the other end. Himalayan taxa spill over to Tibet or vice-versa. Where the same genus occurs both in the Himalaya and Peninsular India (e.g. *Bupleurum, Pimpinella, Peucedanum, Heracleum,* etc.), the number of Himalayan species is usually greater. *Zosima absinthifolia, Hydrocotyle javanica, Oenanthe javanica* and a few more species of wide distribution elsewhere occur both in the Himalaya and Peninsular India. *Pycnocycla glauca, Seseli diffusum, Peucedanum nagpurense, Sanicula elata* and a number of mostly annual weeds from the Mediterranean area or Central or South-western Asia, are represented in the central hills and plains together with a few cultivated species and the cosmopolitan *Centella asiatica*. *Osmorhiza*, an american genus, is distributed in India through Japan and China showing a Arcto-Tertiary relationship of North America and eastern Asia (Constance & Shan, 1948). The other holarctic genera suggestive of a former close affinity with the Arcto-Tertiary Geoflora are *Angelica, Ligusticum, Sium* and *Heracleum* (Mathias, 1965).

Though Mathias (1965) recognised two centres of distribution (Mediterranean and Western United States including Mexico), Pimenov and Leonov (1993) consider Asia as one of the major centres of diversity of Umbelliferae. Pimenov and Leonov (1993) presented a pairwise comparison of distribution of genera amongst the 28 subdivisions/regions of the world, where India (likely to include parts of Pakistan and Myanmar) is recognised as South Asia. This part has the highest pair-wise similarity with South West Asia, followed by with East Asia (China partly), Middle and Central Asia, Europe (West, South, South-east, East, Central), Africa (North, Tropical), North America, Caucasus and South-east Asia, having least similarity with Antarctic, Australia, South America and Oceanea.

Dealing with the distribution of Xizang Umbelliferae, Shan and Sheh (1980) found the dominance of Eurasian and Sino-Himalayan elements. Mukherjee (1978), while discussing the phytogeography of Indian Umbelliferae, found five floristic elements, viz. Sino-Tibetan, Eurasian, African, Mediterranean and Malayan apart from the endemic and indigenous ones. Shan and Sheh (1980) recognised eight types of floristic elements in Xizang umbellifers: Sino-Himalayan, Sichuan-Yunnan - Xizang type, East Asia - North American type, Sino-Japanese type, Indo-Malayan type, Eurasian type, Mediterranean type and Cosmopolitan type.

The present distribution of Indian umbellifers shows the following types of floristic elements:

Endemics: Genera, like *Karnataka, Kedarnatha, Pinda, Polyzygus, Vanasushava, Pleurospermopsis*, etc., a majority of which are Peninsular Indian, probably represent palaeo-endemics. Their affinity may lie with taxa from southern hemisphere. Also a good number of species, specially in genera which have wider distribution, and development elsewhere, are endemic.

South West Asian: Taxa which can grow on drier aspects of moderate altitudes, found in N.W. India and Kashmir. The notable genera are *Ferula, Eryngium, Prangos, Semenovia, Scaligeria, Turgenia, Psammogeton, Zosima*, etc.

Sino-Himalayan: Best developed in Kumaon to Arunachal Pradesh including Nepal and Bhutan. The prominent genra are *Acronema, Chamaesium, Pternopetalum, Haplosphaera, Cortiella, Cortia, Vicatia, Tongoloa, Trachydium*, etc., which may be called endemics to a broader area comprising Himalaya and Tibetan Plateau. Their preference is for higher altitudes with low precipitation and high wind velocity. Yunnan elements have some commonness, though a close similarity is expected with umbellifers from Patkoi range of Nagaland and Mizoram, which unfortunately are not well explored.

Mediterranean: These elements are fairly common in Pir Panjal of Kashmir, Zanskar, Dhauladhar ranges of Himachal Pradesh, Garhwal to Kumaon but the number dwindles further east. The genera of this type are; *Torilis, Anthriscus, Pycnocycla, Trachyspermum, Aegopodium, Berula*, etc.

Eurasian: The elements of this type prefer habitats in colder yet moister parts of Himalayan ranges, even forming disjunct distributions to closely similar habitats in the Peninsular mountain ranges. The common genera are: *Carum, Bunium, Pimpinella, Buplerum, Selinum, Angelica, Peucedanum, Sium, Heracleum, Pleurospermum, Ligusticum, Chaerophyllum, Ciclospermum*, etc.

Eastern Asiatic: This can otherwise be called Sino-Japanese having affinity to North American flora and elements of this type are not of great importance being very few in number, transgressing parts of Himalaya. The notable genera are *Osmorhiza* and *Cicuta*.

Indo-Malayan: Occurring in lower altitudes to warmer parts of India are genera, like *Hydrocotyle, Oenanthe* and *Sanicula* which are Southern hemispheric ones.

Cosmopolitan/Cultivated: *Foeniculum, Coriandrum, Daucus, Apium, Anethum*, etc. mainly as winter crops in warmer parts of India.

The Indian umbellifers, though have a great influene from the floras of adjoining countries, yet the individuality is seen in the development of a number of endemic taxa commensurate with the vast area of varied physiography and climate and a long history can not be precluded.

ECONOMIC IMPORTANCE

Umbellifers yield a number of the common spices and seasoning products as well as some articles of food. For decoration purposes, they are of little use, because flowers are not sufficiently showy and quickly wilt and fade away when collected and put into water.

Great majority are aromatic and include several medicinal and cultivated herbs; the non-aromatic members are acrid and narcotic. The cultivated ones in India are found from quite a long period have not only become perfectly naturalised but are also known to natives and have names in different languages of the country. Some of the economically important umbellifers of India are:

Ammi majus: (Bishop's weed, Lady's lace) Originally from Mediterranean region, introduced chiefly for decorative purposes. Said to have aromatic seeds, used as tonic, stomachic, carminative and diuretic; also for angina pectoris and asthma.

Anethum graveolens: (Dill, Satapuspi, Sowa, Sulpa) Fruits and other plant parts or oil from either, used for flavouring pickles, and other foods, stomachic, carminative, stimulant and other. *A. sowa* is considered as a synonym, though has different chemistry.

Angelica glauca: Himalayan; aromatic root is used as a flavouring agent, stimulant and also used for flatulence and dyspepsia.

Apium graveolens: (Celery, Ajmud, Ajowan). Leaf stalks are used raw as salad or cooked as vegetables; roots used for flavouring soups. Oil from fruits also used for flavouring, for perfume, as fixative and in medicine as stimulant, stomachic, carminative, febrifuge, etc.

Bunium persicum: (Zeera, Zira): Whole supply of zira in Indian bazars comes from this species growing in Kashmir and Himachal Pradesh. Seeds used for culinary purposes, also as carminative and insect repellant.

Carum carvi: (Caraways, Siyah-jra,Jira, Sha jra) - European, introduced; seeds used for flavouring foods and drinks; roots used as vegetable; fruit oils - stimulant, stomachic, carminative, diuretic, anthelmintic and for scabies.

Centella asiatica: (Thankuni, Mandakparni) S.E. Asia. Medicinal, leaves used as tonic, diuretic, anthelmintic, skin diseases and leprosy.

Coriandrum sativum: (Coriander, Dhanyaka, Dhania) Mediterranean. Fruits or oils used in confecitonary, for flavouring gin and liquours, medicinally used as a carminative, stomachic and to added to purgatives prevent gripping, also used in spices.

Cuminum cyminum: (Cumin, Jiraka, Jira or Zeera). S.W. Asia. Used as condiment for many foods and in drinks, ingredients in curry powders. Medicinally used as antispasmodic, astringent, stimulant, carminative, stomachic, diuretic, etc.

Daucus carota: (Carrot, Gajar, Garjara): Cultivated for its edible napiform root, universally used raw as salad or cooked as soups, stews, curries and pickles. The juice is used for colouring butter and other food articles. Medicinally used as a remedy for thread worms, to keep nitrogen balance, as a precursor of Vitamin A, as diuretic, excitant, stimulant, useful in skin afflictions, jaundice and dropsy.

Eryngium foetidum: (Jongali-memedo, podomasala). Mexico. Used as a substitute for coriander in condiments specially leaves. Root is considered stomachic.

Ferula narthex: Iran Baluchistan, to Kashmir. Used as a poor substitute for asafoetida (*F. assa-foetida*) as Hing.

Foeniculum vulgare: (Fennel, Mauri, Saunf). Southern Europe. A large number of varieties and races are in cultivation. Leaves are used in fish sauce, leaf stalks in salad reported to have diuretic properties. Fruits are used for flavouring soups, curries, confectioneries. Fruits and oils are aromatic, stimulant and carminative, specially anticolic and antiflatulant in children. Fennel water is used medicinally as a vehicle of drugs.

Trachyspermum ammi: (Ajowan, Jowan) Africa. Fruit and oil used as condiment and in medicine as a carminative, stomachic, stimulant and many other uses.

Trachyspermum roxburghianum: (Ajmot, Ajmuda, Randhuni). The fruit of this lesser known spicies used for flavouring curries and as an ingredient in curry powders, used in pickles, and as preservative. Leaves are used as a substitute for parseley.

RARE AND THREATENED TAXA

The species of Indian umbellifers, in general do not suffer a threat from over-exploitation but definitely so due to habitat alterations and some biotic pressures specially in the mountains (grazing, tourism, road building, dam construcitons, land slides. A few may suffer from inadequacies in reproductive capacities (*Vanasushava pedata*). But otherwise, as Mukherjee (1983) has noted, rarity as seen in herbaria can be accounted for by under exploration in certain areas. The list of 25 taxa provided by him (Mukherjee, *l.c.*) remains mostly unaltered. Almost all of them are known through their respective type(s) only.

The revised list is as follows: *Acronema nervosum, A. hookeri, A. johrianum, A. pseudotenerum, Sinocarum wolffianum, Angelica nubigena, Angelica sikkimensis, Pimpinella wallichii, Pternopetalum radiatum, Chaerophyllum cachemiricum, Heracleum jacquemontii, Meeboldia achillerifolia, Pycnocycla glauca, Carum villosum, Ligusticum albo-alatum, Bunium nothum, Karnataka benthamii, Zosima absinthifolia, Pinda concanensis, Polyzygus tuberosus, Pimpinella flaccida, P. evoluta* and *Heracleum burmanicum*. Of these, *Carum villosum* is of uncertain generic identity.

There is a need for further explorations in the right season for umbellifers, specially at higher elevations of Himalaya as well as in Arunachal Pradesh, Nagaland and Mizoram. Probably, reproductive biology is also in need of comprehensive study.

REFERENCES

Adanson, M. 1763. *Familles des plantes.* 2 vols. Vincent, Paris.

Adylov, T.A. 1983. *Conspectus florae Asiae Mediae* 7. Academy of Sciences, USSR, Tashkent.

Baillon, H.E. 1867-1895. *Histoire des plantes.* 13 vols. Hachette, Paris.

Baumann, M.G. 1946. *Myodocarpus* und die Phylogenie der Umbelliferen-Frucht. *Bot. Mus. Univ. Zurich.* **177**:13-112.

Bentham, G. 1867. Umbelliferae. In G. Bentham and J.D. Hooker, *Genera Plantarum* **1**: 859-931.

Bradley, J.M. and K.R. Fell, 1966. The anatomy of the fruit of *Heracleum sphondylium* L. *Planta Med.* **14**: 10-18.

Britton, N.L. and A. Brown, 1896-1898. *Illustrated Flora of the Northern United States and Canada.* 3 vols. Scribners. New York.

Burnett, J.F. 1835. *Outlines of Botany,* 2 vols. London.

Calestani, V. 1905. Contributo alla Systematica dell ombrellifere d'europa. Webbea **1**: 89-280.

Cannon, J.F.M. 1978. Umbelliferae: *Flora Zamesiaca.* **4**: 555-621.

Cannon, J.F.M. 1978. Umbelliferae: In Hara, H. and L.H.J. Williams (eds.) *An Enumeration of the flowering plants of Nepal.* **2**:184-190.

Cannon, J.F.M. and E.S. Martins, 1981. Umbelliferae. In Mendes, E.J. (ed.) *Flora Mocambique.* **87**: 1-59.

Cauwet-Marc, A.M. and L. Carbonier (eds.) 1978. *Actes du Ze Smposium Interl. Sur les Ombelliferes.* Pwerpignan.

Cerceau-Larrival, M. Th. 1962. Plantules et pollens d'Ombelliferes. *Mem. Mus. Hist. Nat. Paris.* II. Ser. B. **14**: 1-164.

Chakrabarty, C. 1989. Micromorphological studies on the leaves, bracts and bracteoles in some members of the Indian Umbelliferae. Ph.D. Thesis, Calcutta University (Unpublished).

Chakrabarty, C. and P.K. Mukherjee.1986. Studies on *Bupleurum* in India. I. Secretory structure in leaves. *Feddes Repr*t. **97**: 479-487.

Chakrabarty, C. and P.K. Mukherjee. 1993. *Umbelliferae (Apiaceae) of India*. Oxford & IBH, New Delhi.

Chatterjee, D. 1939. Studies on the endemic flora of India and Burma. *J. Asiat. Soc. Bengal.* **2**(5):19-67.

Clarke, C.B. 1879. Umbelliferae. In: J.D. Hooker, Flora British India. **2**: 665-720. L. Reeve & Co., London.

Clarke, C.B. 1886. Botanical observations made in a journey to the Naga hills. *Journ. Linn. Soc.* **21**: 384-391.

Clarke, C.B. 1989. On the plants of Kohima and Muneypur. *Jour. Linn. Soc.* **25**: 1-107.

Constance, L. 1971. History of the classification of Umbelliferae (Apiaceae) In: Heywood, V.H. (ed.) *The Biology and Chemistry of Umbelliferae*. pp. 1-9. Academic Press, London.

Constance, L. 1987. *Neogoezia* (Apiaceae), a very distinct and elegant genus of Medican Umbelliferae. *Opera Bot.* **92**: 59-71.

Constance, L. and R.H. Shan. 1948. The genus *Osmorhiza* (Umbelliferae). A study in geographic affinity. *Univ. Calif. Publ. Bot.* **23**(3):111-156.

Dalechamps, J. 1586. *Historia generalis plantarum*. 2 vols. Leiden.

Dalzell, N.A. 1850. Contributions to the Botany of Western India. *Hooker's J. Bot.* **2**: 260.

Dawson, J.W. and C.J. Webb. 1978. Generic problems in Australasian Apioideae (Umbelliferae). In: Cauwet-Marc, A.M. and L. Carbonnier (eds.) *Actes Symp. Intnl. sur les Ombelliferes*. pp. 21-32. Perpignan.

De Candolle, A.P. 1830. Umbelliferae. In *Prodr. Syst. natur. reg.* Veg. **4**: 55-250.

Dodoens, R. 1583. *Stripium Historiae Pemptades sex sive Libri.* Antwerp.

Don, D. 1825. Umbelliferae. In: *Prodromus Florae Nepalensis.* pp. 182-185.

Drude, C.G.O. 1898. Umbelliferae. In Engler, A. and H. Prantl (eds.) *Die Natürlichen Pflanzenfamilien.* **38**:63-250, 271.

Edgeworth, M.P. 1846. Descriptions of some unpublished species of plants from North Western India. *Proc. Linn. Soc.* **1**:252-253.

Edgeworth, M.P. 1851. On some unpublished species of plants from North-Western India. *Trans. Linn. Soc.* **20**:51-58.

Endlicher, S.L. 1836-1840. *Genera Plantarum.* Vienna.

Farille, M.A., A.M. Cauwet-Marc, A.M. and S.B. Malla. 1984. Apiaceae Himalayenses I. *Bull. Soc. Bot. France* **131**(1):63-73.

Farille, M.A., A.M. Cauwet-Marc, A.M. and S.B. Malla. 1985. Apiaceae Himalayenses. III. *Candollea.* **40**(2):5059-562.

Froebe, H. 1971. Inflorescence structure and evolution in Umbelliferae. In Heywood, V.H. (ed.) *The Biology and Chemsitry of Umbelliferae.* pp. 157-178. Academic Press, London.

Gamble, J.S. 1919. Umbelliferae. In *Flora of the Presidency of Madras.* **1**(3):554-566.

Guyot, M. 1971. Phylogenetic and systematic value of stomata of the Umbelliferae. In V.H. Heywood (ed.). The Biology and Chemistry of Umbelliferae. pp. 199-216. Academic Press, London.

Haines, H.H. 1922. Umbelliferae In *The Botany of Bihar and Orissa.* **1**(3):404-413.

Hedge, I.C. and J.M. Lamond, J.M. 1987. General remarks, characters. In Rechinger, K.H. (ed.) Umbelliferae. In Flora Iranica. **162**: 5-13.

Hedge, I.C. and J.M. Lamond, 1992. Umbelliferae. In: *Flora of Thailand.* 5(4):442-470.

Hedge, I.C., J.M. Lamond and Rechinger, K.H. 1987. Umbelliferae. In Rechinger, K.H. (ed.) *Flora Iranica*. Akademische Druk, Austria.

Heywood, V.H. 1968. Scanning electron microscopy and microcharacters in the fruits of the Umbelliferae-Caucalideae. *Proc. Linn. Soc. London.* **179**:287-289.

Heywood, V.H. 1971. Systematic survey of the old world Umbelliferae. In: Heywood, V.H. (ed.) *The Biology and Chemistry of Umbelliferae.* pp. 31-42. Academic Press, London.

Heywood, V.H. 1973. The taxonomic position of *Agrocharis* Hochst. and allied genera. *Notes Roy. Bot. Gard. Edinburgh.* **32**(2):211-215.

Heywood, V.H. 1978. Multivariate taxonomic synthesis of the tribe Caucalideae. In: Cauwet-Marc., A.M. and J. Carbonier (eds.) *Actes du Symp. Intenl. Sur les Ombelliferes.* pp. 149-159. Perpignan.

Heywood, V.H. and K.M.M. Dakshini 1971. Fruit structure in the Umbelliferae-Caucalideae. In: Heywood, V.H. (ed.) *The Biology and Chemsitry of Umbelliferae.* pp. 215-232. Academic Press, London.

Hiroe, M. and L. Constance 1958. Umbelliferae of Japan. *Univ. Calif. Publ. Bot.* **31**: 1-144.

Hoffmann, G.F. 1814. *Genera Plantatum Umbelliferarum.* Moscow.

Hoffmann, G.F. 1816. *Plantarum Umbelliferarum genera.* 1(1 & 2). Moscow.

Hutchinson, J. 1959. *The Families of Flowering plants.* ed. 2. 2 vols. Clarendon Press, Oxford.

Hutchinson, J. 1969. *Evolution and Phylogeny of Flowering Plants.* Academic Press, London.

Hylander, N. 1945. Nomenklatorisch und Systematische Studien uber nordische Gefasspflanzen. *Uppsala Univ. Arsskr.* 7:5-337.

Jackson, G. 1933. A study of the carpophore of the Umbelliferae. *Amer. Jour. Bot.* **20**:121-144.

Jussieu, de A.L. 1789. *Genera Plantarum.* Paris.

Kapoor, L.D. and B.K. Kaul 1967. Studies on the vittae (oil canals) of some important medicinal Umbelliferous fruits. I. *Proc. Nat. Inst. Sci. India* B, **33**:1-26.

Karthikeyan, S. 2000. A statistical analysis of flowering plants of India. In: Singh, N.P., D.K. Singh, P.K. Hajra and B.D. Sharma (eds.) *Flora of India, Introductory Volume*, Part II: 218-234. BSI, Dehra Dun.

Kitamura, S. 1960. Umbelliferae. *In Flora of Afghanistan*. 2:281-291.

Krahulik, J.L. and W.L. Theobald 1981. Umbelliferae. In: Dassanayke, M.D. (ed.) *Flora of Ceylon.* 3:479-499. Oxford & IBH, New Delhi.

Koch, W.D.J. 1824. Genera tribuumque Umbelliferarum nova dispositio. Nova Acta Acad. Leop. Carol. **12**: 55-156.

Koso-Poljansky, B.M. 1916. Sciadophytorum systematis lineamenta. Bull. *Soc. Imp. Natl. Moscow.* II. **29**:93-221.

Kowal, T. and H. Wojterska. 1973. Morfologicizne i anatomiczne cechy diagnostyczne owocow wybranych rodzaju *Peucedanum* L. *Pr. Komis. Biol. PTPN.* 35, **7**:457-491.

La Gasca, M. 1821. Dispositio Umbelliferarum Carpologica. *Amen. Nat. Espanas* **1**(2):87-111.

La Gasca, M. 1826. *Observaciones sobre la familia natural de las plantas. Aparasoladas* (*Umbelliferae*). London.

Lindley, J. 1835. Notes upon some of the Himalayan Umbelliferae. In: Royle, J.F. (ed.) *Illustr. Fl. Himal. Mount.* 232-233, pls. 51-52.

Lindley, J. 1836. *A natural system of Botany.* 2nd ed. London.

Linnaeus, C. 1753. *Species Plantarum*, 2 vols. Stockholm.

Mabberley, D.J. 1997. *The Plant Book*, 2nd ed. Cambridge Univ. Press, Cambridge.

Mathias, M.E. 1965. Distribution patterns of certain Umbelliferae. *Ann. Missouri Bot. Gard.* **52**:387-398.

Morison, R. 1672. *Plantarum Umbelliferarum distributionova*. Oxford.

Moynier de Vellopoix, R. 1878. Researches sur les Canaux Secreteurs du fruit des Ombelliferes. *Annals. Sci. Nat.* Ser. 6, **5**:348-365.

Mukherjee, P.K. 1969. *Hydrocotyle himalaica* P.K. Mukherjee, a new *Hydrocotyle* from India. *Indian For.* **95**(7):470.

Mukherjee, P.K. 1969. Some name changes in Indian Umbelliferae. *Indian For.* **95**(8):95.

Mukherjee, P.K. 1970. On the identification and typification of *Pimpinella urceolata* Watt ex Banerjee (Apiaceae). *Bull. Bot. Surv. India* **12**:77-79.

Mukherjee, P.K. 1971. A note on the correct identity of *Pimpinella radiata* W.W.Sm. *Indian For.* **94**:55.

Mukherjee, P.K. 1972. Taxonomic studies on Indian Umbelliferae. Ph.D. Thesis, Calcutta University (Unpublished).

Mukherjee, P.K. 1978. A resume of Indian Umbellifers. In: Cauwet-Marc, A.M. and J. Carbonier (eds.) *Actes Symp. sur les. Internat. Ombelliferes*. pp. 47-70. Perpignan.

Mukherjee, P.K. 1983a. Nomenclatural transfers in Indian Umbelliferae. *Bull. Bot. Surv. India* **24**:42-45.

Mukherjee, P.K. 1983b. Distribution and colleciton of rare umbellifers in India. In Jain, S.K. and R.R. Rao (eds.) *An Assessment of Threatened Plants of India*. pp. 202-206. BSI, Calcutta.

Mukherjee, P.K. 1987, 1988. Apiaceae. In: Nayar, M.P. and A.R.K. Sastry (eds.) *Red Data Book of Indian Plants*. **1**:33-40. BSI, Calcutta.

Mukherje, P.K. 1988. Apiaceae. In: Nyar, M.P. and A.R.K. Sastry (eds.) *Red Data Book of Indian Plants* **2**: 19-30. BSI, Calcutta.

Mukherjee, P.K. and L.Constance 1974. *Vanasushava*, an old South Indian umbellifer renamed. *Kew Bull.* **29**:593-596.

Mukherjee, P.K. and L.Constance 1986a. A new disposition of the South Indian *Heracleum concanense* Dalzell (Umbelliferae). *Kew Bull.* **41**:223-229.

Mukherjee, P.K. and L.Constance 1986b. Two new genera of Indian Umbelliferae/Apiaceae. *Brittonia* **38**:145-149.

Mukherjee, P.K. and L.Constance 1991. New taxa and transfers to Indian Umbelliferae, *Edinburgh Journ. Bot.* **48**:41-44.

Mukherjee, P.K. and L. Costance 1993. *Umbelliferae (Apiaceae) of India*. Oxford & IBH, Calcutta.

Nasir, E. 1972. Umbelliferae. In Nasir, E. and S.I. Ali (eds.) *Flora West Pakistan* **20**:1-169. Karachi.

Nicolson, D.H. 1995. Review of Umbelliferae (Apiaceae) of India by Mukherjee (Mukhopadhyay) Prasanta Kumar & Constance, Lincoln. *Taxon* **44**:115.

Okeke, S. 1978. Morphological variation of bracats, bracteoles and fruits in *Daucus*. In: Cauwet-Marc, A.M. and J. Carbonnier (eds.) *Actes du Symp. Internl. sur les Ombelliferes*. pp. 161-174. Perpignan.

Pimenov, M.G. 1975. Revision du genere *Pachypleurum* Ledeb. et description du nouveau genere *Dimorphosciadium* (Umbelliferae-Apioideae) d'Asie Moyenne. *Bjull. Moscov. Obshch. Ispt. Pri-Ord. Biol.* **80**(3):76-84.

Pimenov, M.G. 1976. Deux especes nouvelles du genre *Ferula* L. en Kirgisia. *Bot. Zurh.* (Leningrad), **61**(9):1230-1231.

Pimenov, M.G. and L. Constance 1985. Nomenclature of suprageneric taxa in Umbelliferae/Apiaceae. *Taxon*. **34**:493-501.

Pimenov, M.G. and E.V. Kljuykov 1987. *Neoconopodium* a new genus of the Umbelliferae from the Himalaya. *Feddes Repert.* **98**:373-378.

Pimenov, M.G. and L.I. Sdobnina. 1973. Sur quelques especes du genre *Libanotis* (Hall) Zinn decrit de Kazakstan. *Bot. Zhurn.* (*Leningrad*) **58**:1485-1492.

Pimenov, M.G. and M.V. Leonov 1993. *The genera of the Umbelliferae.* Kew & Botanical Garden of Moscow University, Russia.

Pimenov, M.G., P.K. Mukherjee, P.K., E.V. Kljuykov and M.V. Leonov 1991. Notes on the genera *Vicatia* DC., *Sindodielsia* Wolff. and *Tongoloa* Wolff (Umbelliferae). *Feddes Repert.* **102**:375-384.

Pimenov, M.G., T. Ostrooumova, L.P. Tankovitch and E.V. Kljuykov, E.V. 1986. La structure anatomique du petiole d'Ombelliferes d'Asie Centrale. *Bull. Mus. Natn. Paris*, Ser. 8. **4**(1):77-99.

Ray, N. 1985. Micromorphological studies of fruits of some members of Indian Umbelliferae. Ph.D. Thesis, Calcutta University (Unpublished).

Ray, N., C. Chakrabarti and P.K. Mukherjee 1987. SEM survey of surface characters and their systematic importance - an appraisal from studies on Umbelliferae. *Plant Science Research* (*Visva Bharati*): 142-148.

Reduron, J.P. 1977. Contribution a l'etude morphologique du petale chez les Ombelliferes. In: Cauwet-Marc, A.M. and J. Carbonnier, (eds.) *Actes Symp. Internal. Sur les Ombelliferes.* pp. 121-127. Perpignan.

Rechinger, K.H. and H. Riedle 1963. Umbelliferae. In: Koie, M. and K.H. Rechinger (eds.) *Symbolae Afghanicae.* V. *Biol. Skr.* **13**(4):27-135.

Reichenbach, H.G.L. 1828. *Conspectus regni vegetabilis.* Leipzig.

Rivas, de S., V.H. Heywood, S. Jury and A.L. Attar 1978. Etude micromorphologique et anatomique du fruit des *Caucalideae* Bentham (Umbelliferae). In: Cauwet-Marc, A.M. and J. Carbonnier (eds.) *Actes Symp. Internal. sur les Ombelliferes.* pp. 175-194. Peripignan.

Rompel, J. 1895. Krystalle von calcium oxalat in der Fruchtwandt der Umbelliferen und ihre verwerthung fur die systematik. *Setzungsber. Akad. Wiss. Wien.* **104**:417-1476.

Roxburgh, W. 1832. *Flora Indica or Descriptions of Indian Plants*. ed. W. Carey. **2**:89-97.

Royle, J.F. 1839. Umbelliferae. In: *Illustrations of the Botany and other branches of the natural history of the Himalayan mountains and of the flora of Kashmir*: 227.

Sandina, I.B. 1957. The significance of the carpological characters in the taxonomy of the genus *Heracleum* L. (in Russian). *Bot. Zuhrn.* **42**:535-559.

Shan, R.H. and M.L. Sheh (eds.) 1979, 1985. Umbelliferae. In *Flora Republicae Popularis Sinicae* **55**(1):318 pp. & **55**(2):282 pp.

Shan, R.H. and M.L. Sheh (eds.) 1980. Xizang Umbellifers: their geographical patterns and floristic characteristics. *Bull. Nanjing Bot. Gard.* **1980**:12-20.

Sprengel, K. 1813. Plantarum Umbelliferarum denuo disponendrum prodromus. Halle.

Sprengel, K. 1820. Umbelliferae. In Roemr and Schultes (eds.) *Systema Vegetabilium*. **6**:315-628.

Sprengel, K. 1825-1828. *Caroli Linnaei ... Systema Vegetabilium*, 16th ed. 5 vols. Gottingen.

Tardieu-Blot, M.L. 1967. *Umbelliferae: Flore du Cambodge, du Laos et du Vietnam*. **5**:1-77.

Theobald, W.T. 1971. Comparative anatomical and developmental studies in the Umbelliferae. In: Heywood, V.H. (ed.) *The Biology and Chemistry of the Umbelliferae*. pp. 177-198. Academic Press, London.

Thorne, R.F. 1968. Synopsis of a putatively phylogenetic classification of the flowering plants. *Aliso* **6**:57-66.

Thorne, 1973. Inclusion of the Apiaceae (Umbelliferae) in the Araliaceae. *Notes Royal Bot. Gard. Edinburgh* **32**:161-165.

Thorne, R.F. 1992. Classification and geography of the flowering plants. *Bot. Rev.* **58**:225-348.

Tichimirov, V.N. and O.N. Galakova. 1965. Materials on the morphology of the group Angelicinae. 1. The investigation of fruit anatomy of *Angelica sylvestris* L. as a lectotype of genus (in Russian). *Bull. Soc. Nat. Moscow Biol.* **70**:111-118.

Tichimirov, V.N. and O.N. Tretyakova. 1967. Materials on morphology of the group Angelicinae. 2. Comparative description of the fruit of the species of the subgenus *Angelica* (in Russian). Bull. Soc. Nat. Moscow. Biol. **72**:43-54.

Tournefort, J.P. 1694. *Elements de Botanique*. 3 vols. Paris.

Tseng, C.C. 1967. Anatomical studies of flower and fruit in the Hydrocotyloideae (Umbelliferae). *Univ. Calif. Publ. Bot.* **42**:1-58.

Van Rheede, H.A. 1678-1703. *Hortus Indicus Malabaricus*. 12 vols. Amsterdam.

Wallich, N.A. 1828-29. *A numerical list of dried specimens of plants in the East India Company's Museum [Wallich Catalogue]* (unpublished).

Walters, S.M. 1961. The shaping of Angiosperm Taxonomy. *New Phytol.* **60**:74-84.

Wight, R. and G.A. Walker-Arnott 1834. *Prodromus Florae Indiae Orientalis*: pp. 365-375.

IMPATIENS

M.S. Swaminathan,
K. Vivekananthan
V.J. Nair

INTRODUCTION

Biological diversity of India is one among the most significant and richest in the World. With just over two per cent of World's landmass (329 million hectares of area), it has about 7 per cent of living resources, one third of which are land- bound. India, therefore, has been designated as one of the 12 mega-diversity centres of the World. As many as 45,000 species of plants and over 77,000 species of animals of the world have so far been recorded from here. This great diversity of plants and animals is due to the vast geographical area extending over many degrees of latitude, varied topography, climatic zones and the position at the junction of so many biogeographic regions and subregions. Biota from Malaysia, humid as well as arid zones of Africa and Europe, temperate regions of Asia, Mediterranean area, west Asian deserts and the subtropical lands of China have intermingled with a vast array of endemic forms, to create this exceptional richness. It, however, looks paradoxical that such a biodiversity rich area of the tropics has become the worst affected region of increasing incidence of biodiversity loss.

The significant new entrants on the biological diversity scene, are the flowering plants and mammals. The flowering plants have produced about 2,50,000 species in just seventy million years of their evolution. This diverse Angiosperm group has colonised every nook and corner of the world and has become the sustainer of all non-green life forms. India has more than 75 per cent of the 425 families (now defined) of flowering plants, classified and found all over the world. Nayar (1977) has recorded about 15,000 species of flowering plants distributed over 2,252 genera and 304 families. Jain (1983) classified 315 families of flowering plants and enumerates the following ten dominant families based on the number of species in the flora of India:

Poaceae (1225 species), Orchidaceae (990), Fabaceae (775), Asteraceae (754), Rubiaceae (495), Cyperaceae (449), Euphorbiaceae (419), Lamiaceae (393) , Acanthaceae (379) and Scrophulariaceae (356).

According to him (Jain, *l.c.*), the ten largest families based on the number of genera that they have are: Poaceae (225 genera), Asteraceae (161), Orchidaceae (145), Fabaceae (123), Rubiaceae (90), Acanthaeae (84), Euphorbiaceae (74), Lamiaceae (68), Scrophulariaeae (66) and Brassicaceae (64). About 35 families of Indian flora have more than 100 species.

Chatterjee (1939) made an estimation of species found in India proper and Myanmar excluding those from Malaya, Sri Lanka and Tibet. Of the dicotyledonous families the following occupy the first ten positions. Papilionaceae (867), Compositae (696), Rubiaceae (551), Acanthaceae (514), Euphorbiaceae (444), Labiatae (421), Scrophulariaceae (273), Rosaceae (257), Balsaminaceae (242) and Asclepiadaceae (234). His survey further reveals that the largest genus in India undoubtedly is *Impatiens* with largest number of species. According to him *Impatiens* (241) is followed by *Primula* (162), *Strobilanthes* (*s.l.*) (152), *Rhododendron* (126), *Eugenia* (103), *Crotalaria* (99), *Gentiana* (93), *Piper* (89), *Ficus* (86), *Pedicularis* (76) and *Senecio* (75).

GEOGRAPHICAL DISTRIBUTION

Impatiens is a subcosmopolitan genus belonging to the family Balsaminaceae and its major centres of diversity are the highlands and mountains of the Old World tropics and subtropics. There are only a few Holarctic species, and none indigenous to South America or Australia (Mani, 1974; Grey Wilson, 1980). It occurs mainly in the montane regions of tropical Asia and Africa. It is also reported from Myanmar, Java, Madagascar, Philippines, Sri Lanka and Sumatra (Bhaskar, 1981). Santapau and Henry (1973) in their *Dictionary of the Flowering Plants in India*, mentions about 600 species in the World and 175 species in India of which many species are endemic and show restricted distribution in certain regions. Mabberley (1987) records about 850 species distributed in the tropics, especially India and North temperate regions [North and Central America (6), Europe (1), Africa (109) and India ca 240 species]. Some of these Indian species' names have gone under synonymy and as such this number is much reduced now.

Hooker and Thomson (1860) in their "*Praecursores ad Floram Indicum - Balsaminaceae*" states that *Impatiens* attains its maximum development in India and it presents a vast assemblage of forms.

Eventhough this genus is in a striking degree local, its species are to a considerable extent well marked and easily defined. It would be difficult to indicate another genus in the vegetable kingdom, presenting amongst its species so many and such different modifications of structure and of which the species are so universally and excessively prone to variations. He further points out that *Impatiens* attains its maximum development in India and that the Western Ghats is the most prolific area in species. Barnes (1939) who made extensive collections on the High Ranges of Kerala published an account of Geraniaceae occurring in that area. There seems to have very little doubt that in respect of species of balsams the High Range is the richest area in the Western Ghats; and consequently of the world" He recorded 12 species of *Impatiens* endemic to High Range and found more than 30 species of them within a radius of 16 km of Munnar and most of them within a much smaller area. Twelve species appear exclusively endemic to the High Ranges.

Hooker (1906) in his '*An Epitome of the British Indian Species of Impatiens*' states that a much greater proportion of the *Impatiens* species is endemic to Western Ghats than in any other area of India. About 24 species are endemic to South of latitude 8° 5' N and the number of species decreases towards North. Probably no endemic species is found North of Mahableshwar (latitude 18° N). Fifty four species have been described from the area Nilgiris to Kanniyakumari. Of these only 12 extend their distribution to the Western Ghats of Maharashtra. Peninsular balsams are in marked contrast to the Himalayan and Burmese ones. Of the two main groups of the genus namely the short capsuled and long capsuled, not even one of the latter is to be found in the Western Ghats. Two sections Scapigerae (with the exception of one species found also in Sri Lanka) and Epiphyticae are confined to peninsular India. Seven species namely, *I. barberi*, *I. denisonii*, *I. goughii*, *I. lawsonii*, *I. ligulata*, *I. omissa* and *I. viscida* belonging to three different sections have the dorsal auricle of wings produced into spur of lip. Of the 61 peninsular Indian species, not even one has two additional lateral sepals a feature that is frequently seen in Western and Eastern Himalayan and Burmese species. Of the species common to northern and eastern India, there are but three namely *I. balsamiana*, *I. chinensis* and *I. oppositifolia* in the peninsula.

Regarding the distribution of balsams in various parts of the Wesern Ghats, Hooker has pointed out that the Palghat Gap acts as the chief dividing factor. Out of the 83 species of balsams so far found in the area of erstwhile Madras Presidency, 36 and 23 occur only in South and North respectively of Palghat Gap. All the 28 caulescent pedunculate species (belonging to Hooker's section Epiphyticae, Subumbellatae and Racemosae) are found on the hills South of the Gap, whereas only two of these namely *I. goughii* and *I. fruticosa* are common to the Nilgiris and other hills towards the North. On the other hand, of the fifteen species of Scapigerae found in the former Madras Presidency ten are found North of the Palghat Gap and only two closely allied species are confined to the South. From their present distribution pattern it seems probable that the scapigerous balsams originataed on the Western Ghats North of the Palghat Gap and the caulescent pedunculate species to the South. It is interesting to note that most of the species outside the suggested area of origin of the group have very small hygroscopically hairy seeds. These restricted distribution pattern may be due to the inefficient dispersal mechanism found in the genus.

According to Chatterjee (1939) *Impatiens* is undoubtedly the largest genus in British India (including Myanmar, but excluding Malaya, Sri Lanka and Tibet) with about 241 species. Bhaskar (1981) studied the genus in South India and states that it contains over 200 species in India, half of which occur in south India. According to him it is phytogeographically a unique genus which has its greatest development in the Indian region. In India the concentration of species is remarkably local and occurs in two well defined regions, *viz.* the Himalaya in the North and Western Ghats. Just like other orophytes or the plants of the 'montane stage' *Impatiens* has a limited geographical amplitude. In India atleast 90 per cent of the species are restricted to the hills.

The balsams are mostly herbaceous annuals completing their life cycle in the monsoon period itself, while some are ephemerals. They are growing in montane niche-specific areas like wet dripping rocks, ravines and clefts of rocks, soils of rocky crevices, cushions of moss on wet rocks, margins of running streams, beds of streams or rivers, marshes, swamps, boggy places, undergrowth in dense moist forests, evergreen and shola forests, wet places in open low level grasslands, high level grasslands and epiphytes on moss clad tree trunks or growing in areas that are exposed to monsoon condition for large part of the year.

The name *Impatiens* is derived from the explosive fruit, a capsule with fleshy pericarp; the outer layer of cells are highly turgid and thus a great strain is put upon the whole. The dehiscence is septifragral and is effected by a touch when the fruit is ripe. The valves roll up inwards with violence and the seeds are scattered in all directions (Airy Shaw, 1973).

Hooker and Thomson (1860) commenced the study of British Indian *Impatiens* with just 100 species. They formed two well limited divisions based on their habit:

1. Scapigerae with tuberous perennial rhizomes; leaves all radical with long scapes and flowers in short terminal racemes.
2. The caulescents group is subdivided into a number of sections like oppositifoliae, subverticillatae, uniflorae, lateriflorae, umbellatae, capitatae, racemosae, primarily based on the habit, foliation and inflorescence character.

Hooker (1874-75) in *The Flora of British India* reports 123 species of *Impatiens* and has divided them into two series (A and B). Series A has Scapigerae, Oppositifoliae, Subverticillatae, Uniflorae, Lateriflorae, Epiphyticae, Umbellatae and Subcapitatae. Series B has Oppositifoliae, Verticillatae, Uniflorae, Axilliflorae, Subumbellatae and Racemosae. Hooker (1906) analysed the *Impatiens* again and the following sections were recognized (1) Scapigerae (2) Epiphyticae (3) Annuae, (4) Microsepalae (5) Tomentosae (6) Subumbellatae and (7) Racemosae. The morphology of the flowers of *Impatiens* has attracted the attention of many scientists who have taken different views on it. In addition, the fragile and delicate nature of floral parts make its study from the herbarium sheets/specimens very difficult. No distinctive differences can be made out from herbarium specimens. Even the great and pioneering authority, Sir J.D. Hooker encountered enormous difficulties in his studies and he himself was not satisfied with the descriptions obtained from herbarium specimens.

The study of Indian *Impatiens* is not only very difficult, but its taxonomy also is little known and inadequately understood. Floral structure, colour pattern, species delimitation, variations, natural hybridisation and speciation are particularly bewildering and perplexing. The distribution pattern, the individuality of northern and southern species, narrow endemism, neoendemics all these have contributed to make it a key genus for phytogeographical studies. After Hooker's masterly treatment, many new balsams have been described from India, but a comprehensive taxonomic treatment is lacking. The Himalayan species, particularly, are very inadequately understood and studied.

Added to these drawbacks, most species make particularly poor herbarium specimens unless a good deal of care and special techniques have been followed. As stated by Hooker (1876), determination of the species of *Impatiens* is difficult in a dried state. It is often impossible to distinguish the floral structure specially the shape of sepals and petals. To overcome all these problems and to help future taxonomic studies in this genus, the following points have to be kept in mind by the future workers during their field studies (Grey-Wilson, 1979).

1. It is required to collect some flowers separately in the field, either by pressing them in soft paper or preserving them in good fixative and dissect them carefully and press the individual parts for keeping in packets. (Special trips are to be conducted to collect the ephemerals and in wetter months when these plants are in great profusion).
2. Sketches of flowers are a valuable addition.
3. It is absolutely essential to record the colour of the flower accurately.
4. The arrangement of leaves in the lowermost nodes (which is lacking in herbarium sheets) has to be noted carefully.
5. Stipule-like processes occurring on the base of the lamina or along the petiole have to be properly studied.
6. Care to differentiate the cleistogamous flowers from regular flowers, to be taken.

DISTRIBUTION PATTERN IN INDIA

According to Hooker and Thomson (1860) the distribution of species of *Impatiens* in British India is as follows:

Kashmir, Kishtwarar and countries west of Sutlej	10
Sutlej to Nepal Frontier	13
Nepal, Sikkim and Bhutan	25
Khasia mountains	21
Malay Peninsula	8
Western Peninsula	41
Ceylon (Sri Lanka)	18

After critically studying further, Hooker (1906) in "*A Epitome of the British Indian Species of Impatiens*" details the number of species as follows:

Western Himalaya from Nepal Frontier to Chitral	25
Eastern Himalaya from the Valley of Khatmandu in Central Nepal to Mishmi Hills in Upper Assam including Tibetan Valley of Chumuli (between Sikkim and Bhutan)	63
Burmese region from Assam to Tenasserim	52
Western (Deccan) peninsula from Central India to Travancore	61

Ahmedullah and Nayar (1987) while enumerating the endemic plants of Indian region states, "of the 178 species of *Impatiens* occurring in India, 70 are endemic to the peninsular India in the southern W. Ghats where they are concentrated" Thus as per this study, the percentage of endemism of Indian Balsams in the peninsular region is 43 per cent while it is about 91 per cent for the whole of India.

Recent studies on *Impatiens* for the Flora of India revealed 203 species. Of these about 137 species are endemic to India. 80 species are distributed in Western Ghats and adjoining regions. Eastern Himalaya and adjoining areas have about 96 species and about 33 species are found in western Himalaya and adjoining regions.

Nair (1992) highlighted the endemism in Western Ghats with special reference to *Impatiens*. This non-endemic genus has a considerable number of endemic taxa in this area. According to him, in India there are more than six well-defined regions of distribution of *Impatiens*. Out of the 140 species with short swollen spindle-shaped capsules and rounded seeds only one occurs in the North-western Himalaya and of the 60 species having elongate, linear or club-shaped capsules and oblong or ovoid compressed seeds not even one occurs in the Western Ghats. There are about 86 species in the Western Ghats. *I. minor, I. oppositifolia, I. pusilla, I. scapiflora* and *I. tomentosa* are found throughout the Western Ghats. The rest of the species are restricted to certain pockets or small areas. The areas of distribution of *Impatiens* in Western Ghats are:

Maharashtra and Karnataka only: *I. dalzelli*, *I. lawii* and *I. pulcherrima*.

Chiefly Karnataka: *I. agumbeana*, *I. barberi*, *I. dendricola*, *I. latifolia*, *I. lucida*, *I. mysorensis*, *I. nataliae*, *I. pendula*, *I. raziana*, *I. rupicola*, *I. talbotii*, *I. scabriscula* and *I. tenella*.

Nilgiris and neighbourhood only: *I. clavicornu*, *I. cuspidata*, *I. debilis*, *I. denisonii*, *I. gardneriana*, *I. gerdoniae*, *I. laticornis*, *L. lawsonii*, *I. lenta*, *I. levingei*, *I. munronii*, *I. neobarnesii*, *I. nilgirica*, *I. orchioides*, *I. phoenicea*, *I. rufescens* and *I. trichocarpa*.

Wynaad and southwards: *I. cordata*, *I. diversifolia*, *I. grandis*, *I. ligulata*, *I. maculata*, *I. modesta*, *I. rheedii* and *I. viscosa*.

Anamalais and Pulney Hills: *I. chandrasekaranii*, *I. crenata*, *I. herbicola*, *I. omissa*, *I. parasitica* and *I. parvifolia*.

Anaimudi and high ranges of Kerala: *I. aliciae*, *I. anaimudica*, *I. coelotropis*, *I. disotis*, *I. elegans*, *I. goughii*, *I. henslowiana*, *I. johnii*, *I. inconspicua*, *I. leptura*, *I. leschenaultii*, *I. munnarensis*, *I. pandata*, *I. pallidiflora*, *I. platyadena*, *I. rivulicola*, *I. tangachee*, *I. verecunda*, *I. verticillata*. *I. viscida*.

Mountains of Tirunelveli and neighbourhood: *I. flaccida*, *I. travancorica*, *I. umbellata*, *I. uncinata*. *I. viridiflora*.

Isolated places: *I. dasysperma*, *I. cochinica*.

It seems that there are about 17 and 20 species of endemic *Impatiens* respectively for Nilgiris and neighbourhood and Anaimudi and High Ranges of Western Ghats. As far as this genus is concerned, these two areas appears to be important centres of speciation.

The endemic species of Himalayan region and Western Ghats are given separately in Annexure I and II. Species having wide distribution outside India and species extending its distribution only to areas bordering India are given in Annexure III and IV respectively.

Vanishing balsams of Indian flora :

Most of the Indian *Impatiens*, particularly the south Indian ones are narrow and neo-endemics and confined to specialised ecological habitats. Added to this, their colonising abilities and regenerative capacities are very poor. Hence, they become extinction-prone. When the habitat is disturbed or destroyed these endemic, niche-specific and monsoonic plants may become rare, vulnerable, endangered or extinct. Several factors may be responsible for the destruction of habitats in the montane regions in Himalaya and Western Ghats.

In South India, Henry *et al.* (1978) reported 19 species of *Impatiens* as rare and threatened while according to Vajravelu and Daniel (1983) 30 species come under this category. Shetty and Vivekananthan (1992) reported 12 endangered balsams in the High Range, Idukki district, Kerala, while Nair (1992) consolidated the list of vanishing balsams of the Western Ghats. In the three volumes of *Red Data Book of Indian Plants* (Nayar and Sastry, 1987, 1988, 1990) 8 balsams have been included under various categories. A list of rare or threatened balsams of South India and Western Himalaya are given below.

Impatiens acaulis - Rare
Western Ghats of Maharashtra, Karnataka, Tamil Nadu and Kerala; Sri Lanka.

Impatiens aliciae Endangered
Munnar, High Range, Idukki Dt., Kerala; Bababudangiri, Chikmaglur Dt., Karnataka.

Impatiens anaimudica Possibly extinct
Anaimudi slopes, Idukki Dt., Kerala.

Impatiens barberi Indeterminate
Western Ghats at Cardamony, Karnataka.

Impatiens chinensis var. *brevicornis* Endangered
Munnar, High Range, Idukki Dt., Kerala.

Impatiens cochinica - Possibly extinct
Western Ghats, Kochi (Kavalay), Ernakulam district, Kerala.

Impatiens coelotropis Vulnerable
Anaimudi slopes, Vagavoorai, Nemakad gap, High Range, Idukki Dt., Kerala.

Impatiens concinna - Indeterminate
Western Ghats (mountains of Malabar).

Impatiens crenata - Rare
Western Ghats of Karnataka, Tamil Nadu and Kerala.

Impatiens dassysperma - Rare
Western Ghats of Karnataka, Tamil Nadu and Kerala.

Impatiens dendricola - Endangered
Thadidi - Kodagu, Karnataka.

Impatiens johnii - Possibly extinct
Kalaar Valley, High Range, Idduki district Kerala.

Impatiens laticornis - Endangered
Kundahs, Nilgiri district Tamil Nadu.

Impatiens lawii - Indeterminate
Western Ghats, Bababudan hills.

Impatiens leptura - Rare
Western Ghats of Tamil Nadu and Kerala. Confined to Anaimalai and High Range.

Impatiens lucida - Rare
Western Ghats of Maharashtra, Karnataka, Tamil Nadu and Kerala.

Impatiens macrocarpa - Possibly extinct
Devicolam, High Range, Idduki Dt., Kerala.

Impatiens munronii - Rare
Western Ghats, Sispara, Nilgiri Dt., Tamil Nadu.

Impatiens nataliae - Rare
Western Ghats of Karnataka and Kerala.

Impatiens neo-barnesii - Endangered
Kundah, Nilgiri peak, Makweti, Nilgiri Dt., Tamil Nadu.

Impatiens nilgirica Endangered
Kundah range, Nilgiri Dt., Tamil Nadu.

Impatiens pallidiflora Vulnerable
Periakanal, Santampara & Devicolam, High Range, Idukki Dt., Kerala.

Impatiens pandata Endangered
Anaimudi slopes, Karunkulam, High Range, Idukki Dt., Kerala.

Impatiens platyadena - Possibly extinct
Kadalaar Valley, Nemakad Gap, High Range, Idukki Dt., Kerala.

Impatiens rivulicola Endangered
Puriar Valley, Munnar, Lockhert Gap, High Range, Idukki Dt., Kerala.

Impatiens setosa

Impatiens stocksii - ?Rare. Indeterminate.

Impatiens talbotii Rare
Agumbe - Shimoga, N. Kanara Dt., Karnataka.

Impatiens verecunda - Possibly extinct
Pereiakanal, Devicolam, High Range, Idukki Dt., Kerala.

Impatiens viridiflora - Rare
Western Ghats in Sivagiri hills, Tirunelveli Dt.,Tamil Nadu.

Impatiens wightiana - Rare
Western Ghats of Tamil Nadu and Kerala. Confined to Anaimalai, Anaimudi and High Range.

Impatiens harrissii - Extremely rare
Western Himalaya.

Impatiens meeboldii - Very rare
Kashmir (endemic)

Impatiens pahalgamensis Rare
Kashmir (endemic).

CONSERVATION

If the large number of endemic species of *Impatiens* are eliminated from our country, it will mean that they will be annihilated from the whole world, will be lost to science and will be struck off from the rolls of biological resources of this earth. Therefore, in our conservation effort, we should give some priority to the genus *Impatiens* of India. Some of the measures required for this are:

1. Taxonomy and distribution has to be studied in detail as a pre-requisite for evolving proper conservation strategies. Fresh collections are to be made and drawings and colour photographs prepared in the field itself during monsoon periods.

2. Photographs of the type materials deposited in the Kew Herbarium, Barnes Herbarium, CAL Herbarium, etc. should be procured and made available to taxonomists to help in locating and collecting the rare species.

3. Special collection techniques suggested by Grey Wilson (*l.c.*) has to be followed.

4. The special habitats of *Impatiens*, like marshes, swamps, moss covered mountain cliffs facing the frontal attack of monsoon, fringes of perennial streams and rivers, shrub savannas, sholas and evergreen forests, etc. should be protected in Western Ghats and Himalaya.

5. Simple listing of endemic and endangered plants may not be sufficient and status reports should be prepared.

6. Intensive and extensive search should be made in the type localities to ascertain whether the apparently vanished or vanishing species are really extinct or in danger of or at the verge of extinction. If they are located, *in situ* conservation measures are to be taken up.

7. As balsams are moisture and monsoon loving plants it will be difficult to propagate them in Botanic Gardens. Hence green house treatment and modern tissue culture methods should be used to multiply the rare and threatened ones among them.

8. An '*Impatiens* Sanctuary' can be established in any montane region where there is frontal attack of monsoon.

ANNEXURE - I

Species endemic to Himalayas

Impatiens acmanthera	*Impatiens khasiana*
Impatiens acuminata	*Impatiens kingii*
Impatiens annulifer	*Impatiens langeana*
Impatiens asymmetrica	*Impatiens laxiflora*
Impatiens bivittata	*Impatiens lemannii*
Impatiens bracteolata	*Impatiens leptocarpa*
Impatiens cirrhipetala	*Impatiens longirama*
Impatiens citrina	*Impatiens lutea*
Impatiens cothurnoides	*Impatiens mackeyana*
Impatiens cuspidifera	*Impatiens majumdarii*
Impatiens cymbifera	*Impatiens mannii*
Impatiens depauperata	*Impatiens marianae*
Impatiens duthiei	*Impatiens meeboldii*
Impatiens exilis	*Impatiens minimiflora*
Impatiens formosa	*Impatiens mishmiensis*
Impatiens gammiei	*Impatiens nigrescens*
Impatiens Impatiens	*Impatiens nummularifolia*
Impatiens graciliflora	*Impatiens occultans*
Impatiens humilis	*Impatiens odontosepala*
Impatiens inayatii	*Impatiens pahalgamensis*
Impatiens infundibularis	*Impatiens paludosa*
Impatiens insignis	*Impatiens pantlingii*
Impatiens jaeschkei	*Impatiens podocarpa*
Impatiens kaliensis	*Impatiens polysciadia*

Impatiens prostrata	*Impatiens trichocladon*
Impatiens reidii	*Impatiens trigonopteris*
Impatiens rubro-lineata	*Impatiens tropaeoliflora*
Impatiens spissiflora	*Impatiens tuberculata*
Impatiens stoliczkai	*Impatiens tubifer*
Impatiens stricta	*Impatiens vexillaria*
Impatiens striolata	*Impatiens violoides*
Impatiens teneriflora	*Impatiens wattii*
Impatiens thomsonii	

ANNEXURE - II

Species Endemic to Western Ghats

Impatiens acaulis var. *granulata*	*Impatiens dalzelii*
Impatiens agumbeana	*Impatiens dasysperma*
Impatiens aliciae	*Impatiens dendricola*
Impatiens anaimudica	*Impatiens denisonii*
Impatiens auriculata	*Impatiens disotis*
Impatiens barberi	*Impatiens diversifolia*
Impatiens campanulata	*Impatiens elegans*
Impatiens chandrasekharanii	*Impatiens floribunda*
Impatiens chinensis var. *brevicornis*	*Impatiens fruticosa*
	Impatiens gardneriana
Impatiens clavicornu	*Impatiens goughii*
Impatiens cochinica	*Impatiens inconspicua*
Impatiens coelotropis	*Impatiens jerdoniae*
Impatiens concinna	*Impatiens johnii*
Impatiens cordata	*Impatiens kleiniformis*
Impatiens crenata	*Impatiens konalarensis*
Impatiens cuspidata	*Impatiens kulamavuensis*

Impatiens laticornis	*Impatiens pendula*
Impatiens latifolia	*Impatiens phoenicea*
Impatiens lawii	*Impatiens platyadena*
Impatiens lawsonii	*Impatiens pulcherrima*
Impatiens lenta	*Impatiens raziana*
Impatiens leptura	*Impatiens rheedii*
Impatiens leschenaultii	*Impatiens rufescens*
Impatiens ligulata	*Impatiens rupicola*
Impatiens lucida	*Impatiens scabriuscula*
Impatiens macrocarpa	*Impatiens scapiflora*
Impatiens maculata	*Impatiens talbotii*
Impatiens minor	*Impatiens tangachee*
Impatiens modesta	*Impatiens tenella*
Impatiens munnarensis	*Impatiens tomentosa*
Impatiens munronii	*Impatiens travancorica*
Impatiens mysorensis	*Impatiens trichocarpa*
Impatiens nataliae	*Impatiens umbellata*
Impatiens neo-barnesii	*Impatiens urcinata*
Impatiens nilgirica	*Impatiens verecunda*
Impatiens orchioides	*Impatiens verticillata*
Impatiens pallidiflora	*Impatiens viridiflora*
Impatiens pandata	*Impatiens viscida*
Impatiens parasitica	*Impatiens viscosa*
Impatiens parvifolia	*Impatiens wightiana*

ANNEXURE - III

Species having wide distribution outside India

Impatiens amplexicaulis (Nepal, Tibet, China)

Impatiens arguta (Nepal, Bhutan, China)

Impatiens brachycentra (Central Asia, China, Pakistan, Afghanistan)

Impatiens chinensis var. *chinensis* (Bhutan, Nepal, Tibet, China, Bangladesh, Malaysia and Vietnam)

Impatiens gamblei (China and Nepal)

Impatiens leptoceras (China)

Impatiens racemosa (Nepal, Tibet, Malay Peninsula)

Impatiens radiata (Nepal, Tibet, Bhutan, Myanmar, China)

Impatiens spinifer (Nepal, Tibet, Bhutan and China)

Impatiens stenantha (Nepal, Bhutan, China)

Impatiens thomsonii var. *thomsonii* (Pakistan and Afghanistan)

ANNEXURE - IV

Species extending distribution to areas bordering India

Impatiens acaulis var. *acaulis* (Sri Lanka)

Impatiens aganantha (Tibet)

Impatiens angustiflora (Bhutan)

Impatiens balforii (Pakistan)

Impatiens benthamii (Bangladesh, Myanmar)

Impatiens bicolor Royle (Nepal and Pakistan)

Impatiens bicornuta (Nepal)

Impatiens bracteata (Bhutan)

Impatiens cathcartii (Bhutan)

Impatiens craddockii (Myanmar)

Impatiens decipiens (Tibet)

Impatiens discolor (Nepal)

Impatiens drepanophora (Nepal)

Impatiens edgeworthii (Nepal)

Impatiens falcifera (Nepal and Bhutan)

Impatiens flaccida (Sri Lanka)

Impatiens flemingii (Pakistan)

Impatiens florigera (Bhutan)

Impatiens glandulifera (Nepal and Pakistan)

Impatiens glauca (Nepal)

Impatiens grandis (Sri Lanka)

Impatiens helferi (Myanmar)

Impatiens henslowiana (Sri Lanka)

Impatiens hobsonii (Nepal)

Impatiens jurpia (Nepal and Bhutan)

Impatiens laevigata (Nepal and Myanmar)

Impatiens latiflora (Bhutan)

Impatiens longipes (Nepal and Myanmar)

Impatiens manipurensis (Bhutan)

Impatiens masonii (Myanmar)

Impatiens oppositifolia (Sri Lanka)

Impatiens porrecta (Myanmar)

Impatiens prainii (Nepal)

Impatiens psittacina (Myanmar)

Impatiens puberula (Nepal and Bhutan)

Impatiens pulchra (Nepal and Myanmar)

Impatiens racemulosa (Bhutan and Bangaldesh)

Impatiens scabrida (Nepal, Bhutan and Pakistan)

Impatiens scitula (Tibet)

Impatiens serrata (Nepal and Bhutan)

Impatiens serratifolia (Nepal)

Impatiens sulcata (Nepal, Tibet, Bhutan and Pakistan)

Impatiens trilobata (Bangladesh and Myanmar)

Impatiens tripetala (Bhutan and Bangladesh)

Impatiens uncipetala (Nepal)

Impatiens urticifolia (Nepal)

Impatiens wallichii (Nepal)

REFERENCES

Ahmedullah,, M. and M.P. Nayar 1987. *Endemic plants of the Indian region Balsaminaceae.* pp. 190-194.

Barnes, E. 1939. The species of Geraniaceae occurring on the Travancore High Range including the description of new balsams. *J. Indian Bot. Soc.* **18**(3): 95-104.

Bhaskar, V. 1981. The genus *Impatiens* L. in South India : Endemism and affinities. *Indian For.* **10**(6): 368-376.

Chatterjee, D. 1939-40. 1981. Some dominant plants of India. *J. Indian Bot. Soc.* **18**: 129-131.

Grey-Wilson, C. 1979. Balsaminaceae. In: K.H. Rechinger, *Flora Iranica.* **2**: 143.

Grey-Wilson, C. 1980. *Impatiens of Africa.* A.A. Balkema, Rotterdam, Netherlands.

Grey-Wilson, C. 1985. *A Revised Handbook to the Flora of Ceylon.* V. *Balsaminaceae.*

Henry, A.N., K. Vivekananthan and N.C. Nair. 1979. Rare and threatened flowering plants of south India. *J. Bombay Nat. Hist. Soc.* **75**(3): 684-698.

Hooker, J.D. and T. Thomson. 1860. Precursores ad Floram Indicum - Balsaminaceae. *J. Linn. Soc.* **4**: 106-157.

Hooker, J.D. and T. Thomson. 1874-75. *The Flora of British India.* 1 - *Balsaminaceae.* pp. 440-483.

Hooker, J.D. and T. Thomson. 1906. An epitome of the British Indian species of *Impatiens. Rec. Bot. Surv. India* **4**: 1-58.

Jain, S.K. 1983. *Flora and vegetation of India an outline.* pp. 1-24. Dept. of Environment, New Delhi.

Mabberley, D.J. 1987. *The Plant-book- A Portable Dictionary of Plants*. Cambridge University Press, Cambridg.

Mani, M.S. 1974. *The Ecology and Biogeography of India*. W. Junk Publishers, The Hague.

Nair, N.C. 1991. Endemism in the Western Ghats with special reference to *Impatiens* L. *Symposium on Rare, Endangered and Endemic Plants of the Western Ghats*. 93-102. Thiruvananthapuram.

Nayar, M.P. 1977. Changing patterns of Indian flora. *Bull. Bot. Surv. India* **19** : 145-155.

Nayar, M.P. and A.R.K. Sastry (eds.). 1987-90. *Red-Data Book of Indian Plants*. Vols. 1-3: BSI, Calcutta.

Santapau, H. and A.N. Henry 1973. *A Dictionary of the Flowering Plants in India*. CSIR, New Delhi.

Vajravelu, E. and P. Daniel 1983. Enumeration - Peninsular India. In: Jain, S.K. and A.R.K. Sastry (eds.) *Material for a Catalogue of Threatened Plants of India*. pp. 8-43. BSI, Calcutta.

Willis, J.C. 1973. *A Dictionary of the Flowering Plants and Ferns*. (8th ed. revised by H.K. Airy Shaw), Cambridge.

FICUS

B.P. Uniyal
D. Basu

The genus *Ficus* [lectotype *F. carica* (Moraceae)] is a fairly large genus comprising *ca* 750 species (Mabberley, 1998) distributed from tropical to warm regions, especially Indo-Malaya to Australia. The species of *Ficus* are commonly found in and around habitations, clearings, disturbed places, rock crevices, forests and ravines up to an altitude of *ca* 2250 m. Many of the species begin their life cycle as epiphyte that later develop aerial roots and finally settle down at the cost of the host plant.

The species of *Ficus* are trees or shrubs, rarely scandent or creeping over rocks, and have milky latex. The flowers in *Ficus* are borne in a globose, oblong or pyriform receptacle called a fig or syconium with a small apical ostiole closed by overlapping bracts. The number of flower varies from two to thousands. The flowers are unisexual and of four kinds, male, female, galls and neuters. The male, female and gall flowers may occupy the same receptacle or the males and galls in one set of receptacles and the females and neuters in another set. The male flowers have 2-6 fid or partite perianth and usually 1-2, rarely 3-6 stamens which are erect in bud. The female flowers have perianth, like male flowers or imperfect or absent and straight or oblique ovary with pendulous ovules. The achenes are fleshy or crustaceous.

Pollination in *Ficus* is very interesting. It is said to be done by Hymenopterous flies that enter into the figs by orifice but fail to come out due to scales and bracts near the mouth of figs. The flies lay eggs and die inside. Eggs are incubated inside, develop into larva and pupa which feed on gall and neuter flowers and develop into flies that come out piercing the wall of figs.

DIVERSITY

Linnaeus (1753) described 7 species in his *Species Plantarum* to which were added a number of taxa, and by 1895 the number of species under *Ficus* had swelled to 618 (*Index Kewensis Plantarum*

Phanerogamarum, 1895). As is evident from the Index, *ca* 91 species appear to have been known from India. King (1888) reported a total of 112 species from the British India, out of which 63 species have their occurrence in India. Besides, he (*loc. cit.*) also listed 22 taxa as undeterminable and excluded them from the main treatment. In the present state of our knowledge about 92 species of the genus are known to occur within the present political boundary of India (Corner, 1965, 1972; Hore, 1984; Rani, 1985; Sreekumar & Debnath, 1992, 1998; Priyadarsanan, 1999).

Region wise, the eastern India with 54 species has the maximum representation. Similarly West Bengal, with 40 species, is the richest state as far as the diversity in the genus *Ficus* is concerned. This is followed by Meghalaya with 36 species, Tamil Nadu with 30 species and Andaman & Nicobar Islands with 27 species.

ENDEMISM

Endemism is poorly observed in *Ficus*. Only a handful of species are endemic mainly to southern India (Ahmedullah & Nayar, 1987; Basak & Thothathri, 1989) and Arunachal Pradesh. Some of the endemic taxa of *Ficus* are listed in table I.

Table I
Endemic taxa of *Ficus*

Name of the taxa	Distribution
Ficus andamanica	Andaman & Nicobar Islands
Ficus angladei	Tamil Nadu
Ficus arnottiana var. *subcostata*	Kashmir, Himachal Pradesh, Uttar Pradesh
Ficus beddomei	Maharashtra, Tamil Nadu
Ficus capillipes	Andaman
Ficus chrysocarpa	Kamorta island
Ficus costata	Nicobar islands
Ficus cupulata	Madhya Pradesh
Ficus dalhousiae	Karnataka, Tamil Nadu

Name of the taxa	Distribution
Ficus guttata	Tamil Nadu
Ficus heterophylla var. *assamica*	Arunachal Pradesh, Sikkim
Ficus lacor	Assam, Sikkim, Uttar Pradesh
Ficus laevis var. *microcarpa*	Kerala, Tamil Nadu
Ficus nigrescens	Manipur, Nagaland
Ficus sub-incisa var. *trachycarpa*	Himachal Pradesh, Kashmir, Uttar Pradesh
Ficus superba	Kerala
Ficus wardii	Arunachal Pradesh
Ficus xiphias	Arunachal Pradesh

ECONOMIC IMPORTANCE

Species of *Ficus* are well known for their sacred values. Peepul, Ashwattha or Bodhi (*F. religiosa*), Wad or Wat (*F. benghalensis*), Pilkhan (*F. arnottiana*), Krishnavat (*F. benghalensis* var. *krishnae*), etc. find a place in epics like, Ramayana and Mahabharata. Besides the species of the genus have different economic uses (Basak & Thothathri 1989) that are presented in Table II.

Information on Ficus will be incomplete unless mention is made of great Banyan trees scattered in different parts of the country. The Great Banyan Tree of the Indian Botanic Garden, Howrah is well known world over. Besides, even larger trees existed in the past in various parts of the country (Basak & Thothathri 1989). A giant tree in Andhra is said to be 50 m in circumference with about 3000 aerial roots. Another banyan tree near Pune is reported to have a circumference of about 984 feet. In Gootybylu, Andhra Pradesh, the total circumference of the crown is said to be around 495 m. The banyan tree near Adyar, Tamil Nadu is large enough to provide space for programmes of dance, drama and music. Some other giant banyan trees are said to occur in Ramohali near Banglaore, Mussanda near Habibpur Railway station, West Bengal and one in Madhya Pradesh also.

Table II
Different uses of the species of *Ficus*

Species name	Bark	Leaves	Roots	Aerial Roots	Figs	Seeds	Latex/Wood
Ficus altissima	Lac	Lac,Caoutchoc					
Ficus amplissima		Anti cholerin, anti cancer, diuretic					
Ficus asperrima		As sand paper for polishing ivory and sandel wood; decoction used in leprosy; as surgical file to remove warts in eyes.					
Ficus auriculata		Fodder		Edible			
Ficus beddomei							Wood as match boxes.
Ficus benghalenses	Astringent, antidiarrhoeal, anti diabetic, tonic.	Diphoretic in abscesses	Fibre, antigonorrhoeial.	Tentpole, rope debility, anaemic, dysentry, vomiting.		Tonic	Anti reumetic, lambago pain, cracked feet, gum and tooth ache; wood for door panel, well covers.

Species name	Bark	Leaves	Roots	Aerial Roots	Figs	Seeds	Latex/Wood
Ficus benjamina	Bath in pain and leprosy.	Decoction with oil used in ulcers.	–	–	–		Wood for match box making.
Ficus callosa							Wood for match boxes making.
Ficus carica		Paste used in leucoderma.			Figs in kidney stones, laxative, demulcent, expectorent, diseases of liver and spleen.		Destroy warts.
Ficus dalhousie	Liver cimplaints, blood purifier.	Skin disease.	–	–	Heart diseases, burning sensation of body, etc		
Ficus drupacea	Rough fibre			–	Figs edible		Latex as medicine.
Ficus elastica						Latex as smear on basket to make water proof.	

Species name	Bark	Leaves	Roots	Aerial Roots	Figs	Seeds	Latex/Wood
Ficus heterophylla		Leaves as sand paper.	Juice of root in colic pain, in cough and asthma, Jaundice				
Ficus. hispida	Tonic for anti periodic.	Fodder	Medicine for fistula.		Galacto-genic.	Seeds purgative.	Wood as match box making.
Ficus microcarpa	Anti billous.	Used in rheumatic and colic pain.	Paste used in wound, bruises.	–	–		
Ficus palmata		Fodder	-	–	Figs demulcent, laxative, in diseases of lungs and bladder; edible.		
Ficus racemosa	Paste with gingelly oil applied to old ulcer, tonic for cattle.	Leaves as antibiotic.	Root antidiabetic.		Figs in stomach pain, edible.	Latex antidiarrahoeal, in piles.	
Ficus religiosa	Urinary trouble, scabies and piles.	Leaves as purgative, in skin diseases.			Figs anti-asthamatic, helps in conception.		

Species name	Bark	Leaves	Roots	Aerial Roots	Figs	Seeds	Latex/Wood
Ficus rumphii	Bark paste used in snake bite.	–	–	–			Latex vermifuge, anti-asthmatic.
Ficus semicordata		–	Root juice in urinary bladder & viceral complaints.		Fig paste in ulcer, mucous.		
Ficus talboti	Anti diarrhoetic, anti leprotic, in ulcer, veneral diseases.		·	·	Figs in diarrhoea, leprosy, haemorrage.	–	
Ficus terminalis	Bark fibre for paper pulp.	Vegetable, fodder for elephants.	–	–			Wood in charcoal preparation, paper pulp.
Ficus tinctoria ssp. *gibbosa*	Stomach trouble	Leaves used in polishing ivory, sandal wood.	–	Root extract as purgative.	–	–	

REFERENCES

Ahmedullah, M. and M.P. Nayar 1987. *Endemic Plants of the Indian Region* Vol. 1. New Delhi.

Basak, R.K. and K. Thothathri 1989. Ethnobotany of *Ficus* L. (Moraceae) in India. *J. Econ. Taxon. Bot.* **13**(2): 291-309.

Corner, E.J.H. 1965. Checklist of *Ficus* in Asia and Australia with keys to identification. *Garden Bull. Singapore* **21**(1): 1-186.

Corner, E.J.H. 1972. Identification lists of Malayasian specimens 43. *Ficus* (Moraceae) from India, Burma, Thailand, Indochina, China, Korea, Japan, Ryukyu, Formosa and Hainan: 735-784.

Hooker, J.D. 1888. *Flora of British India* **5**: 494-537.

Hore, D.K. 1984. Additions to the Indian Flora from Great Nicobar Island. *Bull. Bot. Surv. India* **26**(1-2): 20-25.

Mabberley, D.J. 1998. *The Plant-Book. Bath Press,* Bath, U.K.

Priyadarsanan, D.R. 1999. *Ficus superba* Miq. and *F. fergusoni* (King) Worthington (Moraceae), Two new Reports from India. *J. Bombay Nat. Hist. Soc.* **96**(3): 492-493.

Rani, N. 1985. *Ficus albipila* (Miq.) King (Moraceae) A new Record for India *J. Bombay Nat. Hist. Soc.* **82**: 235-237.

Sreekumar, P.V. 1998. Six new Records of *Ficus* L., (Moraceae) from Andaman Nicobar Islands. *J. Econ. Taxon. Bot.* **22**(1): 199-203.

Sreekumar, P.V. and Debnath, H.S. 1992. *Ficus pendens* Corner (Moraceae). A new Record for India from Nicobar Islands. *J. Econ. Taxon. Bot.* **16**(1): 221-222.

RHODODENDRONS

A.A. Mao
K.P. Singh
P.K. Hajra

The genus *Rhododendron*, a member of the family Ericaceae, was founded by Carl Linnaeus (1837). The word *Rhododendron* is derived from two Greek words *rhodon* (rose) and *dendron* (tree) meaning rose tree. The genus with attractive and beautiful flowers is represented by about 1000 species in the world (Sastry & Hajra, 1983). However, Mabberley (1987) records 850 species in his plant book. They are mostly distributed at higher elevations in the Sino-Himalayan regions with maximum concentration in western China (Pradhan, 1985).The species vary from procumbent dwarfs to magnificent trees up to 30 meters tall. They mostly blossom during summer months from March to June and give attractive appearance to the hills. In India, the species are mostly confined to the Himalayan region, particularly in eastern Himalaya.

The initial important publication on Indian *Rhododendron* was made by Clarke (1882) who recorded 46 species. Since then many species have been described and recorded from North-east India by various workers (Calder *et al.*, 1926; Anonymous, 1947; Razi, 1959; Nayar & Ramamurthy, 1973; Nayar & Karthikeyan, 1981, 1984; Naithani, 1990). Apart from this, some other aspects of Rhododendrons were also studied. A contribution on rare and endemic Indian *Rhododendrons* was made by Sastry and Hajra (1983). Later, preliminary enumerations or inventories of the genus at national and regional levels were made by Pradhan (1985, 1986) and Ghosh and Samaddar (1989). The Rhododendrons of Sikkim-Himalayan region were also dealt in detail by Pradhan and Lachungpa (1990). A revision of the genus was carried out by Chamberlain (1980-82).

In recent years attention has been given to species diversity of different groups and genera, in a particular area. In this context, the abundance of Rhododendrons in India has great significance. A critical study based on literature, herbarium material and authors' own survey work has revealed that there are about 72 species, 20 subspecies and 19 varieties of *Rhododendron* which occur in wild state in Indian flora. In this paper an attempt is made to analyse the species diversity in botanical regions and their distribution in India. However, the taxonomy of the genus is being worked out separately by other scientists in the Botanical Survey of India, under the 'Flora of India' project.

SPECIES DIVERSITY

The species of *Rhododendron* exhibit significant diversity in habit, inflorescence, flower colour and many other aspects. The total number of species in the world comprises about 1000, of which about 72 species and 20 subspecies occur in India. They are widely distributed in the Himalayan region. The western Himalayan region has 8 species while eastern Himalayan region is represented by 71 species. The maximum concentration of these species is observed in Arunachal Pradesh. Out of 72 species known from India, 61 species occur in Arunachal Pradesh alone. It is followed by Sikkim with 27 species, West Bengal with 12 species, Manipur with 5 species, Jammu & Kashmir with 3 species, etc. They show great diversity in habit within different species ranging from small shrublets, measuring 0.5 m to 1 m tall (*R. anthopogon ssp. anthopogon*, *R. calostrotum* ssp. *riparium*, *R. lepidotum*, *R. megeratum*, *R. nivale*, *R. pemakoense*, *R. setosum*, etc.), to shrubs measuring 2 m to 5 m tall (*R. bailey*, *R. beanianum*, *R. boothii*, *R. bulu*, *R. campylocarpum*, *R. cerasimum*, etc.) and trees measuring 5 m and above (*R. barbatum*, *R. cinnabarinum*, *R. falconeri*, *R. grande*, *R. macabeanum*, *R. rex* ssp. *arizelum*, *R. sidereum*, etc.), thereby indicating majority of the species are shrubs. The shape of flowers vary from small thimble-shaped to large lily-like flower. Some have sweet scented flowers, like *R. edgworthii*, *R. johnsteneanum*, *R. taggianum*, etc. The colour of flowers vary from white (*R. formosum* var. *formosum*, *R. lindleyi*, *R. maddenii* ssp. *crassum*, etc.), orange or yellow (*R. kasoense*, *R. megeratum*, *R. nivale*, etc.) and pink or deep red (*R. exasperatum*, *R. keysii*, *R. kendrickii*, etc.). Majority of the species have both terminal as well as lateral inflorescences (*R. arboreum*, *R. barbatum*, *R. beanianum*, *R. campanulatum*, etc.) but others have only terminal inflorescence (*R. anthopogon*, *R. bailey*, *R. boothii*, *R. cerasimum*, etc.). The number of flowers per inflorescence also vary from one (*R. virgatum var. virgatum*, *R. stenaulum*, *R. nivale*, etc.) to many (as in *R. barbatum*, *R. bailey*, *R. decipiens*, etc.). The size of the flowers also vary from 1-2 cm across in *R. nivale* to 12-15 cm across in *R. griffithianum*.

Also, of the Indian species known, 15 species are sometimes either epiphytic on trees or lithophytic on mossy rocks while remaining are terrestrial. These epiphytic and lithophytic species are *R. boothii*, *R. camelliiflorum*, *R. dalhousiae*, *R. dendricola*, *R. edgeworthii*, *R. johnstoneanum*, *R. leptocarpum*, *R. lindleyi*, *R. maddenii ssp. crassum*, *R. megeratum*, *R. nuttallii*, *R. pendulum*, *R. santapaui*, *R. vaccinioides*, and *R. walongense*.

A reference to some poisonous species may further highlight the diversity of Rhododendrons. Some such taxa reported to be poisonous by Pradhan and Lachungpa (1990) are *R. arboreum*, *R. cinnabarinum*, *R. dalhousiae*, *R. setosum* and *R. thomsonii*.

DISTRIBUTION OF TAXA

The distribution of Indian *Rhododendron* is interesting. It is noteworthy in the sense that almost all the species except *R. arboreum* ssp. *nilagiricum* occur in the Himalayan region. Phytogeographically, the Himalaya are divided into two botanical regions, namely the western Himalaya and the eastern Himalaya. The western Himalayan region for the present purpose includes the states of Jammu & Kashmir, Himachal Pradesh and Uttaranchal. Similarly, the eastern Himalayan region, as dealt here, includes the seven sisters states of North-eastern India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura), Sikkim and Darjeeling District of West Bengal. Both western and eastern Himalayan regions have high mountains. Compared with the western Himalayan region, the eastern Himalayan region has higher rainfall and warmer conditions. Like most Ericaceous members, *Rhododendron* prefer acidic, often sandy loamy soil, covered with humus. They often form impenetrable thickets as found in many places in North Sikkim. The eastern Himalayan region harbours all the species except *R. colletianum* which has its extended distribution westwards to Afghanistan and Pakistan. The Rhododendrons represented in western Himalayan region are *R. anthopogon* ssp. *anthopogon*, *R. anthopogon ssp. hypenanthum*, *R. arboreum ssp. arboreum*, *R. barbatum*, *R. camelliaeflorum*. *R. campanulatum*, *R. colletianum*, *R.imberbe* and *R. lepidotum*.

In India, *Rhododendron* are found between 1200 and 6000 m altitude, but majority of them occur between 2200 and 4000 m. Species, like *R. dalhousiae*, *R. dendricola*, *R. johnsteneanum*, *R. arboreum* ssp.

arboreum and *R. maddenii* ssp. *crassum* are found growing at *ca* 1200 m, whereas species, like *R. nivale* and *R. leptocarpum* reach up to 6000 m altitude, growing in alpine areas exposed to the bitter cold, wind and scorching sunrays. Of all the Indian species *R. arboreum* is the most widely distributed occurring from the western to the eastern Himalayan region and also extending to the neighbouring countries, like Bhutan, China, Myanmar, Nepal and Sri Lanka. Many Indian species, such as *R. anthopogon ssp. anthopogon*, *R. camelliaeflorum*, *R. campylocarpum*, *R. ciliatum*, etc. show extended distribution to adjacent countries.

The number of species and their distribution in the different states of India given below is based mainly on the published records and authors' observations in the field. The number of species and their distribution in India and out side are presented in Table I and II.

Table I
The number of Rhododendrons found in different States of India.

States	Species	Subspecies	Varieties
Arunachal Pradesh	61	17	12
Assam	0	1	1
Himachal Pradesh	1	4	0
Jammu & Kashmir	3	3	0
Manipur	5	2	3
Meghalaya	0	2	2
Mizoram	3	1	0
Nagaland	2	3	1
Sikkim	27	11	10
Tamil Nadu	0	1	0
Uttaranchal	3	2	0
West Bengal	12	7	4

Table II
Distribution of Indian Rhododendrons

Name of the Taxon	Status	Distribution: India	Distribution: Other region
1	2	3	4
Rhododendron anthopogon ssp. *anthopogon*		Arunachal Pradesh, Himachal Pradesh, Sikkim and West Bengal. Between 3385 and 5000 m.	Bhutan, China, Nepal and Tibet.
Rhododendron anthopogon ssp. *hypenanthum*		Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Sikkim and Uttaranchal. Between 3385 and 5000 m.	Bhutan and Nepal.
Rhododendron arboreum ssp. *arboreum*		Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Uttaranchal Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and West Bengal. Between 800 and 3080 m.	Bhutan, Myanmar, Nepal, Sri Lanka, Pakistan and Tibet.

1	2	3	4
Rhododendron arboreum ssp. *cinnamomeum* var. *cinnamomeum*		Sikkim and West Bengal at *ca* 2500 m.	Nepal.
Rhododendron arboreum ssp. *cinnamomeum* var. *roseum*		Sikkim and West Bengal. Between 2750 and 3650 m.	Bhutan, China and Myanmar.
Rhododendron arboreum ssp. *delavayi* var. *delavayi*		Arunachal Pradesh, Assam, Manipur and Meghalaya. Between 2500 and 3200 m.	China, Myanmar and Thailand.
Rhododendron arboreum ssp. *delavayi* var. *peramoenum*	Endemic	Arunachal Pradesh. Between 3000 and 3200 m.	
Rhododendron arboreum ssp. *nilagiricum*	Endemic	Tamil Nadu. Between 1500 and 2000 m.	
Rhododendron assamicum	Endemic	Arunachal Pradesh at *ca* 3000 m	
Rhododendron baileyi	Rare	Sikkim. Between 3000 and 4000 m.	Bhutan and Tibet.

1	2	3	4
Rhododendron barbatum		Arunachal Pradesh, Sikkim, Uttaranchal and West Bengal. Between 2500 and 3700 m.	Bhutan, China and Nepal.
Rhododendron beanianum	Rare	Arunachal Pradesh. Between 3000 and 3350 m.	Myanmar.
Rhododendron boothii	Threatened	Arunachal Pradesh. Between 1800 and 2500 m.	Bhutan and China.
Rhododendron bulu	Threatened	Arunachal Pradesh. Between 3000 and 3800 m.	China and Tibet.
Rhododendron calostrotum ssp. *riparium*	Rare	Arunachal Pradesh. Between 3050 and 4500 m.	China and Myanmar.
Rhododendron camelliaeflorum		Arunachal Pradesh, Jammu & Kashmir and Sikkim. Between 2770 and 4000 m.	China, Nepal and Tibet.
Rhododendron campanulatum ssp. *campanulatum*		Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Sikkim, Uttaranchal and West Bengal. Between 2770 and 4300 m.	Bhutan and Nepal.

1	2	3	4
Rhododendron campanulatum ssp. *aeruginosum*	Endemic	Sikkim. Between 4500 and 5000 m.	
Rhododendron campanulatum var. *wallichii*		Arunachal Pradesh and Sikkim at *ca* 4000 m.	Bhutan and Nepal.
Rhododendron campylocarpum ssp. *campylocarpum*		Arunachal Pradesh and Sikkim. Between 3385 and 4310 m.	Bhutan, Myanmar, Nepal and Tibet.
Rhododendron campylogynum	Rare	Arunachal Pradesh. Between 2750 and 4250 m.	China and Myanmar.
Rhododendron cephalanthum ssp. *cephalanthum*	Rare	Arunachal Pradesh. Between 3050 and 4500 m.	China and Myanmar.
Rhododendron cerasinum		Arunachal Pradesh. Between 3000 and 3200 m.	China, Myanmar and Tibet.
Rhododendron chamaethomsonii	Endemic	Arunachal Pradesh. Between 3665 and 5000 m.	
Rhododendron ciliatum		Sikkim. Between 2770 and 3385 m.	Bhutan, China and Nepal.

1	2	3	4
Rhododendron cinnabarinum ssp. *cinnabarinum*		Arunachal Pradesh, Sikkim and West Bengal. Between 3050 and 3950 m.	Bhutan, China, Nepal and Tibet.
Rhododendron cinnabarinum ssp. *xanthocodon*	Threatened	Arunachal Pradesh, Sikkim and West Bengal. Between 3050 and 3950 m.	Bhutan and China.
Rhododendron colletianum		Jammu & Kashmir. Between 3080 and 4000 m.	Afghanistan and Pakistan.
Rhododendron concinnoides	Endemic and threatened	Arunachal Pradesh. Between 2462 and 3385 m.	
Rhododendron coxianum	Endemic	Arunachal Pradesh, at *ca* 1800 m.	
Rhododendron crinigerum var. *crinigerum*		Arunachal Pradesh. Between 3100 and 4000 m.	China and Myanmar.
Rhododendron dalhousiae		Arunachal Pradesh, Sikkim and West Bengal. Between 1850 and 2270 m.	Bhutan and Nepal.

1	2	3	4
Rhododendron dalhousiae* var. *rhabdotum	Rare	Arunachal Pradesh, at *ca* 2500 m.	Bhutan and China.
Rhododendron dalhousiae* var. *dalhousiae		Sikkim and West Bengal. Between 1850 and 2270 m.	Bhutan, China and Nepal.
Rhododendron decipiens	Endemic	Sikkim and West Bengal. Between 2500 and 3000 m.	
Rhododendron dendricola	Rare	Arunachal Pradesh. Between 1200 and 1400 m.	China and Myanmar.
Rhododendron edgeworthii	Rare	Arunachal Pradesh, Sikkim and West Bengal. Between 2100 and 3300 m.	Bhutan, China and Myanmar.
Rhododendron elliottii	Endemic and endangered	Manipur and Nagaland. Between 2700 and 3000 m.	
Rhododendron eudoxum		Arunachal Pradesh. Between 3385 and 4000 m.	China and Tibet.

1	2	3	4
Rhododendron eudoxum* ssp. *tamenium		Arunachal Pradesh. Between 3385 and 4000 m.	Bhutan and China.
Rhododendron exasperatum	Rare	Arunachal Pradesh. Between 3000 and 4000 m.	China and Myanmar.
Rhododendron falconeri* ssp. *falconeri		Arunachal Pradesh, Sikkim and West Bengal. Between 2160 and 4000 m.	Bhutan and Nepal.
Rhododendron falconeri* ssp. *eximium	Endangered	Arunachal Pradesh. Between 3000 and 3500 m.	
Rhododendron formosum* var. *inaequale	Endemic and threatened	Meghalaya, Mizoram and Nagaland. Between 1500 and 2000 m.	
Rhododendron formosum* var. *formosum	Endemic and threatened	Meghalaya. Between 1500 and 2000 m.	
Rhododendron fulgens		Arunachal Pradesh, Sikkim and West Bengal. Between 3080 and 4310 m.	Bhutan, China, Nepal and Tibet.

1	2	3	4
Rhododendron fulvum		Arunachal Pradesh. Between 2460 and 3385 m.	China, Myanmar and Tibet.
Rhododendron glaucophyllum* var. *glaucophyllum		Sikkim. Between 3080 and 3700 m.	Bhutan, Nepal and Tibet.
Rhododendron glaucophyllum* var. *tubiforme		Arunachal Pradesh, at *ca* 3100 m.	Bhutan, China and Myanmar.
Rhododendron grande		Arunachal Pradesh, Sikkim and West Bengal. Between 2160 and 3385 m.	Bhutan, China, Nepal and Tibet.
Rhododendron griffithianum		Arunachal Pradesh, Sikkim and West Bengal. Between 2160 and 2770 m.	Bhutan, Nepal and Tibet.
Rhododendron hodgsonii		Arunachal Pradesh, Sikkim and West Bengal. Between 3080 and 3690 m.	Bhutan, Nepal and Tibet.
Rhododendron hookeri	Rare	Arunachal Pradesh. Between 2500 and 3700 m.	Bhutan.

1	2	3	4
Rhododendron imberbe	Endemic	Arunachal Pradesh and Uttaranchal at *ca* 2770 m.	
Rhododendron johnstoneanum	Endemic and endangered	Arunachal Pradesh, Manipur and Mizoram. Between 1160 and 3000 m.	
Rhododendron kasoense	Rare	Arunachal Pradesh. Between 2500 and 2700 m.	China.
Rhododendron kendrickii	Rare	Arunachal Pradesh. Between 2300 and 2800 m.	Bhutan and China.
Rhododendron keysii	Rare	Arunachal Pradesh and Sikkim. Between 2440 and 3650 m.	Bhutan, China and Tibet.
Rhododendron lanatum		Arunachal Pradesh and Sikkim. Between 3080 and 4000 m.	Bhutan, China and Tibet.
Rhododendron lanigerum		Arunachal Pradesh. Between 3080 and 3385 m.	China and Tibet.

1	2	3	4
Rhododendron lepidotum		Arunachal Pradesh, Jammu & Kashmir, Himachal Pradesh, Sikkim, Uttaranchal and West Bengal. Between 2160 and 4620 m.	Bhutan, China, Myanmar, Nepal and Pakistan.
Rhododendron lepidotum var. *elaeagnoides*		Arunachal Pradesh and Sikkim. Between 2800 and 5000 m.	Bhutan, China, Myanmar, Nepal and Tibet.
Rhododendron lepidotum var. *obovatum*		Sikkim. Between 2900 and 3500 m.	Bhutan and Nepal.
Rhododendron leptocarpum		Arunachal Pradesh and Sikkim. Between 2300 and 4310 m.	Bhutan, China, Myanmar and Tibet.
Rhododendron lindleyi		Arunachal Pradesh, Manipur, Sikkim and West Bengal. Between 1850 and 3080 m.	Bhutan, China, Myanmar, Nepal and Tibet.
Rhododendron macabeanum	Endemic and rare	Manipur and Nagaland. Between 2500 and 3000 m.	

1	2	3	4
Rhododendron maddenii* ssp. *crassum	Rare	Manipur, Meghalaya and Nagaland. Between 2250 and 3000 m.	Bhutan, China Myanmar and Vietnam.
Rhododendron maddenii ssp. *maddenii*	Rare	Arunachal Pradesh and Sikkim. Between 2400 and 3650 m.	Bhutan and China.
Rhododendron megacalyx	Rare	Arunachal Pradesh. Between 2160 and 2770 m.	China and Myanmar.
Rhododendron megeratum	Rare	Arunachal Pradesh. Between 3050 and 4150.	China, Myanmar and Tibet.
Rhododendron mekongense var. *rubrolineatum*	Rare	Arunachal Pradesh. Between 3350 and 4250 m.	China
Rhododendron neriifolium ssp. *phaedropum*	Threatened	Arunachal Pradesh, at *ca* 3000 m.	Bhutan, China and Myanmar.
Rhododendron nivale		Sikkim. Between 4000 and 6000 m.	Bhutan, China and Nepal.

1	2	3	4
Rhododendron niveum		Arunachal Pradesh and Sikkim. Between 3080 and 3700 m.	Bhutan.
Rhododendron nuttallii	Rare	Arunachal Pradesh. Between 1200 and 3650 m.	Bhutan, China and Myanmar.
Rhododendron obtusum		Arunachal Pradesh, at *ca* 1500 m.	Japan and Myanmar.
Rhododendron papillatum	Rare	Arunachal Pradesh and Sikkim. Between 1800 and 3300 m.	Bhutan and Nepal.
Rhododendron pemakoense	Rare	Arunachal Pradesh. Between 2400 and 3050 m.	China.
Rhododendron pendulum	Rare	Arunachal Pradesh and Sikkim. Between 2270 and 3650 m.	Bhutan, China, Nepal and Tibet.
Rhododendron pocophorum* var. *pocophorum	Rare	Arunachal Pradesh. Between 3650 and 4600 m.	China.

1	2	3	4
Rhododendron pruniflorum	Rare	Arunachal Pradesh. Between 3050 and 3950 m.	Myanmar.
Rhododendron pumilum		Arunachal Pradesh and Sikkim. Between 3500 and 4500 m.	Bhutan, China, Myanmar, Nepal and Tibet.
Rhododendron rex ssp. *arizelum*	Rare	Arunachal Pradesh. Between 3000 and 4000 m.	China and Myanmar.
Rhododendron santapaui	Endemic and endangered	Arunachal Pradesh, at *ca* 2300 m.	
Rhododendron setosum		Arunachal Pradesh, Sikkim and West Bengal. Between 2160 and 4950 m.	Bhutan, China, Nepal and Tibet.
Rhododendron sidereum		Arunachal Pradesh. Between 2770 and 3080 m.	China and Myanmar.
Rhododendron sikkimense	Endemic	Sikkim, at *ca* 3700 m.	

1	2	3	4
Rhododendron sinogrande		Arunachal Pradesh. Between 3080 and 4310 m.	China, Myanmar and Tibet.
Rhododendron smithii		Arunachal Pradesh and Sikkim. Between 2160 and 3700 m.	Bhutan and China.
Rhododendron stenaulum		Arunachal Pradesh, at *ca* 2770 m.	China.
Rhododendron stewartianum		Arunachal Pradesh. Between 3080 and 4310 m.	China, Myanmar and Tibet.
Rhododendron subansiriense	Endemic and endangered	Arunachal Pradesh. Between 2600 and 2800 m.	
Rhododendron succothii	Rare	Arunachal Pradesh. Between 3400 and 4200 m.	Bhutan.
Rhododendron taggianum		Arunachal Pradesh. Between 2160 and 3390 m.	China and Myanmar.

1	2	3	4
Rhododendron tanastylum	Rare	Arunachal Pradesh. Between 1850 and 3350 m.	China and Myanmar.
Rhododendron tephropeplum	Rare	Arunachal Pradesh. Between 2450 and 4300 m.	China and Myanmar.
Rhododendron thomsonii ssp. ***thomsonii***		Arunachal Pradesh, Nagaland Sikkim and West Bengal. Between 3390 and 4000 m.	Bhutan, Nepal and Tibet.
Rhododendron x candelabrum	Endemic	Sikkim. Between 3600 and 4300 m.	
Rhododendron thomsonii var. *flocculosa*	Endemic	Sikkim. Between 3600 and 4300 m.	
Rhododendron triflorum var. *triflorum*		Arunachal Pradesh, Sikkim and West Bengal. Between 2160 and 2930 m.	Bhutan, China, Myanmar, Nepal and Tibet.
Rhododendron triflorum var. *bauhiniiflorum*	Endemic and rare	Manipur. Between 2470 and 3080 m.	

1	2	3	4
Rhododendron tsariense		Arunachal Pradesh. Between 2000 and 3000 m.	Bhutan and China.
Rhododendron uvarifolium		Arunachal Pradesh. Between 2160 and 2470 m.	China.
Rhododendron vaccinioides		Arunachal Pradesh, Sikkim and West Bengal. Between 1850 and 3700 m.	Bhutan, Myanmar, Nepal and Tibet.
Rhododendron virgatum var. *virgatum*		Arunachal Pradesh, Sikkim. Between 2160 and 2770 m.	Bhutan, China, and Myanmar.
Rhododendron virgatum ssp. *oleifolium*		Arunachal Pradesh. Between 2200 and 3000 m.	China and Tibet.
Rhododendron veitchianum	Rare	Mizoram. Between 1230 and 1700 m.	Loas, Myanmar and Thailand.
Rhododendron wallichii		Sikkim and West Bengal.	Bhutan, China and Nepal.

	2	3	4
Rhododendron walongense	Rare	Arunachal Pradesh. Between 1500 and 2150 m.	China.
Rhododendron wattii	Endemic and endangered	Arunachal Pradesh, Manipur and Mizoram, at *ca* 2700 m.	
Rhododendron wightii		Arunachal Pradesh and Sikkim. Between 3050 and 4310 m.	Bhutan, China, Myanmar, Nepal and Tibet.
Rhododendron xanthostephanum	Rare	Arunachal Pradesh and Sikkim. Between 1500 and 3000 m.	China and Myanmar.

PHYTOGEOGRAPHICAL AFFINITIES

As mentioned earlier that most of the *Rhododendron* species occur in Sino-Himalayan region. Hence, Indian Rhododendrons show closer affinity with the species of adjacent countries. The species of *Rhododendron* of India and China show more closer affinity than any other neighbouring country as they share 7 species (*R. kasoense*, *R. lanigerum*, *R. pemakoense*, *R. pocophorum*, *R. stenaulum*, *R. uvarifolium* and *R. walongense)*, exclusively common to both countries. Species common only to Bhutan and India are *R. niveum* and *R. succothii.* Similarly, *R. beanianum* and *R. pruniflorum* are common to both India and Myanmar. The species of Nepal and Tibet show common occurrence with the neighbouring countries. Besides, there are numerous species which show extended distribution and common in more than two countries. Some such species are *R. lepidotum* var. *elaeagnoides*, *R. lepidotum* var. *obovatum*, *R. lindleyi*, *R. leptocarpum*, *R. triflorum*, *R. wightii*, etc. However, the total number of Rhododendrons common to India and adjacent countries are presented in the Table III for a quick reference.

Table III
Number of Indian *Rhododendron* species common with adjacent countries

Name of Country	No. of Species	No. of Subspecies	No. of Varieties
China	46	11	11
Bhutan	30	13	10
Myanmar	25	7	7
Tibet	23	6	3
Nepal	18	8	7
Pakistan	2	1	–
Afghanistan	1	–	–
Thailand	1	–	1
Japan	1	Nil	Nil
Loas	1	Nil	Nil
Sri Lanka	Nil	1	Nil
Vietnam	Nil	1	Nil

ENDEMIC, THREATENED AND RARE TAXA

An important consideration of species diversity is how unique are the species in a given area or country. Certain species show restricted distribution to a relatively limited area to which they are called endemic. Rich endemism in any area indicates antiquity of its flora, special condition of climate or micro-climate in the ecosystem, and natural or geographical barriers around the area. India is rich in endemic flora. As far as *Rhododendron* taxa are concerned, Sastry and Hajra (1983) reported 7 species, 2 subspecies and 3 varieties endemic to India. However, according to present estimate, of the 72 species, 20 subspecies and 19 varieties known from India, 12 species, 2 subspecies and 5 varieties are endemic to India. Arunachal Pradesh containing maximum number of endemic species is represented by 9 species and 1 subspecies. It is followed by Manipur and Sikkim with 3 species and 1 subspecies, Mizoram with 2 species, etc.

Apart from endemic taxa, there are about 46 rare, threatened and endangered taxa found within the genus. Out of these, 43 taxa have been recorded as rare and threatened by Sastry and Hajra (1983), two taxa by Naithani (1983) and one taxon by Kataki (1983). These species need to be given special attention for their conservation. All such species including endemic ones with their distribution are presented in the Table II.

USES AND IMPORTANCE

The beautiful, magnificent flowers and evergreen foliage of Rhododendrons have attracted the attention of botanists and horticultural enthusiasts throughout the world. As a result of which today, nearly 50 per cent of the world species are under cultivation worldwide and about 5000 to 6000 hybrids of Rhododendrons have already been developed (Sally & Greer, 1986). These hybrids are sold in the market at high cost. They are mostly grown in the gardens, parks and other important places for their showy and attractive flowers. *Rhododendron* trees can also be introduced as avenue trees along the road sides and residential areas in the hills between 2000 and 4000 m. In U.S.A. and Norway, hybrid Rhododendrons are very popular as avenue trees. However, in order to promote cultivation, publicity and conservation of Rhododendrons, many countries have their own societies or organisations, such as Royal Horticultural Society, London; American *Rhododendron* Society;

Rhododendron Society of Canada; Australian *Rhododendron* Society; *Rhododendron* Species Foundations, International *Rhododendron* Union; *Rhododendron*, *Camellia* and *Magnolia* Group, etc.

Apart from their aesthetic use worldwide, several species of Rhododendrons have ethnic use as well from time immemorial. The dried flowers of *R. arboreum* are supposed to be highly efficacious in checking diarrhoea and blood dysentery. Also, the fresh and dried corolla is given when fish bones get stuck up in the gullet (Pradhan & Lachungpa, 1990). The finely ground leaf powder of *R. campanulatum* is used as snuff and is said to be useful in cold hemicrania (Watt, 1892).

In India, the *Rhododendron* species are mostly utilized by the Bhutias, Lepchas and Nepalis, the inhabitants of the Himalayan region close to their habitats. According to Pradhan and Lachungpa (1990) the leaves of *R. anthopogon* are mixed with those of juniper to provide an incense that is widely used in Bhudhist monasteries. The flowers of *R. arboreum* are used for brewing local wine in Darjeeling District of West Bengal. The corolla of *R. cinnabarinum* is used for making jams by Lamas and Tibetan aristocrats. In Sikkim, the corolla of the same species is fried and eaten as a delicacy. The rough leaves of *R. falconeri* are used for packing apples by the people of North Sikkim. The dense tomentum on the underside of the leaves of *R. fulgens* are scraped and used as wick for lighting fire by the inhabitants of North Sikkim. The wood of *R. hodgsonii* is used for making cups, spoons, khukri handles and walking sticks and its thick leaves with glossy surface are used for packing apples, yak butter and cheese for transportation. In addition, *the Rhododendron* species as a whole provide good firewood as most of the species burn raw owing to resinous exudations.

MAJOR THREATS AND CONSERVATION

In the recent past the Himalayan ecosystem is greatly affected due to various threats posed by the nature as well as by human beings. Since Rhododendrons are the inhabitants of the Himalaya, they are also greatly affected and their population in the nature is gradually dwindling. The main natural threats includes landslides and forest fires which affect the rich growth of Rhododendrons. In a recent survey carried out by Botanical Survey of India in Tawang district of Arunachal Pradesh, it has been observed that thousands of very young plants of many *Rhododendron* species are carried away from high hills to downwards along with huge landslides and finally they are damaged and eliminated, and thus affecting the population growth of these species. Similarly, forest fires damage the virgin forests of *Rhododendron* and thereby reducing the rich growth of the species. The man made threats are very apparent particularly because of the traditional life in hilly and forest areas is closely associated with vegetation, domesticated animals and wildlife. The major threat caused by the man is the clearing of *Rhododendron* forests for construction of roads, dams and new towns in the hills. This has been observed in the areas like Bomdila, Jung, Shergoan, Tawang, Hapoli, Mechuka in Arunachal Pradesh and Gangtok to Nathula, Kupup, Lachung, Khatau, Yumthang in Sikkim. Hundreds of *Rhododendron* trees along with *Abies* are cut down for fuel-wood, used for melting the coal tar for road construction in upper Tawang areas by the Border Road construction personnel. The shifting cultivation in West Kameng, Tawang, Lohit and Subansiri districts of Arunachal Pradesh; Japfo and Saramati hill ranges in Nagaland, Blue Mountain ranges in Mizoram has also decreased the growth and regeneration of *Rhododendron* species in general. This has resulted in most species becoming rare and threatened in nature and hence they require conservation and multiplication.

Like other plant species the conservation of *Rhododendron* 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 *Rhododendron* sanctuaries, Parks, etc. In this direction, some efforts by Sikkim forest department and Sikkim *Rhododendron* Society have already been made by fencing the *Rhododendron* rich sites and declaring them as *Rhododendron* Sanctuary between Lachung and Yumthang in the state. Similar efforts need to be made by Arunachal Pradesh Government as the state is home for more than 50 per cent rare and endemic Indian species. *Rhododendron* rich areas in Tawang and West Kameng districts of Arunachal Pradesh need to be declared as *Rhododendron* Sanctuaries to conserve the rare and endemic species. *Ex situ* conservation can be effected by cultivating *Rhododendron* species in the gardens and parks under suitable climatic conditions or by using tissue culture techniques. The rare and threatened species can be rehabilitated and multiplied at Lloyd Botanic Garden, Darjeeling, and experimental Garden of Botanical Survey of India at Shillong. There should not be much difficulties in introducing these species in Botanic Gardens and Parks as most of them have successfully been introduced and cultivated in the European and American countries. In Sikkim, some species especieally *R. arboreum* are propagated through cuttings. Tissue culture studies of Indian *Rhododendron* are yet to be initiated. However, in the West a lot of work on tissue culture of *Rhododendron* have already been carried out either for commercial or purely for research purpose (Lloyd & McCown, 1981; Anderson, 1984; McCown & Lloyd, 1985; Briggs, *et al.*, 1988; Evers, *et al.*, 1988). Anderson's (1984) revised medium for shoot proliferation of *Rhododendron* is used widely as the standard culture medium and is available in the market in the form of ready formulated medium powder in packets. Successful tissue culture of these species will be a great contribution for rapid multiplication and towards *in vitro* conservation.

REFERENCES

Anderson, W.C. 1984. A revised medium for shoot proliferation of *Rhododendron*. *J. Amer. Soc. Hort. Sci.* **109**: 343-347.

Anonymous 1947. The Species of *Rhododendron*. The Rhododendron Society, Printed in Great Britain by T. and A. Constable Ltd. at the University Press, Edinburgh.

Briggs, B.A., S.M. McCulloch and L.A. Edick 1988. Micropropagation of azaleas using thidiazuron. *Acta Horticulturae* **226(1)**: 205-208.

Calder, C., Narayana Swami and M.S. Ramaswami 1926. List of species and genera of Indian Phanerogams not included in Sir, J.D. Hooker's Flora of British India. *Rec. Bot. Surv. Ind.* **11(1)**: 1-157.

Chamberlain, D.F. 1980-82. A revision of Rhododendron. *Notes R. B. G. Edinb.* **39(1-2)**: 1- 400.

Clarke, C.B. 1882. Ericaceae In: J.D. Hooker, *Flora of British India.* **3**: 462-475.

Evers, P.W., J. Donkers, A. Prat. and E. Vermeer 1988. *Micropropagation of forest trees through tissue culture.* Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen.

Ghosh, R.B. and U.P. Samaddar 1989. The Rhododendrons of the North-East India. *J. Econ. Tax. Bot.* **13(1)**: 205-220.

Kataki, S.K. 1983. Some rare plants in Khasi and Jaitia Hills of Meghalaya. In: Jain, S.K. and R.R. Rao (eds.) *An Assessment of Threatened Plants of India.*pp. 146-150. BSI, Calcutta.

Linnaeus, C. 1837. *Genera Plantarum*. London.

Lloyd, G.and B. McCown 1981. Commercially-feasible micropropagation of mountain laurel, *Kalmia latifolia*, by use of shoot tip culture. *Proc. Int. Pl. Prop. Soc.* **30**: 421-427.

Mabberley, D.J. 1987. The Plant-Book - *A portable dictionary of higher plants.* Cambridge University Press, Cambridge.

McCown, B.H. and G.B. Lloyd 1985. A survey of the response of Rhododendrons to *in vitro* culture. *Plant Cell, Tissue and Organ Culture* **2**:77-85.

Naithani, H.B. 1990. *Flowering plants of India, Nepal & Bhutan (not recorded in Sir J.D. Hooker's Flora of British India.* pp 257-264. Surya Publications, Dehra Dun.

Naithani, H.B. and K.N. Bahadur 1983. New and Rare Taxa of Rhododendron from Arunachal Pradesh. In: Jain, S.K. and R.R. Rao (eds.) *An Assessment of Threatened Plants of India.* pp 116-126. BSI, Calcutta.

Nayar, M.P. and S. Karthikeyan 1981. Fourth list of species of genera of India Phanerogams not included in J.D. Hooker's Flora of British India. *Rec. Bot. Surv. India.* **21(2)**: 131-152.

Nayar, M.P. and K. Ramamurthy 1973. Third list of species of genera of India Phanerogams not included in J.D. Hooker's Flora of British India. *Rec. Bot. Surv. Ind.* **15:** 204-234.

Pradhan, U.C. 1985. A preliminary enumeration of Rhododendrons of the Indian Region. Part 1. *Himal. Plant Journal* **3(8)**: 110-123.

Pradhan, U.C. 1986. A preliminary enumeration of Rhododendrons of the Indian Region. Part 2. *Himal. Plant Journal* **4(11-12)**: 73-76.

Pradhan, U.C. and S.T. Laehungpa 1990. *Sikkim-Himalayan Rhododendrons.* Primulaceae Books, Kalimpong.

Razi, B.A. 1959. A second list of species and genera of India Phanerogams not included in J.D. Hooker's Flora of British India. *Rec. Bot. Surv. India* **18**: 1-56.

Sally, H.E. and H.E. Greer 1986. *Rhododendron Hybrids A guide to the origins.* B.T. Batsford Ltd., London.

Sastry, A.R.K. and P.K. Hajra 1983. Rare and Endemic Species of *Rhododendron* in India - A Preliminary Study. In: Jain, S.K. and R.R. Rao (eds) *An Assessment of Threatened Plants of India.* pp 222-231. BSI, Calcutta.

Watt, G. 1892. *A dictionary of the economic products of India.* **6.** Calcutta.

Rhododendron arboreum

D.K. Singh

Rhododendron thomsonii

D.K. Singh

Rhododendron griffithianum

D.K. Singh

Rhododendron lepidotum

Dev Raj Agarwal

Rhododendron campanulatum

Rhododendron farmosum

2200

Dev Raj Agarwal

Rhododendron campylocarpum

Dev Raj Agarwal

Rhododendron wightii

Dev Raj Agarwal

Rhododendron hodgsoni

HEDYCHIUMS

S.C. Srivastava

The genus *Hedychium* first appeared under the name *Gandasulium* in Rumphious Herbari. Amboin. (1750), but the name, was latter rendered invalid in accordance with the article 13.1 of ICBN. Koenig (1783) described the genus *Hedychium* with an specific epithet "*coronarium*" from Malaya and, thus, established the genus. The genus is exclusively South and South East Asian, which includes exquisitely beautiful and sweetly fragrant plants. Its members are commonly known as garland flowers or ginger lily and all are highly prized among the flowering plants (Paxton, 1868).

Hedychium is a very complex genus of morphologically alike species. Its complexity is apparent from a letter from Wallich written to Roscoe on 4th December, 1824, "I venture to affirm there is not a more difficult family in this whole extent of phanerogamous plants, than that which you have chosen foryour present botanical labours. Its members are as numerous as their discrimination is extremely arduous. I have found the Hedychia difficult beyond what I had anticipated ...." (Roscoe, 1828). However, the genus has got some ethical importance and it can be better understood from the following statement of Roscoe (1828) "..................On account of its fragrance, it is cultivated by native of east, the Malaya women ornamenting their heads with the flowers or sending them to their lovers to remind them their vows"6666.

After the establishment of the genus, numerous species were added from time to time by different workers. Sir J.E. Smith (1811) described four species namely *H. ellipticum*, *H. spicatum*, *H. thyrsiforme* and *H. coccineum* in Rees Cyclopedia from Nepal. Ker-Gawler (1816) added to genus by describing *H. angustifolium*. Further, Roxburgh (1820) described three species, viz. *H. gracile*, *H. flavum* and *H. angustifolium* but the last two species were subsequently treated either under synonymy or as varieties. *H. gracile* and *H. flavum* are the first taxa under the genus described from India.

In the same year Wallich (1820) also added *H. villosum* and *H. speciosum* but subsequently Wallich (1853) himself reduced the latter under the synonymy of former. *H. speciosum*, however, was later reinstated as a valid taxon.

Hedychium gardnerianum and *H. heteromallum*, two more species were added to the genus by Ker-Gawler (1824), but *H. heteromallum* was reduced to synonymy by later workers. Because of the great variability, many species were described from time to time which were either put under synonym or treated as varieties by subsequent workers. Regarding the variability Wallich (*l.c.*) stated "No plants are more subjected to change than those belonging to our genus. This applies equally to their wild and cultivated states and is a constant source of trouble and perplexity to those who wish to study them in their natural place of growth or in gardens and dried specimens are still more difficultly examined due to the delicate fabric of flowers".

Roscoe (1828), while preparing the monograph of Scitaminous plants, dealt with 17 species of which six species were new to the genus viz. *H. aurantiacum*, *H. acuminatum*, *H. maximum*, *H. flavescens*, *H. longifolium* and *H. carneum*. Later, all the species were treated either as synonyms or reduced to varieties. Loddiges (1833) described two more species, viz. *H. stenopetalum* and *H. urophyllum*, but the latter has not been recognised universally J.O. Voigt (1845) gave a list of introduced and cultivated Hedychiums in Calcutta garden along with synonyms and distribution. Joseph Paxton (1868) gave a list of known Hedychiums with their flower colour, native place and phenology. Hooker (1850) established *H. chrysoleucum* which has never been universally accepted. Griffith (1851) described three taxa without any epithet. Wight (1853) too added *H. venustum* and *H. cereneum*. The latter, was, however, reduced to synonymy of *H. venustum* by Wallich (1853).

Wallich (1853) added eleven more taxa to the genus, but only *H. densiflorum*, *H. griffithianum* and *H. gomezianum* could be widely accepted. Horanninow (1862) monograph in his on Scitamineae, described, some new taxa, but none of them are Indian. Clarke (1889) described *H. marginatum*, while Baker (1892) described *H. elwesii*, *H. luteum* and *H. hookeri* and validated the manuscript name of *H. aureum*, *H. villosum* var. *tenuiflorum* and *H. gratum*. Schumann (1904), raised the variety *tenuiflorum* to specific rank and described many new taxa, mostly from Malaysian region.

Till 1910 no addition were made to the genus but W.W. Smith (1911) added one species *H. greenii*. Later Turrill (1914) and Fischer (1936) described *H. subditum* and *H. wardii* respectively. Holttum (1950), while dealing with the Zingiberaceae of Malaya, treated *H. chrysoleucum* as a distinct species, Sastry and Verma (1968) aded one more species *H. longipedunculatum*. Rao and Verma (1969) enriched the genus by describing *H. calcaratum, H. gracillimum, H. dekianum* and *H. rubrum*. Rao and Hajra (1974) described *H. robustum* and *H. radiatum*, while Jain and Srivastava described *H. pynursuleanum*.

Hedychium is a natural and homogenous genus. This is true as most of the species are similar and can not be readily segregated into definite groups on the basis of gross morphology. Because of the close resemblance, the identity of the species on the basis of vegetative characters becomes difficult. *Hedychium* is a highly advanced genus as the plants are herbaceous with simple leaves and inflorescence is a terminal spike. The spike may be dense, cone shaped, where the bracts are closely imbricated, or may be lax, where the bracts are loosely arranged. In young stage the spike is dense and cone shaped. On maturity the spike may remain as such, while in some species the peduncle elongates and results in the lax spike. The flowers are produced in succession which remains intact from 15-30 days. Each spike has 20-65 bracts, each of which in turn is studded with 1-7 (sometimes 9) flowers, thus, totalling about 20-350 flowers per spike. The flowers are inferior, showy, delightfully coloured and pleasantly fragrant. The sepals and petals are united. The flower has only one fertile anther and others modified into staminodes and lip. The anther is from sessile to stalked and exothecous. The carpels are syncarpous with axile placentation.The fruit is capsule, brightly coloured, and dehiscing longitudinally into three valves exposing the seeds. Seeds are brightly coloured, arillate.

Rumphius (1750) was among the earliest botanist to be impressed by the beauty of these plants and gave the name *Gandasulium* meaning the *Queen* of perfumes. The genus is compared with beautiful lilies and thus bear the common name 'Ginger lily' or 'garland flowers'. Considering its beauty many species were introduced into different countries. *H. coronarium* was introduced from India and Nepal to America. Similarly *H. greenii*. was introduced to India from Bhutan. However, all the species included in Roscoe's (*l.c.*) Monograph are stated to be native of either India, Nepal or Bangladesh.

SPECIES DIVERSITY

The genus has about 60 species distributed from subtropical to subtemperate zones of South, South-east Asia and Madagascar. Thus, they show disjunct distribution. The species are more abundant in Indo-China and Indo-Malayan region.

In India, it is represented by 41 species and 7 varieties, mostly confined to eastern Himalays and North-east India and few to western Himalaya and South India (Table I). An analysis of the species shows that Meghalaya is the richest region having 32 taxa i.e. 72 per cent of the total taxa occurring in India. All the species occur in the hills at an altitude ranging from 1,000-3,000 m, except *H. coronarium*.

Table I
Indian Taxa of *Hedychium*

Sl.No.	Name of the species	Distribution
1.	*Hedychium acuminatum*	Himachal Pradesh, Uttaranchal, Sikkim, West Bengal, Meghalaya.
2.	*Hedychium angustifolium*	Uttaranchal, Assam, Meghalaya.
3.	*Hedychium auranticum*	Meghalaya. Endangered.
4.	*Hedychium aureum*	Sikkim, Meghalaya. Endangered.
5.	*Hedychium calcaralum*	Meghalaya. Endemic.
6.	*Hedychium coccineum*	Uttaranchal, Sikkim, N.E. India, Orissa.
7.	*Hedychium coccineum* var. *carneum*	N.E. India
8.	*Hedychium coccineum* var. *longifolium*	Sikkim, N.E. India
9.	*Hedychium coccineum* var. *roscoei*	Uttaranchal, Sikkim.
10.	*Hedychium coronarium*	Throughout India.
11.	*Hedychium coronarium* var. *maximum*	N.E. India. Endemic.
12.	*Hedychium dekianum*	Meghalaya, Tamil Nadu. Endemic.
13.	*Hedychium densiflorum*	Sikkim, West Bengal
14.	*Hedychium edwardsii*	N.E. India
15.	*Hedychium elatum*	Uttaranchal, West Bengal, Meghalaya, Nagaland.
16.	*Hedychium ellipticum*	Uttaranchal, West Bengal, Sikkim, Meghalaya, Mizoram.

Sl.No.	Name of the species	Distribution
17.	*Hedychium elwesii*	Meghalaya. Endemic, possibly extinct.
18.	*Hedychium flavescens*	Meghalaya, Andhra Pradesh, Tamil Nadu, Kerala.
19.	*Hedychium flavescens* var. *chrysoleucum*	Bihar, Sikkim, West Bengal, Assam, Meghalaya, Andhra Pradesh, Tamil Nadu.
20.	*Hedychium flavum*	Meghalaya, Nagaland.
21.	*Hedychium gardnerianum*	Sikkim, West Bengal, Arunachal Pradesh, Meghalaya.
22.	*Hedychium gardnerianum* var. *pallidum*	N.E. India
23.	*Hedychium gomezianum*	Arunachal Pradesh.
24.	*Hedychium gracile*	Sikkim, West Bengal, Meghalaya.
25.	*Hedychium gracillimum*	Arunachal Pradesh, Meghalaya. Endemic.
26.	*Hedychium gratum*	Nagaland. Endemic, known from type collection only.
27.	*Hedychium greenii*	Sikkim, Meghalaya, Nagaland.
28.	*Hedychium griffithianum*	Meghalaya.
29.	*Hedychium griffithianum* var. *glanduligerum*	Meghalaya.
30.	*Hedychium hookeri*	N.E. India. Endemic.
31.	*Hedychium longifolium*	Sikkim, Meghalaya.
32.	*Hedychium longipedunculatum*	Arunachal Pradesh, Nagaland. Edemic.
33.	*Hedychium luteum*	Meghalaya, Extremely rare, knownn through a single sheet in CAL.
34.	*Hedychium marginatum*	Nagaland. Endemic, rare.
35.	*Hedychium pynursulaeanum*	Meghalaya. Endemic.
36.	*Hedychium radiatum*	Arunachal Pradesh. Endemic.
37.	*Hedychium robustum*	Arunachal Pradesh. Endemic.
38.	*Hedychium rubrum*	Uttaranchal, Meghalaya, Nagaland.
39.	*Hedychium speciosum*	Meghalaya. Extremely rare, possibly extinct.

Sl.No.	Name of the species	Distribution
40.	*Hedychium spicatum*	Himachal Pradesh,Uttaranchal, Sikkim.
41.	*Hedychium stenopetalum*	West Bengal, Aruachal Pradesh, Assam, Manipur, Meghalaya.
42.	*Hedychium squarrosum*	Assam, Meghalaya.
43.	*Hedychium tenuiflorum*	Meghalaya. Endemic, rare.
44.	*Hedychium thyrsiforme*	Uttaranchal, Sikkim, West Bengal.
45.	*Hedychium urophyllum*	Meghalaya. Endemic.
46.	*Hedychium venustum*	Maharashtra, Tamil Nadu, Kerala. Endemic.
47.	*Hedychium villosum*	West Bengal, Arunachal Pradesh, N.E. India.
48.	*Hedychium wardii*	Arunachal Pradesh. Endemic, rare

An analysis of the world taxa shows that 16 taxa are confined to India and they are endemic (Table I). This accounts for *ca* 26.6 per cent of the total world species and 37.2 per cent of the Indian taxa. Further, 10 taxa are endemic to North-eastern region and three to eastern Himalaya. Two species are common to Assam and Arunachal Pradesh and only one to Malabar and Deccan.

H. coronarium, *H. spicatum* and *H. flavum* are important as they yield essential oils used in delicate and high quality of perfumes. The aerial stem of *H. coronarium* is useful raw material for manufacture of high quality paper which are resistant to folding and breaking. Besides its therapeutic uses, *H. spicatum* is also used as an ingradient of "Abir".

While two species of the genus, viz. *H. elwesii* and *H. speciosum* have possibly vanished from their Indian haunts, some other taxa, like *H. aureum*, *H. gratum*, *H. luteum*, *tenuiflorum*, *H. wardii*, etc. are rare as they are known either through their type collection only or have only sporadically been collected in Indian flora. A concerted effort is, therefore, needed to try and relocate such taxa in not only there known places of occurrence but also from regions having similar phytoclimatic conditions.

REFERENCES

Baker, G.J. 1892. Scitamineae. In: J.D. Hooker, *Flora of British India* **6:** 225.

Clarke, C.B. 1889. *J. Linn. Soc.* **5:** 75.

Fischer, C.E.C. 1936. *Kew Bull.* **1936:** 283.

Griffith, W. 1851. *Notulae ad Plantas Asiaticas*. Calcutta.

Holtum, R.E. 1950. The Zingiberaceae of Malaya Peninsula. *Gard. Bull. Singapore* **27**(2): 155-156.

Hooker, J.D. 1850. *Curtis Bot. Mag.* **6:** t 4516.

Horanninow, P. 1862. *Prodromus Monographiae Scitaminerum.*

Ker Gawler, J.B. 1816. *Bot. Reg.* t. 157.

Ker Gawler, J.B. 1824. *Bot. Reg. t.* 774.

Koenig, J.G. 1783. *Retz. Observ.* **3:** 73.

Loddiges, G. 1833. *Botanical Cabinet*. London.

Paxton, J. 1868. *Botanical Dictionary.* London.

Rao, A.S. and D.M. Verma 1969. Notes on *Hedychium* Koenig, including four new species from Khasi & Jaintia Hills, Assam. *Bull. Bot. Surv. India* **11:** 120-128.

Rao, A.S. and Hajra, P.K. 1974. *Hedychium radiatum & H. robustum* (Zingiberaceae) two new species from Kameng district, Arunachal Pradesh. *Bull. Bot. Surv. India* **16:** 163-166.

Roscoe, W. 1828. *Monandrian Plants of the Order Scitamineae* Liverpool.

Rumphius, G.E. 1750. *Herbarium Amboinense. Amstelaedami* (Amsterdum).

Sastry, A.R.K. and D.M. Verma. *Hedychium longipedunculatum*, a new species of Zingiberaceae from Subansiri district, North East Frontier Agency. *J. Bombay Nat. Hist. Soc.* **65**(2): 2963.

Schuman, K. 1904. In: K. Engler, *Das Pflanzenreich Heft* **20**: 40.

Turill, W.B. 1914. *Hedychium coronarium* and allied species. *Kew Bull.* **1914**: 370.

Voigt, J.O. 1845. *Hortus Suburbans Calcuttensis* Calcutta.

Wallich, N. 1820. *Hedychium* Kön. Additions and observation. In: W. Roxburgh, *Flora Indica* **1**: 12-13.

Wallich, N. 1853. Initiatory attempt to define the species of *Hedychium*. Hooker J. Bot. **5**: 321-329; 367-377.

Wight, R. 1853. *Icones Plantarum Indiae Orientalis*. Vol. IV. t. **2008**-2012, 2030. (Repr. ed. 1963). Weinheim.

BAMBOOS

A.K. Banerjee

Bamboos are known to the people of this country for a long time. and traceable to Kautilya's *Arthasashtra* (400 B.C.). In Sanskrit the bamboos are known as '*Venu*' In early days, the tribals and rural populations of this country used bamboo skin to incise umbilical-cord during child birth, and even today bamboo poles are being used to carry dead bodies for cremation. Due to its strong culm and height, the bamboos are playing pivotal roles in the daily life of the human beings.

The bamboos are placed under the family Bambusaceae (erstwhile under Graminae or Poaceae). Van Rheede (1678-1693) in his monumental treatise '*Hortus Malabaricus*' described two species of bamboos from this part of the continent. Linnaeus (1753) enumerated single species, while Roxburgh (1814) in '*Hortus Bengalensis*' mentioned seven species of bamboos under different genera. The first monograph on bamboos of British India was published by Munro (1868) covering the present India, Myanmar, Bangladesh, Sri Lanka, Pakistan and Nepal. He had reported 95 species in 21 genera. Kurz (1876, 1878) and Brandis (1899) contributed additional information for this group of plant. Gamble (1896) has done monumental work in this field and published '*Bambuseae of British India*' in which 115 species under 16 genera were taken into account, reducing some of the genera worked out by Munro (1868). Since then, a number of taxonomists like Blatter (1929), Parker (1929), Deogun (1937), Holttum (1956, 1958), Raizada and Chatterjee (1963), McClure (1967), Bahadur (1979), Bahadur and Naithani (1976, 1978, 1983), Soderstrom (1985), Sodestrom and Ellis (1988), Vermah and Bahadur (1980), etc. had made noteworthy contributions on the studies of bamboos. Besides Raizada and Chatterjee (1963), Naithani and Bahadur (1982), Majumdar (1983, 1989), Bennet (1988), Naithani and Bahadur (1982), Naithani and Bennet (1980) and Naithani (1992) have also aded a few new species to the list of bamboos of India. Negi (1993) had reported that one-tenth of the bamboos of the world, or approximately 100 species, are available in India, alone. Recently Seethalakshmi and Kumar (1998), recorded 128 species of bamboos from India in 18 genera, of which 5 genera and 41 species are introduced (Table I).

Table I
Genera and number of species of bamboos naturally occurring and cultivated in India
(source : Seethalakshmi & Kumar, 1998)

Genus	Number of species		
	Natural	Introduced	Total
Arundinaria	2	0	2
Bambusa	12	14	26
Chimonobambusa	1	0	1
Dendrocalamus	7	8	15
Dinochloa	5	1	6
Gigantochloa	2	5	7
Melocanna	0	2	2
Ochlandra	9	0	9
Oxytenanthera	1	1	2
Phyllostachys	2	3	5
Pleioblastus	1	0	1
Pseudosasa	0	1	1
Pseudoxytenanthera	4	0	4
Racemobambos	3	0	3
Schizostachyum	17	1	18
Sinarundinaria	18	3	21
Thamnocalamus	3	0	3
Thyrsostachys	0	2	2
Total	87	41	128

Bamboos are found generally in all tropical and sub-tropical regions of the world especially in Asia and South America. No species grows wild in Europe. In Asia, bamboos are occurring in India, Bangladesh, Myanmar, Sri Lanka, Nepal, Bhutan and most of the countries of South-East Asia, China and Japan. A few species are also available in tropical Africa and Australia. The distribution pattern of the different genera and species of bamboos in India are unique and diverse in nature. The distribution is basically dependent on the ecological parameters, i.e. precipitation, altitude, longitude and latitude of the area. Most of the bamboos are distributed either in the North eastern region of the country comprising the states of West Bengal, Sikkim, Assam, Meghalaya, Nagaland, Manipur, Arunachal Pradesh, Mizoram and Tripura where annual precipitation is maximum and ranges between 2189 to 11422 mm, particularly at Kalimpong and Cherrapunji respectively, and in the tropical evergreen forests of the West Coast and Western Ghats, where the mean annual rainfall is between 1500-5000 mm. On the other end Jammu & Kashmir does not have any species of Bamboo (Seethalakshmi & Kumar, 1998). Besides these, they prefer humus soil and high humidity. It has been assessed by Vermah and Pant (1981) that out of total forest area of 75 million hectare in India, bamboos are growing in 10 million hectare, and this is 13 per cent of the entire forest area.

Munro (1868) has classified the distribution patterns of bamboo's into five zones as enlisted hereunder:

1. **North-West India**

In this zone the areas of Bihar, Awadh, Siwalik, Punjab, Rajasthan and some parts of North Western states are included. The dominant species are *Dendrocalamus strictus* and *Bambusa arundinacea*, and these are growing scattered in patches in dry deciduous forests up to an elevation of 1000 m, whereas only *Drepanostachyum falcatum* two species of *Thamnocalamus* and two species of *Yushania* are being recorded from this sub-Himalayan area. Out of these *Drepanostachyum falcatum* and *Thamnocalamus spathiflorus* are prominent. Besides these, *Bambusa balcooa* is growing in the villages of Bihar. In this area, about 11 species of bamboos are found growing, out of which population of *Yushania jaunsarensis* is being depleted in Uttaranchal and *Dendrocalamus hookeri* in Himachal Pradesh and these species have become either rare or threatened.

2. **Central India and Deccan Plateau**

This area covers plateau of Chota-Nagpur, Orissa, Madhya Pradesh, western Maharashtra, Deccan Plateau and northern Karnataka. Two species of bamboos are dominant in this region. *Dendrocalamus strictus* is found growing on the slopes of deciduous forests, while *Bambusa arundinacea* grows around the springs of the hilly regions. On the Eastern Ghats, *Bambusa tulda* and species of *Pseudoxytenanthera* grow abundantly. The Parashnath hills of Chota-Nagpur is well represented by *Dendrocalamus strictus* var. *sericeus*. About six genera are recorded to be occurring in this region.

3. Western Ghats and Coastal areas

This zone comprises the Tamil Nadu, Kerala, Karnataka, Konkan slopes of Western Ghats, and Eastern and Western coastal areas of the Pininsular India. The important bamboos of this area are *Pseudoxytenanthera* (with four species), *Ochlandra* (with eight species) and *Yushania* (with three species). Out of these *Ochlandra travancorica* is quite significant and grows in grooves. It has been observed that *Schizostachyum beddomei* is distributed in the dense forests of the Western Ghats, whereas *Bambusa arundinacea* and *B. vulgaris* are predominant in the coastal areas of Kerala (Malabar). In all there are sixteen species of bamboos growing in this geographical zone. It appears that due to over exploitation five species of *Ochlandra* and one species of *Yushania* have become rare in the region.

4. Bengal, Assam, Eastern Himalaya and North-East Frontier

This area comprises the states of West Bengal, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Mizoram and Tripura. This region of India has very rich collection of bamboos represented by 49 species in 12 genera. In most of the villages of West Bengal *Bambusa tulda*, *B. balcooa* and *B. arundinacea* are being cultivated to meet the economic demands. In terai region of the Sikkim Himalaya *Dendrocalamus hamiltonii* is very common, whereas *Bambusa tulda* and *Dendrocalamus sikkimensis* are growing up to 1000 m altitude. In the North-eastern states, particularly in the hills of Nagaland and Meghalaya, several species of bamboos are growing. These are *Bambusa tulda*, *B. khasiana*, *Gigantochloa hasskarliana*, *Dendrocalamus hookeri*, *D. hamiltonii*, *Pseudostachyum polymorphum*, *Melocanna baccifera*, etc. Besides these, a few species of *Drepanostachyum*, *Yushania*, *Chimnobambusa* and *Thamnocalamus* also occur in this region.

In this region species, like *Yushania rolloana*, *Drepanostachyum khasianum*, *Neomicrocalamus manii*, *Phyllostachys assamica*, etc. are endemic. There restricted distribution between 1500-2000 m altitude, together with the loss of habitat, etc. has made them rare or vulnerable to various threats.

5. Andaman and Nicobar Islands

The forests of Andaman & Nicobar Islands are enriched with climbing bamboos, viz. *Dinochloa scandens* and *Gigantochloa nigrocillata*, and shrubby bamboos, like *Bambusa atra* and *Schizostachyum kurzii* growing mostly in the tropical forests of South Andamans. *Dinochloa scandens* and *D. nicobariana* are endemic to this area.

Champion and Seth (1968), however, arranged the distribution of bamboos more specifically into the following forest types:- (i) Bamboo brakes of Himalayan moist temperature forests, (ii) Tropical evergreen or semi-evergreen forests of Assam, Cachar, Orissa, Andamans, West-coast, etc., (iii) Moist or mixed deciduous forests, (iv) Moist Siwalik sal forests and (v) Dry Peninsular sal forests of Singhbhum, Bihar and Sambalpur of Orissa.

Some of the bamboo species of North East or elsewhere in India are also common with Myanmar, Andamans or Sri Lanka, e.g. *Yushania elegans* is available in Naga hills and Myanmar; *Bambusa tulda* in West Bengal, Assam, and Myanmar; *B. pallida* in Sikkim, Assam, Khasi hills and upper-Myanmar; *Pseudoxytenanthera ritcheyi* in Garo hills, Orissa, Chittagong of Bangladesh, Myanmar and Andamans. *Bambusa arundinacea*, which grows throughout India except the sub-Himalayan tracts and Gangetic plains, is also found in Myanmar and Sri Lanka. Similarly *Bambusa atra* of the Andaman Islands is distributed in Java and Malayan Archipelago. Bamboos, like *Yushania walkeriana*, *Y. wrightiana*, *Y. densiflora*, *Ochlandra setigera*, etc. grow both in the South-Indian hills of Nilgiri, Pulney and Annamalais as well as in the forests of Sri Lanka.

The above distribution pattern clearly suggests a past land connection between Indian mainland, Andamans, Sri Lanka and the countries in Indian Archipelago.

The bamboos exhibit wide diversity in form, structure and colour. Some of the species are as tall as 20-25 m, while some are few cm in height. *Dendrocalamus giganteus* is an example of the former and *Yushania densiflora* for latter. The culm diameter also varies from 25 cm to 2 cm. Some are erect, shrub-like, *Schizostachyum kurzii* and *Bambusa atra* while, the others may be climbing or trailing in habit e.g. *Dinochloa andamanica, D. nicobariana* etc. There are three major growth forms of bamboo species in India. Tree forms represent about 45 per cent, 36 per cent are shrubs and about 19 per cent are climbers occurring mostly in closed canopy of the evergreen forests (Prasad & Gadgil, 1981).

Due to their various shape and colour, some of the bamboos are being used in ornamental horticulture, e.g. *Bambusa glaucascens* in making ornamental hedges for its low height and compactness; *B. ventricosa* for its pitcher like swollen culms; *B. vulgaris* var. *striata* for its pale yellow culm with green strippes; *Dinochloa maclellandii* for its zig-zag culm; *Dendrocalamus giganteus* for its magnificient gigantic stem and *Gigantochloa atter* for its black culm.

The rhizomes of bamboos are mainly of two types, viz - *Pachymorph* where the rhizome is knotty, producing buds which results into culms from the knots, e.g. species of *Bambusa* and *Dendrocalamus*, and *Leptomorph* where the long rhizome pushes its way underground and sends out rootlets or buds, from where the aerial culms grow, e.g. *Melocanna*.

Great variations are noticed in respect of the inflorescenes. Sometimes, the spikelets appear in leafy branches, in other they form gigantic panicles. The spikelets may have few or many flowers, varying from species to species. Flowering in bamboos is rather irregular and they may be classified according to their flowering behaviour into following groups:

Species flowering annually or nearly so: e.g. *Bambusa atra, Gigantochloa atter, Ochlandra sivagiriana*, etc.

Flowering after 5-10 or more years : e.g. *Ochlandra travancorica, Dendrocalamus strictus*, etc.

Species flowering after a lapse of 10-50 years : e.g. *Thyrsostachys oliveri*, etc.

After gregarious flowering, the bamboo groves generally die including rhizomes, but in case of annual flowering the growth usually continues in some species. Recently, all the bamboo groves of *Bambusa arundinacea* died after gregarious flowering stretched from Jakpur of Midnapur district of West Bengal to Bhadrak and Balasore districts of Orissa (Pandey *et al.*, 1991).

Culm-sheaths which surround the young shoots and nodes provide very important diagnostic characters to distinguish one species from the other. Since the flowering in most of the bamboos are not regular, hence taxonomists often identify the species of bamboos based on the characters of culm-sheaths and of the rhizome. The sheath has three main parts:

(i) ***Sheath proper*** - corresponding to the petiole of the ordinary leaves which in bamboos forms a broad expansion with its base attached at the node of culm. Sometimes the sheath is thick and smooth, as in most of the species of *Bambusa* and *Dendrocalamus* but it is coriaceous in texture in species of *Dinochloa*. Some species have dense felted hairs all over the outer surface of the sheath but nearly glabrous on the inner surface, e.g. *Dendrocalamus giganteus*

(ii) ***The blade*** which is rather imperfect and corresponds to the blade of a ordinary leaf and is inserted on top of the sheath. It is developed into different shapes, sizes and forms and often becomes decurrent into fringed auricles. In most of species of the *Dendrocalamus, Melocanna, Phyllostachys, Thyrsostachys*, etc. the imperfect blade is narrow, more or less triangular and pointed, while it is comparativley broader in species of *Bambusa, Gigantohloa, Cephalostachyum* and *Dinochloa.*

(iii) ***The ligule*** Like leaves of grasses it is inserted on the inner surface at the junction of the sheath and the imperfect blade. The character of this structure, however, is not very significant for identificaiton of individual species.

The bamboo, being a poor man's timber, have age old relationship with the people. The strength of culm, their straightness, together with the easy way of handling made them suitable for various purposes. They provide materials for preparation of houses, bridges, ladders, mats, umbrella, handles, sticks, fences, bows and arrows, scaffolding, handles for various agricultural implements and tools, toys and various other goods. Bamboo leaves are used for thatching huts and houses and also valued for fodder. Some of the bamboos possess medicinal properties. "*Tabashir*" or "*Banslochan*", largely used as a cooling tonic, is obtained from the nodal joints of *Bambusa arundinacea*.

Rhizome of bamboos are used as handle of billhook and materials for manufacturing of Polo balls. It is understood that this ball is being manufactured in a large scale in the villages of Howrah district of West Bengal. The rhizomes, on account of interwoven root system, prevents soil erosion. During the last few decades, the bamboos are also used in paper industry and in preparation of handicraft materials. It is calculated that more than two million tons of bamboos are used as raw materials in paper industry annually. Besides these, it has been reported by Thammincha (1987) that in the canning factory in Thailand about 350-400 tons of steamed bamboo shoots are being produced annually and exported to Japan. In India, particularly in North-eastern states, the tribals are using young bamboo shoots as food and for making pickles. Recently, a new use of bamboo, "Bamboo Reinforced Cement Concrete Construction" has been evolved at Forest Research Institute, Dehra Dun. In this method, bamboos are used as reinforcing material, replacing steel in the construction of roof-slabs, beams, electric poles, etc. Now a days bamboos are being used as an indoor decorative plant in big hotels, bunglows, etc.

Due to over exploitation of bamboo forests for paper cottage industry, habitat loss, forest fires, etc., species of bamboos may soon become threatened or rare. Though some of the State Forest Departments have started bamboo plantations here and there in patches, but this is meagre in comparison to the destruction of bamboo forests. According to Negi (1993) 24 species of bamboos in 11 genera have become rare or threatened because of various biotic pressure.

However, for conservation of bamboos, centers have been established in the Indian Botanic Garden, Howrah; Forest Research Institute, Dehra Dun, Kerala Forest Research Institute, Peechi, State Forest Research Institute, Chesa (Arunachal Pradesh) etc. Some others are still in a developing stage. Cultivation of bamboos in parks and gardens, pots, and display of ornamental bamboos in hotel corridors are increasingly becoming popular these days. The conservation of bamboos and its hybridization may become plausible in near future due to successful growing of bamboo plantlets through tissue culture and induction of flowering in culture flasks (Nadgauda *et al.*, 1990). Similar experiments have been tried successfully at the Regional Plant Resource Centre, Bhubaneswar, Orissa through multiple shoot induction from mature explants, by axillary bud proliferation and *in-vitro* flowering by tissue culture of bamboos (Das & Rout, 1991; Rout & Das, 1995).

CONSERVATION

Due to continuous exploitation of forest produce, forest fire etc., the deterioration of bamboo forests also are increasing day by day. To maintain and conserve genetic resources, *in-situ* and *ex-situ* conservation is of prime importance of the day. These are summerized as follows:

In-situ Conservation

Some bamboo-rich areas of the country, particularly in North-eastern region and Western Ghats, may be identified and declared as "Bamboo Sanctuaries" Some portion of the denuded areas in the forests can also be selected for plantation of bamboo seedlings or culms during appropriate season for boosting the future economy.

Ex-situ Conservation

Establishment of Regional Bambusetum under the aegies of the Botanical Survey of India at different experimental gardens to maintain the germplasm of the country, and for the taxonomic and phenological studies and regeneration of bamboos. These may help in future breeding programmes and development of high yielding bamboos. The tissue culture technique may also help in the mass reproduction of bamboos and selection of better clones. Besides, storage of seed by scientific method should also be taken up.

REFERENCES

Bahadur, K.N. and H.B. Naithani 1976. Range extension of the bamboo *Cephalostachyum pergracile* Munro. *Indian For.* **102**(9): 596-601.

Bahadur, K.N. and H.B. Naithani 1978. On a rare Himalayan Bamboo. *Indian For.* **1**(1): 39-43.

Bahadur, K.N. and H.B. Naithani 1979. Taxonomy of Bamboos. *Indian J. For.* **2**(3): 222-241.

Bahadur, K.N. and H.B. Naithani 1983. On the Identity, nomenclature, flowering and utility of the climbing bamboo *Melocalamus compactiflorus*. *Indian For.* **109**(8): 566-568.

Bennet, S.S.R. 1988. Notes on the Exotic Bamboo *Thyrsostachys siamensis* Gamble. *Indian For.* **114**(10): 711-712.

Blatter, E. 1929. The Indian bamboos brought up-to-date. *Indian For.* **5**(10): 541-562.

Brandis, D. 1899. Biological notes on Indian bamboos. *Indian For.* **25**(1): 1-25.

Champion, H.G. and S.K. Seth 1968. *A Revised Survey of the Forest Types of India*. Delhi.

Das, P. and G.R. Rout 1991. Mass multiplication and flowering in bamboo *in-vitro*. *Orissa J. Hort.* **19**: 118-121.

Deogun, P.I. 1937. The Silviculture and management of bamboo (*Dendrocalamus strictus*). *Indian For. Rec.* **2**(4): 75-173.

Gamble, J.S. 1896. The Bambuseae of British India. *Ann. Roy. Bot. Gard. Calcutta* Vol. 7.

Holttum, R.E. 1956. The classification of Bamboos. *Phytomorphology*, **6**: 73-90. 1956.

Holttum, R.E. 1958. The Bamboos of the Malayan Peninsula. *Gard. Bull. Singapore* **16**: 1-135.

Kurz, S. 1876. Bamboo and it's use. *Indian For.* **89**(3): 194-199.

Kurz, S. 1877. Forest Flora of British Burma. 2. Calcutta.

Linnaeus, C. 1753. *Species Plantarum*. Stockholm.

Majumdar, R.B. 1983. Three New Taxa of Indian bamboos. *Bull. Bot. Surv. India* **25**(1-4): 235-238.

Majumdar, R.B. 1989. Bambusoideae In : Karthikeyan, S., S.K. Jain, M.P. Nayar, and M. Sanjappa, *Florae Indicae Enumeratio-Monocotyledonae.* pp. 274-283. BSI, Calcutta.

McClure, F.A. 1967. *The Bamboos-A Fresh Perspective.* Havard Univ. Press, Cambridge.

Munro, W.A. 1868. Monograph of the Bambusaceae. *Trans. Linn. Soc. Lond.* **26:** 1-157. 1868.

Nadgauda, R.S., V.A. Parasharami and A.F. Mascarenhas 1990. Precocious flowering and seedling behaviour in tissue cultured bamboos. *Nature* **344:** 335-336.

Naithani, H.B. and S.S.R. Bennet 1980. *Pleioblatus simonii* (Cariere) Nakai A Bamboo new to India from Arunachal Pradesh. *Indian For.* **112**(1): 85-87.

Naithani, H.B. and K.N. Bahadur 1982. A new species of Bamboo from India. *Indian For.* **108:** 212-214.

Naithani, H.B. and K.N. Bahadur 1992. A new species of Bamboo *Schizostachyum* Nees from Arunachal Pradesh, India. *Indian For.* **118**(3): 230-231.

Negi, S.S. 1993. *Biodiversity and it's Conservation in India.* Indus Pub. Co., New Delhi.

Pandey, H.S., A.K. Banerjee and R.K. Chakraverty, 1991 Aatmadahankari Venu. *Vanaspativani* (Hindi), **2**(2): 16-18.

Parker, R.N. 1929. The Indian Bamboos. *Indian For.* **5**(10): 560-562.

Prasad, S.M. and M. Gadgil 1981. Conservation of Bamboo Resource of Karnataka. *Tech. Rep.*, K.S.C.S.T.

Raizada, M.B. and R.N. Chatterjee 1963. A new bamboo from South India. *Indian For.* **89**(5): 362-364.

Rout, G.R. and P. Das, 1995. Isozyme profile during somatic embryogenesis and *in-vitro* flowering in *Bambusa vulgaris*. *J. Plant Biochem. & Biotech.* **4:** 43-45.

Roxburgh, W. 1814. *Hortus bengalensis*. Miss. Press, Serampore.

Seethalakshmi, K.K. and M.S. Muktesh Kumar 1998. *Bamboos of India, a compendium.* BIC, India; KFRI; INBR, New Delhi.

Soderstrom, T.R. 1985. Bamboo Systematics; Yesterday, Today and Tomorrow. *J. Am. Bamboo Soc.* **6**(1-4): 4-16.

Soderstrom, T.R. and R.P. Ellis 1988. The Woody Bamboos (Poaceae: Bambuseae) of Sri Lanka: A Morphological - Anatomical Study. *Smith. Contribution to Bot.* **72:** 1-75.

Thammincha, S. 1987. Role of Bamboos in Rural Development and Socio-economics - A Caste Study in Thailand. In : *Recent Research in Bamboos*. pp. 359-365. I.D.R.C., Canada.

Van Rheede, H.A. 1678-1693. *Hortus Malabaricus*. Amsterdam.

Vermah, J.C. and K.N. Bahadur 1980. Country Report and Status of Research on Bamboos of India. *Indian For. Rec.* **6**(1): 1-28.

Vermah, J.C. and M.M. Pant 1981. Production and utilization of bamboos. *Indian For.* **7**(8): 465-476.

Dendrocalamus giganteus

Dinochloa maclellandii

Bambusa ventricosa - an ornamental bamboo

Bambusa ventricosa -
an ornamental bamboo with swollen culms (close up)

Bambusa vulgaris var. *striata* - an ornamental bamboo

AGRICULTURAL PLANTS

D.K. Hore

There are three levels of diversities in plant kingdom. Firstly, the ecosystem diversity which refers to independent communities of species and their physical environment with characteristic assemblages of plants. Secondly, the species diversity which refers to species or cultivars of species within a given area. Thirdly, the genetic diversity which refers to the variation in genes and genotypes between and within the species where the species permits an organism to adapt to changes in environment. The diversities in agricultural plants support our social and economic system by way of providing the food security and nutrition. In nature diversities comprise traditional landraces, primitive cultivars, wild and weedy relatives of cultivated plants. Such variations occur among them due to continuous evolution over the time and space. High yielding varieties, resulting from research programme and natural outcrossing, also constitute a part of diversity. The present day plant breeders are dependent and in search of such original genepool which can help them develop desired crop varieties.

Physio-geographically, Indian subcontinent has been divided into 8 regions (excluding Myanmar) by Chatterjee (1939). Similarly, based on physiography, climate and cultural characteristics, the ICAR has recognised 8 agro-climatic regions in the subcontinent (Murthy & Pandey, 1978). The region is termed as 'Hindustani Centre' (Zeven & Zhukovsky, 1975), where 152 cultivated species are enumerated and considered to have been originated and diversified. About 35 species of agri-horticultural importance were domesticated in the Indian gene centre. Approximately 160 species, (combining the exotic and indigenous plants) are presently cultivated. (Chandel & Rana, 1995). Over 325 wild relatives of various crop plants which hold a natural reservoir of genes, are native to this subcontinent (Arora & Nayar, 1984). Floristically, the Indian gene centre is extremely rich. Over 15000 species of higher plants, of which 4900 species are endemic are known to occur in the region. Of these, 800 species are of ethnobotanical interest and well over 1200 species are of medicinal importance. There are about 1500 threatened forest species in India.

Interestingly, just 28-30 species constitute the major food plants that feed the global population, and 55 plant families have contributed to all the supply of domesticated species (Harlan, 1975). These are distributed/

concentrated in twelve regions of crop diversity (Zeven & Zhukovsky, 1975). Apart from the conventional cultivated crop species, 43 less known cultivated edible plants have also been recognised in Hindustani (Indian) region of diversity (Arora, 1985) which include tuberous, vegetable, fruit and seed/nut types.

AGRICULTURAL CROP DIVERSITY

Indian subcontinent is rich in Agricultural crop diversity. A large number of crops have originated and diversified here (Table I).

Causes and extent of crop diversity

Based on agro-ecological situations and phytogeographical regions of India, Arora (1991) has provided an overview of crop plant diversity, their wild relatives and diversity in economic plants, in a nutshell. Floristic accounts on the region were provided by Hooker (1872-97), Kanjilal (1934-40), Bor (1960) and subsequently the scientists from the Botanical Survey of India. Factors responsible for the occurrence of genetic diversity are: (i) ecogeographical and physiographical diversity (ii) diverse environment (iii) less to heavy precipitation (iv) ethnic communities and their complete dependence on agriculture especially in Himalayan regions (v) crop introduction from the adjacent countries (vi) natural migration (vii) remoteness and inaccessibility of the area leading to selection and maintenance of primitive cultivars.

With regard to cultivated species the total gene pool for each crop and their diversities is not yet fully understood. The hilly regions of the country is dominated by tribal people, whose basic profession is agriculture. Cropwise, occurrence of such indigenous/native diversities are stated below:

Cereals

Rice (*Oryza sativa*) is the principal crop of the country. More than 30 high yielding varities (HYV) are cultivated under different rice ecosystem. About 50,000 land races of rice are considered to to be occurring in India (Paroda & Malik, 1990). These are mostly concentrated in the North-eastern region, tribal dominated areas of Bihar, Orissa. Madhya Pradesh, Andhra Pradesh extending to Karnataka, Tamil Nadu and Kerala. Based on the exploration and collection of germplasms (Hore & Sharma, 1991) more than 8000 rice diversities have been recorded from

Table I
Agri-horticultural crop species native to India

Crop group	Crop	Name	Family
I. CEREALS	Rice	*Oryza sativa* (various *indica* types)	Poaceae
	Dwarf wheat	*Triticum aestivum* ssp. *sphaerococum*	"
II. PSEUDOCEREALS/ MILLETS	Kodo millet	*Paspalum scrobiculatum*	"
	Ragi	*Eleusine coracana*	"
	Raishan	*Digitaria cruciata* var. *esculenta*	"
	Job's tear	*Coix lacryma jobi* var. *ma yuan* and var. *stenocarpa*	"
III. PULSES	Black gram	*Vigna mungo*	Leguminosae
	Moth bean	*Vigna aconitifolia*	"
	Pigeon pea	*Cajanus cajan*	"
	Horse gram	*Dolichos uniflorus*	"
	Velvet bean	*Mucuna utilis*	"

Crop group	Crop	Name	Family
IV. OILSEEDS	Rai	*Brassica campestris*	Brassicaceae
	Sarson	*Brassica campestris* var. *sarson*	"
	Toria	*Brassica campestris* var. *toria*	"
V. VEGETABLE	Brinjal	*Solanum melongena*	Solanaceae
	Cucurbits	*Luffa acutangula*	Cucurbitaceae
		Luffa cylindrica	"
		Trichosanthes dioica	"
		Citrullus lanatus	"
		Cucumis sativus	"
		Coccinia indica	"
	Radish	*Raphanus sativus*	Brassicaceae
VI. TUBER CROPS	Taro	*Colocasia esculenta*	Araceae
	Yam	*Dioscorea* spp.	Dioscoreaceae
	Foot yam	*Amorphophallus campanulatus*	Araceae
VII. FIBRE CROPS	Jute	*Corchorus capsularis*	Tiliaceae
	Tree cotton	*Gossypium arboreum*	Malvaceae
	Sunhemp	*Crotalaria juncea*	Leguminosae

Crop group	Crop	Name	Family
VIII.SPICES AND CONDIMENTS	Turmeric	*Curcuma longa*	Zingiberaceae
	Ginger	*Zingiber officinale*	"
	Bengal cardamom	*Amomum aromaticum*	"
	Large cardamom	*Amomum subulatum*	"
	Black pepper	*Piper nigrum*	Piperaceae
IX. BEVERAGE	Tea	*Camellia sinensis*	Theaceae
X. FRUITS	Mango	*Mangifera indica*	Anacardiaceae
	Orange, Lime and Lemons	*Citrus* spp.	Rutaceae
	Phalsa	*Grewia asiatica*	Tiliaceae
	Bael	*Aegle marmelos*	Rutaceae
	Lotka	*Baccaurea sapida*	Euphorbiaceae
	Banana	*Musa* spp.	Musaceae
	Jack Fruit	*Artocarpus heterophyllus*	Moraceae
XI. SUGAR YIELDING CROP	Sugarcane	*Saccharum officinarum*	Poaceae
		Saccharum sinense	"

Crop group	Crop	Name	Family
XII BAMBOOS		*Bambusa arundinacea*	Bambusaceae
		Bambusa polymorpha	"
		Bambusa strictus	"
		Bambusa tulda	"
		Cephalostachyum capitatum	"
		Dendrocalamus hamiltonii	"
		Dendrocalamus longispathus	"
		Melocanna baccifera	"
		Neohouzeaua dullooa	"
		Sinocalamus giganteus	"

the North-eastern region alone of the country. At least 9 taxa of wild relatives of rice have been found in localised pockets (Hore & Sharma, 1993). The various deep water varieties of rice need special attention, particularly in Assam state. Black kerneled rice is a novelty of Manipur while red kerneled is of Mizoram. Autumn rice is cultivated in every state of the eastern India, whereas summer rices is cultivated in Assam, Meghalaya and Tripura (Borthakur, 1992). Both winter and summer rice cultivation is absent in Arunachal Pradesh.

Maize (*Zea mays*) is second major crop, especially in hilly regions of the country. In plains, it is widely cultivated in Andhra Pradesh, Orissa, Bihar and northern Madhy Pradesh·Abundant variability has been observed in this crop and the NBPGR Regional Station Shillong has collected so far at least 800 diversities. Dent and Flint corn are mostly found while pop and waxy type are rare in cultivation. Based on the occurrence of maize diversities, Singh (1975) has classified them in 15 distinct races and 3 subraces and published the catalogue of indigenous maize germplasms on 1971 accessions (Singh, 1995). The state of Nagaland, Manipur and Sikkim is a potential area of maize crop diversity. The production may be enhanced and encouraged if the farmers get proper storage, transportation and marketing facilities. Except from the naturally occurring hybrids of corn, the invasion of HYVs is very less in North-eastern region. The introduction of *Euchlaena mexicana* (Teosinte) and *Tripsacum dactyloides* (Gama grass) is a recent one in some localised area as forage crop. These two genera are closely related to corn crop and played a dominant role in the understanding of evolution of maize.

Barley (*Hordeum vulgare*) is one of the oldest cultivated cereals. It is distributed in peninsular tract, western and northern Madhya Pradesh, Rajasthan, eastern Maharashtra and parts of Karnataka. The crop has limited cultivation in the high altitude regions of Arunachal Pradesh and Sikkim. Perhaps due to less consumption and preference, cultivation is not popular in eastern India. A few varieties, however, were collected by the NBPGR, Shillong from Arunachal Pradesh and Sikkim state. Mostly they are naked type, awned and cold adaptable. Similarly, wheat (*Triticum aestivum*) is cultivated of higher altitudes of these two states and these are cold tolerant genotypes. The introduction of HYV, like *Kalyan-sona* and *Sonalika* in Assam is performing well due to their wide adaptability and resistant to loose smut. The crop is widely cultivated in northern Indian states, peninsular North-western, central plains, drier parts of Maharashtra, Karnataka and Andhra Pradesh.

Pseudocereals

Buckwheat ***(Fagopyrum esculentum)*** is one of the minor grain crops said to be a native of central Asia. The distribution of this crop is in hilly tracts of North-eastern states, and entire subtropical to temperate West Himalayan range. In North-eastern region it is cultivated in Meghalaya, Manipur, Arunachal Pradesh and Sikkim. Dwarf varieties are introduced in plains of Assam to a limited scale. *Fagopyrum cumosum*, is a wild relative of cultivated species, which is perennial type and found in Meghalaya (Joshi & Paroda, 1991).

Amaranth is another crop which is extensively cultivated in North-western and central plains, eastern Maharashtra, West Himalayan states of Himachal Pradesh, Uttaranchal and Jammu & Kashmir. In North-eastern region, North Bengal and Sikkim *Amaranthus tricolor, A. caudatus* and *A. spinosus* are very much relished as leafy vegetable. Grain Amaranth, *A. hypochondriacus* is cultivated in high altitude region of Himachal Pradesh, Uttaranchal, Sikkim and Arunachal Pradesh. The importance of this future food crop is well documented (Joshi & Rana, 1991).

Chenopods (Chenopodium album) is also a substitute cereal crop in high hills of both western and eastern Himalaya. The species is cultivated in jhoomland as mixed crop. Tall variety bears a heavy inflorescence and the apical portion bends due to its weight. This variety is usually cultivated in high hills of Nagaland. Variability is pronounced in plant height, leaf size, days to flower, maturity, inflorescence size and grain yield. The promising potentialities of this crop in western Himalayan region have been studied by Tej Pratap and Kapoor (1987).

Millets

These are small-seeded cereal and forage grasses which embrace ten genera of family Poaceae. The species include *Pennisetum americanum, Setaria italica, Panicum miliare, Eleusine coracana, Paspalum scrobiculatum, Echinochloa frumentacea, Brachiaria ramosa, Eragrostis tef, Digitaria* sp. and *Coix lacryma-jobi*. Among the millet growing countries, India occupies the first position where it is grown throughout the country especially in tribal areas. In North-eastern region, the major cultivated millets are Foxtail millet (*Setaria italica*); Finger millet (*Eleusine coracana*); Kodo millet (*Paspalum* *scrobiculatum*); Pearl millet (*Pennisetum americanum*); Raishan (*Digitaria cruciata* var. *esculenta*) and Job's tear (*Coix lachryma-jobi*). Within these species, again there exist a good number of variabilities, especially in foxtail (panicle and caryopsis characteristics) and finger millet (arrangement of spikes). Tribal pockets of Madhya Pradesh, Arunachal Pradesh and Meghalaya (Garo Hills) are rich in diversities of *Coix*, *Eleusine* and *Setaria* (Arora, 1977). Raishan (*Digitaria cruciata* var. *esculenta*), an obsolete crop of West Khasi Hills of Meghalaya is gradually disappearing due to changes in food habit (Singh & Arora, 1972).

Jowar (Sorghum bicolor) is another important food and fodder crop of dryland agriculture. Cultivation of *Sorghum* and their variability are available in tribal pockets of the country. The cultivation is done for the grains which are palatable and seeds differ in size, colour and shape.

The distribution of various cultivated millets and their wild relatives (Bor, 1960) in the country are given in Table II.

Table II
Distribution of cultivated and wild millets in India
(after Bor, 1960)

Species	Distribution
Eleusine indica	Wild in plains and hills up to 1700 m.
Eleusine coracana	Cultivated in hills in between 600-2000 m.
Avena sativa	Cultivated in Arunachal Pradesh.
Avena fatua	Introduced and naturalised in Meghalaya.
Setaria italica	Cultivated throughout the hilly region up to 1700 m and in tribal pockets of M.P., A.P., Orissa and Bihar.
Setaria glauca	Wild in hills and plains.
Pennisetum americanum	Upper Assam.
Pennisetum alopecuroides	Naga Hills in between 1300-1600 m
Sorghum nitidum	Common in high altitude grasslands.
Sorghum halepense	Plains of Assam.
Coix gigantea	Khasi Hills of Meghalaya.

Species	Distribution
Coix lacryma-jobi	North-eastern Hill region (above 1000 m)
Panicum miliare	Tribal belt of A.P., Orissa, Bihar, M.P., and Maharashtra
Paspalum scrobiculatum	M.P., Bihar and Orissa

Pulse crops or grain/poded legumes

Pulses are the important crop which produce root nodules, fix atmospheric nitrogen and thereby improve soil fertility. They contribute sufficient protein in the diet, besides serving as excellent forage and cattle feed. The cultivated area is about 20 per cent of the total area under food grain crops in the country. The major cultivated species of the country and their wild relative(s) are given in table III.

Table III
Grain/vegetable/legumes of India

Cultivated species	No. of available diversities	Wild related species
A. Grain Legumes		
1. Rice bean *Vigna umbellata*	40, covering 5 botanical varities like var. *major*, var. *rymbaija*, var. *macrocarpa*. etc.	*V. capensis*, *V. cantiang*, *V. vexillata*, *V. pilosa* (Chadel *et al.*. 1988).
2. Adzuki bean *Vigna angularis*	Introduced	–
3. Green gram *Vigna radiata*	26 cultivars	var. *sublobatus*
4. Black gram *Vigna mungo*	27 (cultivars)	var. *niger* var. *viridis*
5. Khesari *Lathyrus sativus*	–	
6. Soybean *Glycine max*	9 cultivars	
7. Cowpea *Vigna sinensis*	9 cultivars	ssp. *catjang*, ssp. *sesquipedalis*

Cultivated species	No. of available diversities	Wild related species
8. Pigeon pea *Cajanus cajan*	90	*Atylosia barbata*; *A. lineata*, *A. elongata* *A. scarabaeoides* *A. sericea*
9. Lentil *Lens culinaris*	17 cultivars	–
10. Pea *Pisum sativum*	20 cultivars and 6 varities, like var. *hortense* var. *arvense* etc.	–
B. Vegetable legumes		
1. Sem *Dolichos lablab*	10	*Dolichos falcatus* *D. biflorus*
2. French bean *Phaseolus vulgaris*	12	–
3. Jack bean *Canavalia ensiformis*	1	–
4. Tree bean *Parkia roxburghii* (Sharma *et al.*, 1993).	2	–
C. Tuberous legumes		
1. *Moghania vestita*	1	Confined mostly to Khasi and Jaintia Hill districts of Meghalaya. (Singh & Arora, 1973).
2. *Eriosema chinense*	1	An under exploited and under utilised tuberous herb growing on hilly slopes.
3. *Pachyrhizus erosus*	2	Assam, Meghalaya, West Bengal, Bihar.

Oil Seeds

Oil extracted from seeds have been used by the man as ingradient of various food preparations. These are contributed by various plant species. Edible oil are much used in plains of the region while use of vegetable oil is very less. There are 203 varieties of oil seeds identified, released and introduced in cultivation: 44 varieties have been developed and introduced after selection and screening from germplasm directly (Table IV).

Table IV
Oil-seed diversity in India

Crop Species	Area of concentration of diversities'	Wild relatives
Sesame		
Sesamum indicum	U.P., M.P., Rajasthan, A.P., Orissa, Gujarat, Tamil Nadu.	*S. alatum*, *S. prostratum*, *S. radiatum*, *S. laciniatum*
Groundnut		
Arachis hypogaea	Gujarat, A.P., Karnataka, Tamil Nadu and Maharashtra.	–
Niger		
Guizotia oleifera	Introduced in Assam plains	–
Castor		
Ricinus communis	A.P., Gujarat, Orissa and Karnataka	–
Sarson		
Brassica campestris var. *sarson* (Yellow and brown)	Uttar Pradesh, Rajasthan, Madhya Pradesh, Haryana, Punjab, Bengal, Bihar, Orissa and Gujarat.	–
Toria		
B. campestris var. *toria*	–	–
Indian Mustard		
Brassica juncea	–	–
Black Mustard		
Brassica nigra	–	–

Crop Species	Area of concentration of diversities	Wild relatives
Bhanjira		
Perilla frutescens	Subtropical areas of NE Region. (Sharma *et al.*, 1989).	*P. ocimoides*
Linseed		
Linum usitatissimum	M.P., U.P., Maharashtra, Bihar.	*L. angustifolium*.

Vegetables

Plenty of vegetable crops are grown in the country. This ranges from sole crops to leafy vegetable which are more commonly used in hills due to their growth and adaptation with respect to temperature and altitude. The remarkable polymorphic variabilities are observed in cucurbits (Hore & Sharma, 1990), especially in North-eastern India which includes diverse varieties and land races (Table V).

Table V
Diversity in cucurbits in India

Cultivated species		Area of concentration for diversities	Range of diversity
1.	*Cucurbita maxima*	Throughout the country.	Extensive
2.	*Cucurbita moschata*	Hilly areas	Moderate
3.	*Cucurbita ficifolia*	Meghalaya	Introduced and naturalised.
4.	*Cucurbita pepo*	Meghalaya, Mizoram.	Limited.
5.	*Coccinia grandis*	Assam, West Bengal.	Limited.
6.	*Cucumis sativus*	Throughout the country.	Wide.
7.	*Cucumis callosus*	Foothills of Meghalaya and Mizoram.	Confined to limited pockets.
8.	*Luffa acutangula*	Tropical areas of Assam.	Wide.
9.	*Luffa cylindrica*	Tropical and subtropical areas of Assam, Meghalaya, Manipur, West Bengal.	Moderate.

Cultivated species	Area of concentration for diversities	Range of diversity
10. *Momordica charantia*	Throughout the country.	Moderate.
11. *Momordica cochinchinensis*	Assam, Meghalaya, Manipur, West Bengal.	Limited.
12. *Momordica dioica*	Garo hills.	Rare.
13. *Trichosanthes anguina*	Meghalaya, Tripura, Assam, West Bengal.	Limited.
14. *Trichosanthes dioica*	Tropical areas of Assam, Tripura, West Bengal, Bihar.	Limited.
15. *Cyclanthera pedata*	Hills of Meghalaya, Manipur, Nagaland and Arunachal Pradesh.	Meagre.
16. *Benincasa hispida*	Assam, Nagaland, Meghalaya, West Bengal, Bihar and Uttar Pradesh.	Wide.
17. *Lagenaria siceraria*	Throughout the country.	Wide.
18. *Sechium edule*	High hills of Meghalaya, Manipur, Mizoram, Nagaland, Sikkim Darjeeling in West Bengal.	Moderate.

Wild species or relatives of cultivated cucurbits like *Cucumis hystric, Hodgsonia macrocarpa, Luffa aegyptica, Cucumis callosus, Gymnopetalum cochinchinensis, Bryonopsis laciniosa* and *Trichosanthes cordata* are invaluable material for breeding programme.

Similarly, Okra (*Abelmoschus esculentus*) is cultivated in tropical and subtropical regions of the country. Wide range of variability exist in shape, size and longitudinal fissures of immature fruits. Perkin's long, green cultivar is recommended for hilly areas. The sparsely distributed. *A. manihot, A. moschatus* are two wild relative of this crop. At least 13 promising cultivars are cultivated throughout the country.

Brinjal (*Solanum melongena*) has got primary centre of origin in India and there are extensive variability in the country. They can be classified primarily into two groups according to their longivity, i.e. annual and perennials. Three botanical varities such as var. *esculentum*, var. *surpentinum* and var. *depressum* are widely cultivated. At least 50 different cultivars exhibiting the range of morphological variability in size, shape, colour and weight exist in the country. The other related species and wildly occurring species of *Solanum*, that grow in the country are listed in table VI.

Table VI
Diversity in Solanums in India

Species	Remarks
Solanum macrocarpon	Introduced in NE region.
Solanum xanthocarpum	Used as vegetable and for medicinal purpose.
Solanum indicum	Domesticated, used as vegetable and medicine.
Solanum mammosum	Possibly introduced, ornamental with high solasadine percentage.
Solanum khasianum	Wild and cultivated for solasadine alkaloid.
Solanum torvum	Wild, sold in the market of Mizoram.
Solanum barbissetum	Ripe fruits are eaten.
Solanum ferox	Wild, leaves are used medicinally.
Solanum spirale	Wild, but domesticated for medicinal purpose in Arunachal Pradesh.
Solanum sisymbrifolium	Native of America, wildly grown in Meghalaya.
Solanum kurzii	Endemic to Garo Hills, Meghalaya, edible.
Solanum gillo	Introduced in NE region as vegetable.

Species of chillies such as *Capsicum annum* and *Capsicum frutescens* are very much used as vegetable in as much as they are priced for spices and flavouring dishes. Based on the survey in theNorth-eastern region, NBPGR, Regional Station, Shillong has already identified more than 50 chilli diversities, which are already characterised and conserved in the National Gene Bank.

Tuber crops

Tuber crops play a dominant role in the life of tribal people in India. They are much used as food and require little care for cultivation. The major genera of this group include Taros (*Colocasia, Alocasia, Xanthosoma*), Yams (*Dioscorea* spp.), Potato (*Solanum tuberosum*) and sweet potato (*Ipomoea batatas*). Cassava (*Manihot esculenta*) is an introduced crop in this region. The major species of this group are :

(a) ***Taros***: *Colocasis esculenta*; *C. affinis*; *C. fallax*; *C. mannii*; *Alocasia cucullata*; *A. fallax*; *A. macrorrhiza*; *Xanthosoma sagittifolium* etc.

(b) ***Elephant foot yam***: *Amorphophallus campanulatus*.

(c) ***Yam***: The species belonging to the genus *Dioscorea* are considered as yams. It is very large genus comprising over 600 species. About 12 are known for edible purposes. They grow in eastern and southern India. The plants are rhizomatous or tuberous. A few species are of importance as food crops such as *Dioscorea alata, D. esculenta, D. bulbifera, D. hamiltonii* and *D. pentaphylla*. Morphologically, twining of stem character distinguises the species. Bulbils are the storage organ in some species. Yams are rich in carbohydrates, starch grains and vitamin C. Calcium, Iron and Phosphorus are among the components of the mineral fraction of the tuber. Certain yam species contain quantities of alkaloids (Dioscorine) and steroid derivatives (Diosgenin). The edible fresh *Dioscorea* species can be utilised in boiled, pounded, mashed and fried form. There are also industrial form of uses in the preparation of corticosteriod drugs, poisonous alkaloids for pharmaceutical purposes and oral contraceptives from Diosgenin.

The diversity in yams of North-eastern region is listed in Table VII.

Sugar yielding crops

The main source of sugar is *Saccharum officinarum*. Though cultivation and production of sugar is very less but the region is bestowed with rich genetic resources and the wild relatives of closely and allied genera (Hore & Sharma, 1995). The major related wild genera of *Saccharum* are *Erianthus, Miscanthus, Sclerostachya* and *Narenga*. Their occurrence and population are frequent and abundant in their respective habitat. The state of Meghalaya, Manipur and Arunachal Pradesh are rich in sugarcane diversities, where the cultivation is very limited. Commercial cultivation are largely done in the state of Uttar Pradesh, Maharashtra, Tamil Nadu and Karnataka, where at least 50 varieties are grown.

Table VII
Species and varieties of *Dioscorea* and their distribution in the North–eastern states

Species Name	Varieties	Distribution
Dioscorea alata	var. *alata* var. *tarri* var. *vera*	Assam (North Lakhimpur), Meghalaya, Mizoram (Aizawl, Sairang, Bunglang).
Dioscorea arachnida	–	Assam, Meghalaya.
Dioscorea belophylla	–	Arunachal Pradesh, Meghalaya, Nepal, Bhutan.
Dioscorea. bulbifera	var. *crispata* var. *pulchella*	Arunachal Pradesh, Assam, Meghalaya, Mizoram (300 to 1800m).
Dioscorea cumingii	var. *inaequifolia*	Assam (North Lakhimpur, Karbi Anglong).
Dioscorea decipiens	–	–
Dioscorea deltoidea	–	Arunachal Pradesh (Kameng district)
Dioscorea esculenta	–	Meghalaya (Garo Hills)
Dioscorea glabra	–	Assam (Goalpara, North Lakhimpur, Dibrugarh, Kamrup)

Species Name	Varieties	Distribution
		Arunachal Pradesh (Siang, Lohit, Khonsa), Meghalaya (Garo Hills, Nongpoh), Nagaland (Kohima)
Dioscorea hamiltonii	–	Tripura (Damcherra, 35 m.), Arunachal Pradesh (Siang, Khonsa), Meghalaya (Garo Hills, Ri Bhoi area – Umtrew), Assam (Kaziranga, Kamrup).
Dioscorea hispida	var. *hispida* var. *daemona*	Assam (Kamrup, Darrang), Meghalaya (Ri Bhoi, Garo Hills), Mizoram (Lungleh)
Dioscorea japonica	–	Nagaland, Mizoram.
Dioscorea kumaonensis	var. *kumaonensis* var. *stramenea*	Meghalaya (Jowai, Jarain) Nagaland.
Dioscorea lepcharum	–	Assam, Arunachal Pradesh.
Dioscorea listeri	–	Assam, Arunachal Pradesh, Nagaland.
Dioscorea melanophyma	–	Arunachal Pradesh, Meghalaya, Sikkim
Dioscorea oppositifolia	var. *oppositifolia* var. *Assamica*	Assam (Nagaon, Karbi Anglong, North Cachar Hills), Meghalaya (Jowai), Arunachal Pradesh (Lohit, Subansiri and Khonsa)
Dioscorea pentaphylla	var. *pentaphylla*	Assam (Kaziranga), Meghalaya (Mawphlang, Nartiang, Nongstoin, Jowai, Rongrem in Garo Hills, Arunachal Pradesh (Khonsa, Siang, Subansiri), Nagaland (Kohima).
	var. *communis*	Assam.
	var. *hortorum*	Assam.
	var. *kussok*	Assam, Mizoram (Bunglang).
	var. *suli*	Arunachal Pradesh (Siang).

Species Name	Varieties	Distribution
Dioscorea prazeri	–	Sikkim, Assam, Nagaland.
Dioscorea pubera	–	Meghalaya (Khasi Hills).
Dioscorea pyrifolia	var. *ferruginea*	Arunachal Pradesh, Assam.
Dioscorea scortechinii	–	Assam (Sibsagar).
Dioscorea trinervia	–	Meghalaya (Shora to Dawki, shaded forests), Arunachal Pradesh (Khonsa)
Dioscorea wallichii	–	Arunachal Pradesh (Aka hills).
Dioscorea wattii	–	Meghalaya, Assam (North Lakhimpur), Arunachal Pradesh (Lohit), Tripura (Chandrapur), Sikkim

Beverage

India is considered as secondary centre of origin for tea. Tea crop is cultivated mainly in Nilgiris, North Bengal, Assam and Tripura states of the country. *Camellia sinensis* and its various clones contributing high yield are maintained by Tea gardens. Besides that *C. kissi, C. caudata, C. japonica,* are three other and related species of Tea occurring in the North-eastern region (Singh & Bezbaruah, 1988). *Camellia sasanqua* and *C. irrawadiensis* are two introduced species. The major wild relatives of tea are *Gordonia excelsda, Eurya, japonica, Eurya acuminata* and *Schima wallichi*. The primary centre of tea is considered to be the mountains of China and North of North-eastern India. The secondary centre is Assam where *C. sinensis* var. *assamica*, is cultivated. In southern India, Nilgiri hills is another region where tea crop is cultivated extensively.

Fibre crops

A wide range of various fibre yielding crop diversities are occurring in the country including their wild relatives (Table VIII):

Table VIII
Diversities in some fibre crops in India

Crop(s)/Species	Wild relatives	Distribution
Cotton		
Gossypium arboreum	–	Widely distributed in India
G. herbaceum	–	Garo Hills, Meghalaya
Bombax ceiba	–	Assam, West Bengal, Bihar
Jute		
Corchorus capsularis *C. olitorius*	–	Assam, Meghalaya, West Bengal, North Bihar, South East Orissa, eastern U.P.
Mesta		
Hibiscus cannabinus	var. *viridis* var. *ruber* var. *simplex* var. *vulgaris* var. *purpureus*	Assam, Tripura, West Bengal
Roselle		
Hibiscus sabdariffa	–	Garo Hills, Assam and West Bengal
Ramie		
Boehmeria nivea	*B. utilis*, *B. regulosa*	Assam, Meghalaya
Matcane		
Schumannianthus dichotomus	–	Lower Assam (plains) and North Bengal.
Hemp		
Cannabis sativa	–	Wildly grown in Assam and Meghalaya as secondary vegetation, in localized pockets.

Spices

Ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*) are well adapted crop of hilly region. Variability in these crops were noticed in respect of their fiber and curcumin content respectively. Besides that, black pepper (*Piper nigrum*), true cardamom (*Elettaria cardamomum*), Cinnamon (*Cinnamomum zeylanicum*) and Tejpat (*C. tamala*). Bengal cardamom (*Amomum aromaticum*) and Nepal Cardamom (*Amomum subulatum*) are cultivated in Assam and Sikkim areas. Out of 172 various spice yielding species of Indian subcontinent, 49 species occur in Western Ghats (Nair & Ravindran, 1988).

Promising cultivars of ginger, namely '*Thingalaidon*' and '*Thingpui*' are originally derived from their wild relatives from Lushai Hills of Mizoram. These varieties are well distributed in Meghalaya as well. Similarly, '*Lakadong*' variety of turmeric is well known for its high curcumin content and the home of the variety is Jowai in Meghalaya. *Curcuma zedoaria* grows wildly in Meghalaya and Assam plains from which '*Shoti*' (barley) food is prepared.

Leaves of coriander (*Coriandrum sativum, Eryngium foetidum*), peppermint (*Mentha piperata*) are used for flavouring and are also eaten as salad with cooked food, in most parts of the country.

Fumitories and Masticatories

Two species of tobacco, *Nicotiana tabacum* and *N. rustica* are cultivated extensively for the purpose of smoking and chewing. The former species is grown in Andhra Pradesh, Karnataka, Gujarat, Bihar and West Bengal while the latter needs cooler climate and hence grown in limited scale in most of the hill districts of the Northern and North-eastern states. The occasionally found wild tobacco plants are probably escapes from cultivation. Inter-specific crosses have been made to introduce male sterilizing cytoplasms and genes conditioning resistance to diseases. At least 30 different varieties of tobacco were released by Central Tobacco Research Institute (CTRI), Rajahmundry, which are suitable for cigarette, chewing, bidi, cheroot and hookah preparation purposes.

Fruits

The cultivation of fruits in India dates back to ancient times. While the fruits, like mango, banana, phalsa, jack fruit, bael, amla, lemons, citrons are of Indian origin, peach, sweet orange, litchi appear to have come from China. Some common fruits such as guava, papaya, sapota, custard apple, pineapple have been introduced from continental America by Portugese settlers. On the other hand temperate fruits and nuts, like apple, pear, plum, cherry, almond, apricot, walnut, pome-granate, pistachio-nut, grapes came from central Asiatic region.

The area under different major fruit cultivation in North-eastern region is given in table IX, whereas a list of major fruits that are available (both under cultivation and wild) in the country along with the number of their cultivars and wild relatives and distribution, has been provided in Table X.

There are a few dozen of economicaly important minor fruits which could be appropriately exploited through their large sale cultivation (Pandey *et al.*, 1993). This can help the farmers earn cash in odd and difficult time. The potential species of this category include *Elaegnus latifolia, Elaegnus pyriformis. Rubus ellipticus, Rubus lasiocarpus. Myrica esculenta, Myrica sapida. Pyrus pashia. Prunus nepalensis. Baccaurea sapida. Castanopsis indica. Viburnum foetidum, Calamus erectus, Gynocardia odorata, Emblica officinalis, Artocarpus lakoocha, Garcinia lanceafolia, Manglfera sylvatica, Citrus aurantium, Citrus medica, Musa balbisiana, Phoenix humilis* and *Elaeocarpus floribundus.*

Bamboos

Bambos are the predominaant species of the North-eastern region and can be termed as 'Green Gold' Approximately 63 different species, covering 19 genera of Bamboos, are occurring in this region (Sharma *et al.*, 1992). The utilisation of various bamboo species is associated with the daily life of tribal communities. Besides, the four paper mills in the region solely depend on Bamboos as raw materials for manufacturing of paper pulp. The major bambo vegetation is concentrated in North Cachar and Mikir Hills. Sporadic distribution of various species is extended up to 1500 m altitude or beyond in the hills right from the plain areas of the region. The genera that are occurring in the region are *Arundinaria, Bambusa, Cephalostachyum, Chimnobambusa, Dendrocalamus, Dinochloa, Gigantochloa, Melocalamus, Melocanna, Neohouzeaua, Oxytenanthera, Phyllostachys, Thamnocalamus, Semiarundinaria, Pseudostachyum, Pleioblastus, Teinostachyum, Sinobambusa* and *Thyrsostachys.* Number of species available in the state of Arunachal Pradesh, Meghalaya and Assam are 41, 38 and 33 respectively, while some species are common to all these states.

Table IX

Area under important fruits in North-eastern Region (in thousand hectares)

State	Pineapple	Orange/ Citrus	Banana	Apple	Pear	Stone fruits	Papaya	Mango	Guava	Coconut	Other	Total
Arunachal Pradesh	0.256	1.667		2.312	0.125	0.305						4.665
Assam	3.40	2.00	20.00				2.48			5.0	1.10	25.98
Manipur	6.02	4.00	8.50		1.60	0.40	0.2	0.1	1.0		2.00	23.82
Meghalaya	7.30	4.80	2.875		0.30	0.31					1.60	17.851
Mizoram	0.21	0.38	0.9				0.69					2.18
Nagaland	0.11	0.364									-	
Tripura	2.83	1.21	8.50				0.30			0.8		7.14
Total	20.126	14.417	35.075	2.312	2.025	1.015	3.67	0.1	1.0	5.8	4.70	84.44

Table X
List of major Fruit crops in India

Common name	Species	No. of cultivars in the country (approx.)	No. of wild relatives (approx.)	Distribution
Tropical				
Mango	*Mangifera indica*	998	4	Tropical areas of Assam, Meghalaya, Mizoram, Tripura, Andaman & Nicbar Islands.
Litchi	*Litchi chinensis*	09	–	Introduced in Assam, Tripura, Bihar, U.P.
Jackfruit	*Artocarpus heterophyllus*	3	4	Foot hills and plains of entire tropical belt of eastern and southern India.
Jamun	*Syzygium cumini*	1	2	Tropical and subtropical regions of India.
Water Rose Apple	*Syzygium aqueum*	1	–	Tropical and subtropical areas of Assam, Meghalaya, Tripura and West Bengal.
Custard apple	*Annona squamosa*	1	1	Throughout North India
Elephant apple	*Dillenia indica*	-	2	Assam, foot hills of Arunachal Pradesh, Tripura.
Wood apple	*Aegle marmelos*	–	2	Tropical areas of U.P., W.B., Assam, Meghalaya, Bihar and Tripura.
Ber	*Zizyphus mauritiana*	18	5	Plains of U.P., Rajasthan and Haryana

Common name	Species	No. of cultivars in the country (approx.)	No. of wild relatives (approx.)	Distribution
Carambola	*Averrhoa carambola*	1	1	Plains of Assam, Meghalaya and Tripura.
Cashewnut	*Anacardium occidentale*	1		A.P., Karnataka, Kerla, Tamil Nadu, Orissa. Introduced in lower altitude/ foothills of Garo and Mikir Hills.
Coconut	*Cocos nucifera*	2		Coastal areas of Indian states, lower Assam, Tripura, Andaman & Nicobar Islands.
Pineapple	*Ananas comosus*	7		Introduced and naturalised.
Papaya	*Carica papaya*	12	1	Introduced and naturalised.
Pome granate	*Punica granatum*	8		Sporadically introduced in home garden, in Rajasthan, U.P., J.&K. and Meghalaya.
Water-melon	*Citrullus lanatus*	1		Assam plains - riverbed areas, Delhi Haryana, Rajasthan, U.P.
Cucumber	*Cucumis sativus*	8	2	Throughout NE region and tropical belt of India.
Aonla	*Emblica officinalis*	5	2	Plains and hills of Meghalaya, central and southern India.
Jalpai	*Elaeocarpus floribundus*	–	1	Lower hills of Mizoram.

Common name	Species	No. of cultivars in the country (approx.)	No. of wild relatives (approx.)	Distribution
Guava	*Psidium guajava*	11	1	Tropical and Subtropical (up to 1000 m.) regions of India.
Mangosteen	*Garcinia mangostena*	–	1	Meghalaya.
Banana	*Musa acuminata* *Muisa balbisiana*	70 03	14 –	Throughout the tropical and subtropical zones of the country.
Subtropical				
Lime, lemon and orange	*Citrus* spp.	17 plus 52 varities in NE region.	–	Lime and lemon in both tropical and subtropical region while orange occurs in subtropical zone only (Kaul, 1981).
Passion fruit	*Passiflora edulis*	2	–	Meghalaya, Nagaland.
Mulberry	*Morus alba*	1	1	Assam, Meghalaya.
Peach	*Prunus persica*	8	5	Mehgalaya, Jammu and Kashmir.
Pear	*Pyrus communis*	7	3	Himachal Pradesh, Meghalaya, Nagaland and Arunachal Pradesh.
Plum	*Prunus domestica* spp. *institia*	11	–	Meghalaya, Mizoram, U.P., H.P., J&K., Tamil Nadu (Nilgiris).

Common name	Species	No. of cultivars in the country (approx.)	No. of wild relatives (approx.)	Distribution
Strawberry	*Fragaria vesica*	3	–	Hills of NE region.
Apple	*Malus sylvestris*	34	2	H.P., Jammu & Kashmir, Uttaranchal, Arunachal Pradesh, introduced in Nagaland.
Docynia	*Docynia hookeriana*	1	1	Meghalaya.
Cotoneaster	*Cotoneaster rotundifolia*	1	7	Meghalaya.
Sorbus	*Sorbus lanata*	1	8	Meghalaya (mostly apomictics).
Rubus	*Rubus ellipticus*	–	16	Meghalaya, Nagaland, Arunachal Pradesh.

Canes

This economic plant species has enough potentialities because of its wide spread occurrence. Large scale extractions resulted in diminishing of the population. The recorded species belong to the genera *Calamus, Daemonorops* and *Plectocomia*. A synoptic description of different species of canes of NE region and strategies for their conservaiton was discussed by Hore (1994).

Orchids

The orchids have immense horticulture significance. The long lasting, beautiful flowers can earn handsome amount of foreign exchange through cut flower trade. There are over 1100 species covering 169 genera in India of which over 700 species occur in North-eastern region. On the basis of occurrence and importance of the species, a new project Directorate on Orchids has been established by the ICAR in Sikkim. An analysis of occurrence of North-east Indian orchids has been presented by Kataki *et al.* (1984) and Hore and Sharma (1990).

Apart from agricultural plants, there are also a good number of diversities in other economic plants which includes (a) medicinal and aromatic plants (b) wild forage plants (c) native ornamental plants and (d) forest trees. Commercial cultivation of economically important species is not done in large scale. In fact, they are extracted from nature randomly. In case of forest tree species, leaving aside some monoculture cultivation (*Tectona grandis, Shorea robusta, Michelia champaca, Lagerstroemia flos-reginae, Gmelina arborea, Anthocephalus chinensis, Pinus khasiana*), most of the diversified tree species are subjected to felling without any regeneration/afforestation. In recent years, the most sought after trees are *Taxus wallichiana* and *Aquillaria malaccensis*. These are being exploited illegally from the habitat randomly for commercial purpose.

Responsibilities and action of NBPGR

Against this rich crop diversity scenario in the country NBPGR together with its Regional Stations, located in different agroclimatic zones has been entrusted with the responsibilities for collection, evaluation and *ex situ* conservation of crop genetic resources of the country. Since 1976, the scientists of the Bureau have collected more than ninety two thousand indigenous germplasm accessions belonging to several crops. About 30 per cent area of the country, which are unapproachable or inaccessible is still to be explored. There is a large network of Biosphere Reserves, National Parks, Game Sanctuaries, Reserve Forests situated in the country. Assessment of plant genetic wealth in such reserves is not yet fully understood. The Nokrek Biosphere Reserve of Garo Hills has been declared as gene sanctuary for *Citrus indica* (Singh, 1981). Habitat preservation of *Nepenthes khasiana* (Pitcher plant) in Jarain at the behest of Botanical Survey of India by the Forest Department is an ideal approach for conservation. Similar approach is needed for conservation of *Lilium mackliniae* of Sirohi hills in Ukhrul district of Manipur.

The Bureau has distributed about 127842 accessions of various crop germplasm to different research institutes during the period 1976-1992 (Rana, 1993).

Attention has also been given to popularise the under utilised crops and to increase their yield potentialities so that they can serve as alternate food plants. Experiments have been undertaken on such crops through the All Indian Co-ordinated Research Project on under-utilised and under-exploited plants, at different ICAR research centres.

Introduction of exotic crop plants which can adapt in local environmental condition is another function of the Bureau. The desert type exotic guava, kiwi fruit, passion fruit are now well acclaimatised. Cutlivation of forgotten crops (*Digitaria cruciata* var. *esculenta, Passiflora quadrangularis, Tetragonia expansa, Vigna umbellata* var. *rymbaija, Moghania vestita, Perilla frutescens,* wild races of *Allium sativum*) are needed to be continued in order to avoid their further genetic erosion.

CONSERVATION

Conservation of plant genetic resources is an important aspect, which is followed through *in-situ* and *ex-situ* methods. The former strategy was initiated in early seventies, when India became a member of the MAB programme launched by UNESCO. The object is to conserve for present and future use, the diversity and integrity of biotic communities within natural eco-systems and to safeguard the genetic diversity of species on which their continuous evolution depends.

In-situ conservation include the protection of large area under different categories, such as in the form of Biosphere Reserves, Wildlife Sanctuaries, Gene Sanctuaries, Nature Reserves or habitat preservation/plot. This way the entire biomes is safeguarded and the extinction of species is deterred, but there is little impact on useful plants, unless the protection law is strictly enforced. The system allows the wild species to remain in their natural communities. For semi-wild or semi-cultivated species, it helps to domesticate the economic plants thereby safeguarding the landraces in their respective regions of cultivation. On the other hand *ex-situ* conservation leads to domestication in gardens, farm gene banks, seed banks, germ plasm bank, etc. Further, the plant parts or vegetatively propagated material can be maintained through tissue/meristem cultures.

In India, ecosystem based conservation i.e. *in situ* conservation are being undertaken in the form of Biosphere Reserves and National Parks. However, the information about the availability of various genetic diversities in economic plants in these areas is still scanty. Nokrek reserve in Meghalaya and its adjacent places possess at least 10 varieties of *Citrus* and 6 varieties of foxtail millets. The sacred groves of the Khasi and Jaintia hills of Meghalaya are unique examples of the prevalence of traditional values dating back to the palaeolithic times of human history. These are forbidden forests and none is allowed to cut trees or kill animals inside these forests. Through the belief, religious and cultural, the forest is being conserved, which is a natural storehouse of at least 650 species of orchids, 450 species of grasses, 68 species of bamboos and 65 species of rhododendrons.

The Manas wildlife sanctuary in Assam is rich in *Dalbergia sissoo, Elaeocarpus ganitrus, Terminalia myriocarpa* and *Mesua ferea.* Similarly, the ecosystem of Kaziranga ranged from marshy grasslands to mixed hilly deciduous forest, where emphasis has been laid on animal diversities inhabiting these ecosystems.

The proposed Namdapha Biosphere reserve in Arunachal Pradesh is dominated by variety of tree species of forestry significance. The 'Hollung' tree (*Dipterocarpus retusus*) is a novelty of this reserve in addition to 50 timber yielding species. The forest is tropical and subtropical evergreen type and the vegetation can be classified in three storey which encompasses the floristic elements belonging to tree, shrubs, herbs, lianas, climbers, stragglers, epiphytes, saprophytes, palms, banana and orchid group. The surveyed area and the floristic analysis reveal that there are about 1150 plant species occurring in this reserve (Chauhan, 1994).

The state of Mizoram is rich in indigenous bamboos and banana. It has a total of 941 sq. km. area under reserve forests. Blue Mountain area is rich in orchids and Rhododendrons. Submontane forests in the state are rich in *Mangifera sylvatica, Parkia roxburghii, Aquillaria malaccensis.* The natural forest at higher elevations in Mamit-Tuidam area are also conserved. Multiplication of cane species in such habitat is a good attempt by the forest department. The state needs to establish a *Bambusetum* where the representative species of bamboos can be conserved. The state is also rich in diversity within various *Citrus* species.

Two Wildlife Sanctuaries and two Game Reserves are established so far in Nagaland state. The region, adjacent to Myanmar, is rich in various important economic plants. *Panax pseudo-ginseng* has recently been discovered from the state. The state has established a Botanical Garden at Kohima. A good number of variabilities in hill paddy, maize, soybean, rice bean, Job's tear, tuberous crops, cucurbits are available in the state. The distribution of *Citrus indica* is also found in Intangki Reserved Forest. *Vanda coerulea, Heliconia dasyantha, Ensete superba* and *Citrus ichangensis* are some other novelties of the state.

Manipur has hardly 225 sq. km. area under protected forest which include one National Park and one Wildlife Sanctuaries. The state has various genotypes of *Mangifera* and wild relatives of *Saccharum. Zizania latifolia*, an aquatic species considered as a wild relative of cultivated rice, is also found in Loktak lake. The state is rich in cultivated paddy diversities. The black kerneled rice is available in high hills of Ukhrul district. Siroy hills is famous for 'Siroy lily' (*Lilium mackliniae*) which is considered as endangered species.

The state of Tripura is the smallest one among the North-eastern region, where only four Wildlife Sanctuaries are there. Jampui hills area, adjacent to Mizoram state, is rich in *Citrus, Zizyphus* species. The wild relative of Guava (*Psidium guianensis*) is available sparsely in the hills of West Tripura district. The state is also rich in paddy, jute and bamboo germplasm. The bamboo based cottage industry of the state is major revenue earner for the state.

Ex situ conservation of crop genetic resources is a vital task of NBPGR by way of storing different crop germplasm material in National Gene Bank. For vegetatively propagated material the germplasm are conserved in *in-vitro* repositories and clonal Field Gene Banks.

At the end of 1992 the base collections in National Gene Bank at NBPGR and *in vitro* conservation at National Facility for Plant Tissue Culture Repository (NFPTCR), New Delhi are as follows :

Table XI
Status of *ex-situ* conservation at NBPGR, New Delhi
(after Rana, 1993)

Ex-situ conservation methods	Crop groups	No. of accessions
I. Long term storage (-20°C)	Cereals	45,909
	Pulses	22,536
	Millets	14,288
	Oilseeds	15,408
	Vegetable	5,993
	Fibre crops	3,212
	Narcotics	790
	Medicinal and aromatic plants	152
	Pseudocereals	736
	Improved varieties	904
II. Medium term storage (+4°C)	Indigenously collected samples.	34,515
	Voucher specimens of exotics.	20,760
III. *In-vitro* Storage		
i. 10°C for 12 to 16 months	*Allium* spp.	47
ii. 25°C ranging from 8 to 15 months	*Ipomoea, Dioscorea, Zingiber, Curcuma, Musa, Citrus* and *Rauvolfia* sp.	472
	Total:	1,65,922

Besides, there are 30 National Active Germplasm Sites under the ICAR system who are also the paratners for PGR systems for the relevant crop in the country.

REFERENCES

Annonymous 1995. *Basic statistics of Northeastern India*. Northeastern Council Secretariat, Shillong.

Arora, R.K. 1977. Job's-tears (*Coix lacryma-jobi*) a minor food and fodder crop of Northeastern India. *Econ. Bot.* **31**(3): 358-366.

Arora, R.K. 1985. Genetic resources of less known cultivated food plants. *NBPGR Sci. Monogr.* **9**: 1-126.

Arora, R.K. and E.R. Nayar 1984. Wild relatives of crop plants in India. *NBPGR Sci. Monogr.* **7**: 1-90.

Arora, R.K. 1991. Plant diversity in the Indian gene centre. In: Paroda, R.S. and R.K. Arora (eds.) *Plant Genetic Resources Conservation and Management Concepts and Approaches*. pp 25-54. IBPGR, New Delhi.

Bor, N.L. 1960. *The Grasses of Burma, Ceylon, India and Pakistan (excluding Bambuseae)*. Pergamon Press, Oxford

Borthakur, D.N. 1992. Genetic resources of North-east region. In *Agriculture of the North-eastern Region with Special Reference to Hill Agriculture*. pp. 108-126. Beecee Prakashan, Guwahati.

Chandel, K.P.S., R.K. Arora and K.C. Pant 1988. Rice bean a potential grain legume. *NBPGR Sci. Monogr.* **12**: 1-60.

Chandel, K.P.S. and R.S. Rana 1995. Plant genetic resources system An Indian perspective. In: Arora, R.K. and V. Ramanatha Rao (eds.) *Proceedings of the South Asia National Coordinators Meeting on Plant Genetic Resources*. pp 25-43. IPGRI, New Delhi.

Chatterjee, D. 1939. Studies on the endemic flora of India and Burma. *J. Royal Asiat. Soc. Bengal*, N.S. (Science). **5**: 19-67.

Chauhan, A.S. 1994. Resource potential of proposed Namdapha Biosphere Reserve of North eastern region. *Indian J. Hill Farmg.* **7**(1): 22-29.

Haridasan, K. and D. Deori 1991. A list of plants not recorded in the flora of British India that are recorded from or found in Arunachal Pradesh. *Arunachal For. News* **9**(2): 21-34.

Harlan, J.R. 1975. *Crops and Man.* American Society of Agronomy, Crop. Science Society of America, Madison, Wisconsin, USA.

Hooker, J.D. 1872-97. *The Flora of British India.* Vol. 1-7. L. Reeve & Co., London.

Hore, D.K. and B.D. Sharma 1990. Cultivated cucurbits and their wild relatives in India. *Indian J. Pl. Genet. Resources* **3**(1): 81-90.

Hore, D.K. and B.D. Sharma 1990. Orchids of Northeastern India and their conservation. *J. Orchids Soc. India* 4(1 & 2): 113-122.

Hore, D.K. and B.D. Sharma 1991. The collecting, conservation, evaluation and uses of rices of South Asia with special reference to Northeast India. *Indian J. Pl. Genet. Resources* **4**(1): 61-72.

Hore, D.K. and B.D. Sharma 1993. Wild rice genetic resources of Northeasst India. *Indian J. Pl. Genet. Resources* **6**(1): 27-32.

Hore, D.K. and B.D. Sharma 1995. Diversity and distribution of sugarcane complex in NE India. *Indian J. For.* **18**(1): 38-42.

Joshi, B.D. and R.S. Paroda 1991. Buckwheat in India. NBPGR, Shimla, *Sci. Monogr.* **2**: 1-117.

Joshi, B.D. and R.S. Rana 1991. Grain Amaranths: The Future Food Crop. *NBPGR, Shimla, Sci. Monogr.* No. **3**: 1-152.

Joshi, B.D. and R.S. Rana 1995. French Bean in India. NBPGR Shimla, *Sci. Monogr.* **5**: 1-168.

Kanjilal, U.N., P.C. Kanjilal and A. Das 1934-1940. *Flora of Assam.* Vol. I-IV. Govt. of Assam.

Kataki, S.K., S.K. Jain and A.R.K. Sastry 1984. Distribution of Orchids of Sikkim and North East India. *Plant Conserv. Bull.* **5**: 1-38.

Kaul, G.L. 1981. *Development of horticulture in Northeastern region a case study of North Cachar Hills District.* NEC Secretariat, Shillong.

Murthy, S.R. and S. Pandey 1978. Delineation of agro-ecological regions of India. 11th Congress, International Society of Soil Science, Edmonton, Canada.

Nair, M.K. and P.N. Ravindran 1988. Genetic resources in spices their diversity and utilisation in India. In: Paroda, R.S., R.K. Arora and K.P.S. Chandel (eds.) *Plant Genetic Resources Indian Perspective.* pp 419-428. NBPGR, New Delhi.

Pandey, G., B.D. Sharma, D.K. Hore and N.V. Rao 1993. Indigenous minor fruit genetic resources and their marketing status in Northern hills of India. *J. Hill. Res.* **6**(1): 1-4.

Paroda, R.S. and S.S. Malik 1990. Rice genetic resources, its conservation and use in India. *Oryza* **27**: 361-369.

Partap, T. and P. Kapoor 1987. The Himalayan grain Chenopods-III. An underexploited food plant with promising potential. *Agric. Ecosystems Environ.* **19**: 71-79.

Sharma, B.D., D.K. Hore and S. Mandal 1989. *Perilla*: an oil and protein rich under exploited crop of Northeastern hills. *J. Oilseeds Res.* **6**: 386-389.

Sharma, B.D., D.K. Hore, G. Pandey and B.M. Wadhwa 1992. Genetic resources of Bamboos in the Northeastern region of India. *Indian J. For.* **15**(1): 44-51.

Sharma, B.D., D.K. Hore and J.S. Salalm 1993. *Parkia roxburghii* useful tree of Northeastern India, *Indian J. Pl. Genet. Resources* **6**(2): 171-173.

Singh, B. 1975. *Races of Maize in India.* ICAR, New Delhi.

Singh, B. 1981. *Establishment of First Gene Sanctuary in India for Citrus in Garo Hills.* Concept publishing Company, New Delhi.

Singh, H.B. and R.K. Arora 1972. Raishan, *Digitaria* sp. minor millet of the Khasi hills, India. *Econ. Bot.* **26**(4): 376-380.

Singh, H.B. and R.K. Arora 1973. Soh-phlang, *Moghania vestita* a leguminous root crop of India. *Econ. Bot.* **27**(3): 332-338.

Singh, I.D. and H.P. Bezbaruah 1988. Genetic resources in tea. In: Paroda, R.S., R.K. Arora and K.P.S. Chandel (eds). *Plant Genetic Resources - Indian Perspective.* pp. 435-442. NBPGR, New Delhi.

Rana, R.S. 1993. Indian National Plant Genetic Resources System. In: Rana, R.S. *et al.* (eds.) *Conservation and Management of Plant Genetic Resources*. pp. 1-18. NBPGR, New Delhi.

Zeven, A.C. and P.M. Zhukovsky, 1975. Dictionary of cultivated plants and their centres of diversity. Pudoc, Centre for Agricultural Publishing and Documentation, Wageningen.

Diversity in rice genotypes

Variability in maize cultivars

Variability in *Benincasa hispida*

Psidium guainensis - wild relative of guava

Canavalia ensiformis - Jack Bean

Perilla frutescens - a promising oil-seed crop

Musa rosea - an endangered wild relative of banana

Musa sikkimensis - a wild relative of banana

D.K. Singh

Amomum subulatum - a wild relative of large cardamom

D.K. Singh

Abelmoschus manihot - a wild relative of lady's finger

MEDICINAL PLANTS

N.P. Singh
V. Mudgal
K.K. Khanna
S.C. Srivastava

Since the advent of human life, man had to depend on his biotic and abiotic environment for sustenance and survival. Since the dawn of civilisation and with increasing needs they attempted to discover the remedies in order to cope with various disorders/illness by manipulating their accumulated knowledge. Traditionally herbal medicines and nature cure were the only treatment available to mankind the world over. In ancient times, sages and saints were growing some of the medicinal plants, besides others, in their house yards for immediate availability for treating the ailments.

In India, record on the utility of natural and plant products to cure ailments appeared in *Rigveda* dating back to 4500-1600 BC., wherein 67 plant species were mentioned which have been botanically equated later on. The Yajurveda includes 81 prescriptions for curing several diseases, of which 100 Sanskrit name of herbs have been identified botanically. A number of therapeutic recipies, time, method of treatment and trade on herbs have also been given in the *Atharvaveda* and about 290 herbs named in Sanskrit have been botanically equated. Thus, India had a rich knowledge on plant based drugs for preventive and curative medicines.

It will be unjustified if the mention of *Tantra* by Agnivesha is avoided. The first recorded treatise on the collection and utility of herbs and herbal products is *Charak Samhita* (1000-800 BC) wherein about 800 plant and plant products have been included for therapeutic treatment under 150 chapters of eight sections. Depending upon the physiological action the plant drugs divided into 57 groups. The most systematic and advanced knowledge on tne principles of treatment appeared sometimes 800-700 B.C. by Sushruta, father of Indian Surgery, named as *Sushruta Samhita* where the emphasis is given on anatomy and surgery. It has 186 chapters under six sections and includes about 400 plants of medicinal utility. The Ayurveda therapy came into existence with the appearance of *Vedas* and was elaborated by Charak and Sushruta. The next landmark in Ayurveda is *Astanga Hridaya Samhita* by Vagabhatta which appeared around 700 A.D. It has 120 chapters under 6 section and according to Vagabhatta, Ayurveda consists of 8 branches which even hold true today. The eight branches are (i) *Shalyatantra* (Major surgery) (ii) *Shalakyatantra* (Minor surgery) (iii) *Kayachikitsa* (Medicine) (iv) *Bhutvidya* (Psychiatry) (v) *Kaumarbhritya* (Paediatrics) (vi) *Agadatantra* (Toxicology) (vii) *Rasaynatantra* (Chemistry) and (viii) *Vajeekaranatantra* (Aphrodisiac and rejuvenation). These three treatises, viz. *Charak Samhita*, *Sushruta Samhita* and *Astanga Hridaya Samhita* are together known as *Vrihat Trayi* of Ayurveda.

Some attempt has been made to provide the list of plants in the three monumental work or *Vrihat Trayi* and it is estimated that there are about 1500 plants and plant products in *Vrihat Trayi*, but only about 775 plants could be equated to their botanical names. The *Kashyapa Samhita* mainly deals with mother and child health care. In 12th century, Madhavakar's *Madhavanidana* came to light which deals mainly with diagnosis. In 14th century *Sharngadhara Samhita*, a systematised Ayurvedic materia, medica was written by Sharanghara. The highly esteemed treatise *Bhava Prakasha* (1500 A.D.) written by Acharya Bhava Misra includes about 470 medicinal plants and is very frequently referred by Ayurvedacharyas. These three treatises namely *Madhavanidana*, *Sharngadhara* and *Bhava Prakash* are together known as *Laghu Trayi*.

Unani system of medicine, also mainly based on natural products, originated about 400 B.C. in Greece, and was brought to India through Arab by Unani physicians. There was lot of similarity between Unani system and Ayurvedic system of medicine as the combination of these two systems resulted in the origin of Unani-Tibbati system of medicine which became very popular among the practitioners. The *Siddha* system was supposed to be gifted by Lord Shiva and this system was very much popular among *Dravida*. Approximately 1000 plants, animals and their products have been documented to be used under this system. In the ancient period human beings were very close to the natrual surroundings and were using the natural resources for various requirements. The advancement of knowledge led to developmental activities which gradually separated the human society from their surrounding natural resources.To fulfil the lacuna several *Nighantu Granthas*, *Bheshaj Samhita* came to light. Some of the outstanding *Nighantus* are *Rajanighantu*, *Madanapalanighantu*, *Dhanavantrinighantu* and *Gudchyadinighantu*. However, most of the medicinal properties of plant drugs disscussed in various *Nighantus* are based on *Vrihat Trayi*. Thus, the golden period of the Ayurveda could be considered between 800 B.C. 1000 A.D. But Buddhist period also witnessed the addition of large number of new plant based drugs and their systematic cultivation. This is another step towards enriching of *Materia Medica*. In *Materia medica*, drugs are classified according to their physiological action and they also include details on the habitat, parts used, time and method of collection and storage of medicinal plants. In India preventive (prophylactic) plant drugs were is use in 16th century and a treatise on drugs used in Indian medicine was published in 1563 by Garcia D' Orta, a portugese Physician, who lived in India. The treatise was based on his several years of experience in indigenous system of medicine (Table I).

Gradually, the traditional system of Indian medicine lost its significance and remained out of practice because the country was repeatedly invaded by foreigners which resulted in the destruction of manuscripts written on palm leaves. The invaders came with their own medicines and practitioners. They gradually popularised their own system of treating the ailments which was largely accepted by the countrymen, thus neglecting indigenous system of Indian medicine. However, the indigenous system of Indian medicine could not be ignored for long due to their strong efficacy and received fresh attention by the western medical practitioners, like Dymock (1883), Dymock, *et al.* (1890-99) and Waring (1897). Sir George Watt (1889-1904) published his monumental work, the *Dictionary of Economic Products of India* in 4 volumes. Sir R.N. Chopra initiated the scientific investigation on Indian medicinal plants in the School of Tropical Medicine at Calcutta and published the work in the book *Indigenous Drugs of India* (1933) which is credited for 180 plant drugs and also established the confirmed activity and pure constituents from plants for modern medicine. Kirtikar and Basu (1935) published the account on medicinal plants of the country in the book *Indian Medicinal Plant* (4 volumes) which includes the diagnostic characters, distribution, local names and uses of 2165 taxa under 911 genera. In 1927, Nadkarni (revised and enlarged in 1954) published the *Indian Materia Medica* in two volumes which includes short diagnosis, distribution, local names and therapeutic uses of 2671 taxa under 982 genera. Later, Chopra *et al.* (1956) compiled the *Glossary of Indian Medicinal plants* which is mainly based on Nadkarni (*l.c.*) and Kirtikar and Basu (*l.c.*) works and, includes 2535 taxa under 920 genera along with commentary on distribution, therapeutic properties and essential chemical constituents of medicinal plants.

Subsequently extensive surveys and researches on Indian medicinal plants were undertaken and consequently several research papers and articles were published which formed the basis of the *Supplement to Glossary of Indian Medicinal Plants* (Chopra *et al.*,1969). During the years to follow, several publications on medicinal plants were also brought out by different workers from time to time (Dey, 1980; Caius, 1986; Chatterjee & Pakrashi,1991 Jain & De Filipps 1991).

Table I
Medicinal properties of some plants as described by Garcia D' Orta.

Name of the plant	Medicinal properties/ailments
Acacia catechu	Anithelmintic, eye diseases, stomach, intestine, teeth/gum throat affections.
Banana	Fever
Betel	Stomach/intestine, teeth/gum affections
Bhang	Aphrodisiac, sedative
Bitter gourd	Fever, diuretic, liver, kidney, bladder affections, sedative.
Camphor	Burn, sedative, antiseptic, stimulant.
Cardamom	Teeth/gum affections.
Cashewnuts	Antihelmintic, antiasthmatic
Cinnamon	Nervous problems, stomach/intestine affections.
Clove	Fever, pain, teeth/gum affections.
Cocos nucifera	Nervous disorder, arthritis, purgative.
Convolvulus turpethum	Purgative
Curcuma longa	Eye diseases, itch.
Curcuma zedoaria	Pain, snake-bite/poison.
Ferula asafoetida	Aphrodisiac.
Mangifera indica	Anithelmintic

Name of the plant	Medicinal properties/ailments
Azadirachta indica	Anithelmintic, nervous affections, wounds, cuts, antiseptic, skin diseases and as insecticides.
Nutmeg, mace and opium	Nervous problems
Opium	Aphrodisiac, stimulant.
Piper chebula	Aphrodisiac, stomach/intestine affections
Sandalwood	Fever, liver/kidney/bladder affections.
Styrax benzoin	Aphrodisiac, stomach/intestine affections.
Sweet flag	Pregnancy, nervous problems.
Tamarind	Purgative, wound, cuts.

Recently, Rastogi and Mehrotra (1990, 1991, 1993) compiled and published the *Compendium of Medicinal Plants* (in 3 volumes) which deals with the chemical constituents, their structure and the significant therapeutic uses of important medicinal plants. The advancement of Ethnobotany and interest in the subject has also led to the discovery of some new medicinal plants. In the present article only the highly recognised and efficacious medicinal plants have been included. An estimation by World Health Organisation has indicated that there are more than 20,000 species of medicinal plants in the world. Further, based on the different publications, it has been estimated that there are about 2000 medicinal plants in India, and more than 6780 industries are engaged in the production of medicines employed in different systems of practice viz., Allopathic, Ayurvedic, Unani and Homeopathic. It is worthwhile to note that about 80 per cent of the human population in India are still dependent on nature for remedies, and this can be well understood from the fact that almsot all the systems of medicine are largely based on drugs of plant origin. Indeed, about 80 per cent of the raw plant materials form the basis of these systems, and even the most modern system of allopathic drugs have their prototype in plants. An estimation given in Table II shows the total number of plants used in major systems of medicine.

Table II
Number of plant species used in various systems of medicine

System of practice	Number of plants
Ayurveda	800
Unani	305
Homeopathy	425
Siddha	250

Almsot in all the systems either the whole plant or different parts of the plants are used in various preparation. So, an estimation of plant species based on partwise use and matters isolated from plants are given in Table III.

Table III
Plant used parts and derivatives used in various systems of medicine

Plant part/derivative	Number of species
Whole plant	570
Tubers and roots	685
Stem	319
Leaf	275
Flowers /inflorescence	201
Fruits and seeds	401
Alkaloid	522
Volatile oil	450
Essential oil	396
Saponin	255
Gum, resins, oleo-resins	165
Tannin	110

Some of the plants whose latinised specific epithets indicate their pronounced efficacy in diseases are given below:

Acacia anthelmintica	Anithelmintic
Brayera anthelmintica	Anithelmintic
Cassia fistula	Fistula
Centratherum anthelminticum	Anithelmintic
Exogonium purga	Purgative
Hydnocarpus anthelmintica	Anithelmintic
Holarrhena antidysenterica	Dysentery
Leonurus cardiaca	Trembling heart
Polyporus anthelminticus	Anithelmintic
Pulicaria dysenterica	Dysentery
Soymida febrifuga	Febrifuge
Tylophora asthmatica	Asthma

The vegetation of India is very rich and can well be understood from the statement of Sir J.D. Hooker (1904) which reads "The Flora of British India is more varied than that of any other country of equal area in the eastern hemisphere, if not in the globe". He again stated that the vegetation of Khasia hills is the richest in India and probably in Asia. The varied and rich nature of flora is due to the geographical position ranging from temperate to tropical, climate from torrid to arctic and arid to a maximum of humidity, the surface rising from sea level to the heights above plant limits. It also enjoys almost all types of soils which helps in luxuriant growth of flora, including the medicinal plants too. Like the other vegetational components, the medicinal plants too show some specificitily about the vegetational/altitudinal zones and phytogeographical units. A brief account of their occurrence in different ecosystems is given below:

Medicinal plants of cold desert

The medicinal plants in this zone usually grow in Ladakh of Jammu & Kashmir, Lahaul-Spiti in Himachal Pradesh, some parts of Uttaranchal, Sikkim and Arunachal Pradesh. The plants growing in this region are well adapted by becoming bushy in appearance with profuse tomentum and deep penetrating rootstock. The herbaceous plants are only visible when the snow has melted. Some of the important medicinal plants growing in this region are *Aconitum heterophyllum, A. palmatum, A violaceum, Anemone obtusiloba, A. narcissiflora, Artemisia dracunculus, A. sacrorum, A. sieversiana, Astragalus multiceps, A. webbianus, Berberis petiolaris, B. umbellata, Botrychium lunaria, Capparis spinosa, Cardamine pratensis, Clematis orientalis, Corydalis ramosa, Delphinium caeruleum, D. cashmerianum, Ephedra gerardiana, E. major, Gentiana decumbens, G. kurroo, G. tenella, Geranium molle, G. pusillum, Geum urbanum, Hyoscyamus niger, Mentha arvensis, M. longifolia, Nardostachys grandiflora, Nepeta cataria, Papaver nudicaule, Pedicularis siphonantha, Picrorhiza kurroa, Plantago brachyphylla, Podophyllum hexandrum, Rhododendron lepidotum, R. setosum, Saussurea obvallata,* etc.

Medicinal plants of alpine region

Plants in this region are bushy in appearance and appear when the snow melts between June to October. Some of the important medicinal plants growing in this region are species of *Aconitum, Anemone, Artemisia Astragalus, Atropa, Bergenia ligulata, Betula utilis, Corydalis govaniana, Delphinium brunonianum, D. denudatum, D. elatum, D. vestitum, Epilobium angustifolium, Inula racemosa, I. royleana, Meconopsis aculeata, M. napalensis, Mentha longifolia, Nardostachys grandiflora, Picrorhiza kurroa, Salix babylonica, Saussurea hypoleuca, S.eostus, Swertia purpurascens, Thymus serpyllum,* etc.

Medicinal plants of sub-alpine region

Plants growing in this region are *Abies webbiana, Acer caesium, A. oblongum, Aesculus assamica, A. indica, Ajuga bracteosa, Artemisia maritima, A. persica, A. scoparia, Asparagus filicinus, Berberis insignis, B. petiolaris, B. wallichiana, Betula alnoides, B. utilis, Cardamine impatiens, Bunium persicum, Coptis teeta, Cotoneaster microphyllus, C. racemiflora, Gentiana olivieri, G. tenella, Geranium lucidum, G. rotundifolium, Hyssopus officinalis, Jurinea macrocephala, Lactuca serriola, Oxalis acetosella, Paeonia emodi, Rheum acuminatum, R. emodi, Rhododendron anthopogon, R. campanulatum, Salix babylonica, Sorbus acuparia, Swertia purpurascens,* etc.

Medicinal plants of temperate region

Some of the plants of this region are *Astragalus strobiliferus, Berberis aristata, B. wallichiana, Carthamus lanatus, Cedrus deodara, Chenopodium botrys, Cimicifuga foetida, Clematis smilacifolia, Codonopsis ovata, Colchicum luteum, Cotoneaster bacillaris, Crocus sativus, Daphne papyracea, Descurainia sophia, Dioscorea deltoidea, Dracocephalum moldavicum, Ephedra intermedia, Eryngium caeruleum, Euphrasia officinalis, Fritillaria roylei, Galium vernum, Geum alatum, Iris ensata, Juglans regia, Onosma bracteatum, Polygala sibirica, Senecio jacquemontianus,* etc.

Medicinal plants of sub-temperate region

The medicinal plants growing in the forests of this region are *Acorus calamus, Amomum aromaticum, A. subulatum, Aneilema nudiflorum, Apium, graveolens, Aquilaria malaccensis, Asparagus adscendens, Bauhinia purpurea, Berberis aristata, Cinchona calisaya, Cinnamomum iners, C. zeylanicum, Clematis napaulensis, Desmodium triquetrum, Hedychium spicatum, Gynocardia odorata, Hypericum patulum, Leea aequata, Quercus lamellosa, Rhus parviflora, Salvia lanata, Senecio densiflorus, Soymida febrifuga,* etc.

Medicinal plants of tropical region

The medicinal plants growing in the tropical forests are *Abutilon hirtum, A. indicum,* species of *Acacia, Achyranthes aspera, Alstonia scholaris, Aristolochia bracteata, A. indica, Asparagus racemosus, Bischofia javanica, Boswellia serrata, Buchanania lanzan, Butea monosperma, Calotropis gigantea, Capparis decidua, C. spinosa, Cassia fistula, Catharanthus rosea, Centella asiatica, Curcuma longa, Curculigo orchioides, Cuscuta reflexa, Desmodium triflorum, Dillenia indica, Elephantopus scaber, Emblica officinalis* species of *Euphorbia, Flacourtia indica, Garcinia morella, Gardenia gummifera, Hemidesmus indicus, Holarrhena antidysenterica,* species of *Solanum, Stephania hernandifolia, Streblus asper, Strychnos nux-vomica, Symplocos racemosa,* species of *Terminalia, Trichosanthes bracteata,* etc.

Medicinal plants of desert region

The humidity in this region is very less due to very scanty rain and thus the region is characterised by warm, dry climate. Some important medicinal plants growing in this region are *Achyranthes aspera, Acacia nilotica, A. senegal, Aerva lanata, A. tomentosa, Anticharis glandulosa, Argemone mexicana, Asphodelus fistulosus, A. tenuifolius, Astragalus hamosus, Barleria prionitis, Bergia odorata, Boerhavia diffusa, Boswellia serrata, Calligonum polygonoides, Calotropis gigantea, C. procera, Capparis decidua, C. grandis, Cassia auriculata, Chloris virgata, Cleome brachycarpa, Commiphora mukul, Diospyros tomentosa, Dipccadi erythraeum, Dolichandrone falcata, Erythrina suberosa, Euphorbia antiquorum, E. granulata, Flemingia strobilifera, Gisekia pharnacioides, Grewia villosa, Heliotropium eichwaldi, Leucas cephalotes, Pavonia odorata, Zygophyllum simplex,* etc.

Medicinal plants of tidal region

Arthrocnemum indicum, Avicennia officinalis, A. tomentosa, Barringtonia asiatica, B. racemosa, Borassus flabellifer, Caesalpinia nuga, Caryota urens, Cassytha filiformis, Cerbera manghas, Ceriops tagal, Citrullus colocynthis, Dolichandrone spathacea, Enicostema littorale, Euphorbia alata, Excoecaria agallocha, Launaea pinnatifida, Nipa fruticans, Rhizophora mucronata, etc.

Medicinal plants of aquatic nature

They either grow in water or wet palces, e.g. *Asteracantha longifolia, Ceratopteris siliquosa, Hydrolea zeylanica, Ipomoea reptans, Nelumbo nucifera, Neptunia oleracea, Nymphaea alba, N. rubra, N. stellata, Nymphoides indicum, Pistia stratiotes,* etc.

Different species of a genus and different genera of a family are employed for the treatment of various ailments in different traditional systems and thus reveal a great diversity in medicinal properties at generic level. Only one species of *Putranjiva, viz. P. roxburghii* grows in India and has a respectable position among the medicinal plant kingdom. Likewise 27 species of *Aconitum* occur in India and 20 (66.6 per cent) of them are highly exploited in medicines. In the same way 4 out of 5 species of *Ferula* (80 per cent) are utilised for medicinal purposes. Some of the important medicinal plants along with total number of species occurring in India and the number exploited for medicinal purposes are given in Table IV.

Table IV
Total number of species of some genera in India and their number of species of medicinal importance.

Name of genus	Name of family	Total no. species in India	No. of species of medicinal importance
1	2	3	4
Abrus	Fabaceae	2	2
Acacia	Mimosaceae	25	14
Acalypha	Euphorbiaceae	10	4
Achyranthes	Amaranthaceae	4	2
Aconitum	Ranunculaceae	27	20
Albizia	Mimosaceae	14	7
Amaranthus	Amaranthaceae	20	10
Amomum	Zingiberaceae	11	4
Andrographis	Acanthaceae	18	2
Argemone	Papaveraceae	2	1
Aristolochia	Aristolochiaceae	15	7
Artemisia	Asteraceae	34	11
Asparagus	Liliaceae	20	8
Barleria	Acanthaceae	26	9
Bauhinia	Caesalpiniaceae	30	9
Berberis	Berberidaceae	70	9
Brassica	Brassicaceae	12	8
Caesalpinia	Caesalpiniaceae	12	8
Callicarpa	Verbenaceae	10	6
Capparis	Capparaceae	30	6
Cassia	Caesalpiniaceae	30	15
Cinchona	Rubiaceae	6	5
Cinnamomum	Lauraceae	25	12

1	2	3	4
Cissus	Vitaceae	8	5
Citrus	Rutaceae	12	10
Cleome	Capparaceae	15	6
Coptis	Ranunculaceae	1	1
Costus	Zingiberaceae	1	1
Cotoneaster	Rosaceae	25	14
Crocus	Iridaceae	1	1
Crotalaria	Fabaceae	97	11
Croton	Euphorbiaceae	20	10
Curcuma	Zingiberaceae	20	10
Delphinium	Ranunculaceae	18	9
Desmodium	Fabaceae	50	12
Dioscorea	Dioscoreaceae	50	9
Ephedra	Ephedraceae	10	6
Euphorbia	Euphorbiaceae	80	25
Ferula	Apiaceae	5	4
Ficus	Moraceae	70	20
Garcinia	Clusiaceae	25	11
Gloriosa	Liliaceae	1	1
Glycyrrhiza	Fabaceae	1	1
Grewia	Tiliaceae	45	12
Hibiscus	Malvaceae	35	15
Indigofera	Fabaceae	70	12
Ipomoea	Convolvulaceae	60	17
Iris	Iridaceae	15	7
Juniperus	Cupressaceae	5	4
Kaempferia	Zingiberaceae	12	4
Leea	Leeaceae	20	5
Leucas	Lamiaceae	40	7
Mentha	Lamiaceae	8	7
Nardostachys	Valerianaceae	1	1
Ocimum	Lamiaceae	7	4
Oldenlandia	Rubiaceae	10	8

1	2	3	4
Paeonia	Paeoniaceae	1	1
Papaver	Papaveraceae	10	7
Picrorhiza	Scrophulariaceae	2	1
Pinus	Pinaceae	5	5
Piper	Piperaceae	50	9
Plantago	Plantaginaceae	10	8
Putranjiva	Euphorbiaceae	1	1
Ranunculus	Ranunculaceae	30	10
Rauvolfia	Apocynaceae	5	4
Rheum	Polygonaceae	12	9
Rhododendron	Ericaceae	80	10
Rhus	Anacardiaceae	15	8
Salix	Salicaceae	40	8
Saussurea	Asteraceae	5	8
Solanum	Solanaceae	40	13
Strychnos	Loganiaceae	22	8
Swertia	Gentianaceae	35	10
Terminalia	Combretaceae	13	13
Tinospora	Menispermaceae	4	3
Valeriana	Valerianaceae	15	4
Vitex	Verbenaceae	15	7
Withania	Solanaceae	2	2
Zingiber	Zingiberaceae	18	3
Ziziphus	Rhamnaceae	17	6

Exotic Medicinal Plants

The flora of India is very rich and varied. Due to geographical position and variety in climate and terrain of the country there are a large number of floristic elements, including medicinal plants, from different adjoining and far off countries today form part of our flora. Hooker (1904) stated that India has a mixture of flora of the surrounding countries, like Malayan and Chinese elements on the East, European and African on the West and Siberian on the North. Chatterjee (1947, 1960) stated that the introduction and naturalisation of foreign plants have occurred by sea, river and land invasion. The history of introduction dates back to the early Aryans who invaded India from countries situated in the North-west. They carried a number of economic plants alongwith them, and thereafter several invaders, explorers, scientific institutions, birds, animals, wind, river, etc. have further added a number of plants. As the flora of the country is not yet fully known, the exact number of exotic plants occurring in India is not well known. However, Maheshwari (1960) has stated that 40 per cent of the Indian flora is of exotic origin. Further, it has been estimated that about 25-30 per cent of medicinal plants are of exotic origin. Some exotic medicinal plants and the country from where they have been introduced are given in Table V.

Table V
Some exotic medicinal plants in Indian flora

Name	Country/place of origin
Agave americana	America
Aglaia odorata	Malaya
Aloe barbadensis	South Africa
Alpinia officinarum	China
Alstonia macrophylla	Malaya
Anacyclus pyrethrum	North Africa
Ananas comosus	South America
Anthemis nobilis	Europe
Argemone mexicana	Mexico
Arnica montana	Western and central Europe
Asarum europaeum	Temperate Europe and North Asia
Asparagus officinalis	Africa
Astragalus sarcocola	Persia
Berberis vulgaris	Europe
Blepharis edulis	Arabia
Bromus catharticus	South America
Caesalpinia coriaria	North America and West Indies
Caltha edulis	Tropical Africa

Name	Country/place of origin
Ceratonia siliqua	East Mediterranean
Cheiranthus cheiri	South Europe
Chlorophora excelsa	America
Chrysobalanus icaco	America and Africa
Cinnamomum camphora	China, Japan
Cinnamomum javanicum	Malaya
Cochlearia aromatica	Eastern Europe
Commiphora myrrha	Arab
Convolvulus scammonia	Mediterranean
Crescentia cujete	Tropical America
Cymbalaria muralis	Europe
Cytisus scoparius	Europe
Datura innoxia	Mexico
Derris malaccensis	Malaya
Euphorbia tirucalli	Africa
Ferula jeschkeara	Arabia
Gardenia jasminoides	Japan, China
Guazuma tomentosa	Tropical America
Guizotia abyssinica	Tropical Africa
Haematoxylum campechianum	Tropical America
Helianthus annuus	America
Helleborus niger	Central and South Europe
Helleborus viridis	Europe
Hibiscus cannabinus	Africa
Hibiscus mutabilis	China
Humulus lupulus	North America
Hura crepitans	Tropical America
Hypericum chinense	Sino-Japan
Hydnocarpus anthelmintica	Sino-Japan
Ilex aquifolium	Europe
Ilex paraguariensis	Brazil

Name	Country/place of origin
Ipomoea tuberosa	Tropical America
Jatropha curcas	Tropical America
Jatropha gossypifolia	Brazil
Jatropha multifida	South America
Lantana camara	Tropical America
Manilkara kauki	Malaya
Maranta arundinacea	Tropical America
Martynia annua	Mexico
Meriandra bengalensis	Abyssinia
Mentha arvensis	Sino-Japan
Mimosa pudica	Tropical America
Opeopanax chironium	Europe
Opuntia coccinellifera	Mexico and Peru
Opuntia dillenii	Mexico
Opuntia nigricans	Mexico
Opuntia stricta	South America
Opuntia vulgaris	Brazil and Argentina
Picea abies	Sweden and Russia
Pithecellobium dulce	America
Plumbago alba	West Indies
Plumbago rubra	Mexico
Polianthes tuberosa	Mexico
Ricinus communis	Africa
Rosmarinus officinalis	Europe, North America
Scoparia dulcis	America
Syzygium aromaticum	Moluccas
Vigna rosea	West Indies
Tamarindus indica	Africa

There are several drugs with varied therapeutic value mentioned in old literature by their vernacular names, but there is a lot of confusion in botanically equating the plants. In some cases more than one plant species with different therapeutic properties have been known by a single vernacular name thus the herbal practitioners, botanists and chemists face a great challenge in correctly identifying the plant botanically refered to a particular vernacular name. Various pharmaceutical industries, particularly Ayurvedic, Unani, Homoeopathic, etc. mention the vernacular names in their various formulations so the botanical identity may be fixed with the identification of sample used by them. The question may be raised whether they are used for the same therapeutic properties given in the literature or for some other. The desired therapeutical properties as mentioned in literature may not be obtained by using the different plants and thus the drug may not be effective. The problem may be solved to some extent by the chemical analysis of the plants in the same composition as given in literature and this will provide the answer whether drug is obtained from more than one plant. The list of such plants is exhaustive but Chopra *et al.* (1969) indicated that there are 194 species under 133 vernacular names. Some such vernacular names and the different species under them with therapeutic uses are given in Table VI.

Table VI
Vernacular names applied to two or more botanical taxa alongwith their medicinal uses

Vernacular name	Botanical name	Therapeutic uses/ medicinal properties
Ajamoda	*Apium graveolens*	Diuretic, used in anasarca and Colic.
	Trachyspermum roxburghianum	Carminative, stimulative, stomachic, used in dyspepsia, hiccough, vomitting and pain in bladder.
Alarka	*Calotropis procera*	Used in dysentery, elephantiasis, and intermittent fever, diphoretic.
	Solanum trilobatum	Cough, chronic bronchitis.
Anjali	*Artocarpus hirsutum*	Used in bulbous and swollen testicles.
	Casia alata	Ringworm, snake bite, bronchitis, asthma and eczema.

Vernacular name	Name of taxa	Therapeutic uses/ medicinal properties
Arjuna	*Lagerstroemia speciosa*	Narcotic, purgative, astringent, stimulative, febrifuge.
	Terminalia arjuna	Tonic, astringent, febrifuge, used in heart diseases, bilious affections, sores.
Arlu	*Caesalpinia sepiaria*	Emmenagogue, laxative.
	Oroylum indicum	Astringent, tonic, diphoretic, carminative, stomachic, purgative, used in scorpion sting, diarrhoea, dysentery, back sores, rheumatism.
Bakla	*Anogeissus latifolia*	Astringent, used in scorpion sting and snake bite.
	Phaseolus vulgaris	Tonic, emollient, used in eye weakness.
	Vicia faba	Shoot efficacious in rousing the durnkard from stupor.
Bui	*Kochia indica*	Cardiac stimulative, used in weak and irregular heart.
	Otostegia limbata	Children's gum and ophthalmic infections.
	Pulicaria crispa	Applied to bruises, headache.
Kandal	*Kandelia rheedii*	Used in diabetes.
	Rhizophora mucronata	Astringent, used in diabetes.
	Sonneratia caseolaris	Used in swelling, sprain and haemorrhage.
Karai	*Capparis parviflorum*	Antihelmintic, used in flu, dysentery.
	Diospyros ebenum	Astringent, Attenuant, lithotriptic.
	Heynea trijuga	Tonic, stupefying.

Vernacular name	Name of taxa	Therapeutic uses/ medicinal properties
Manali	*Exacum lawii*	Laxative, used in eye and kidney diseases.
	Indigofera aspalathoides	Astringent, demulcent, used in leprosy, cancerous affections, toothache, oedematous tumours.
	Indigofera pulchella	Used in cough and applied locally in chest pain.
Mayurshikha	*Actinopteris dichotoma*	Used as styptic and antihelmintic.
	Adiantum caudatum	Used in skin diseases diabetes, cough and fever.
	Celosia argentea	Demulcent, astringent, used in diarrhoea, excessive menstrual discharge, painful micturition, cough and dysentery.
Palai	*Cryptocarya wightiana*	Used in elephantiasis, rheumatism and swelling.
	Manilkara kauki	Tonic, febrifuge, antihelmintic, astringent, used in ophthalmic infections, leprosy, thirsty delirium, disorder of many secretions, infantile diarrhoea and beri-beri.
	Wrightia tomentosa	Used in menstrual and rena complaints.
Tukhmmalanga	*Lallemantia royleana*	Cooling, sedative, used in flatulence and constipation.
	Nepeta elliptica	Dysentery.
	Salvia aegyptiaca	Diarrhoea, gonorrhoea, eye diseases and haemorrhoids.
Brahmi	*Bacopa monnieri*	Nervous tonic, diuretic, used in asthma, epilepsy and insanity.
	Centella asiatica	Tonic, used in skin diseases, leprosy, syphilis and to improve memory.

There are approximately 4,000 diseases all over the world. WHO has estimated that about 20,000 species of medicinal plants are employed in various traditional systems for the treatment of various ailments in 73 countries but subsequently it was found that there are several replications and the list was reduced to 10,000. A comparative number of family, genera and species employed for the treatment of different ailments in various traditional systems of medicine in India and adjacent countries is given in Table VII.

Table VII
Comparative account of taxa used as medicines in various traditional systems in India and adjacent countries

Country	No. of family	No. of genera	No. of species
India	200	920	2,800
Nepal	120	425	810
Sri Lanka	82	380	550
Bhutan, Pakistan and Bangladesh	57	105	340

In India approximately 380 ailments have been recognised and about 2,000 medicinal plants are used to cure the diseases. The following list (Table VIII) provides information on total number of species used in the treatment of different diseases.

Table VIII
Number of taxa exploited/referred for the treatment of various ailments

Ailments/properties	No. of taxa
Abortion	106
Abscess	320
Antihelmintic	55
Aphrodisiac	35
Asthma	125

Ailments/properties	No. of taxa
Biliousness	80
Burns	55
Cancer	15
Cholera	70
Cardiac complaints	23
Catarrh	22
Cold	220
Cough	240
Diabetes	42
Digestive disorder	340
Diuretic	60
Dropsy	36
Dyspepsia	69
Epilepsy	30
Eye diseases	85
Fever	285
Gonorrhoea	96
Gout	48
Haemorrhage	40
Hair care	50
Hysteria	31
Impotency	40
Intestinal disorder	185
Jaundice	38
Kidney diseases	38
Leprosy	54
Leucoderma	22
Malaria	25
Menstrual complaints	120
Oedema	39

Ailments/properties	No. of taxa
Paralysis	31
Pain	255
Piles	89
Pre and Post natal treatment	39
Purgative	76
Rheumatism	60
Skin diseases	160
Sores	53
Spermatorrhoea	21
Syphilis	44
Tuberculosis	25
Ulcer	81
Urinary complaints	120
Veneral diseases	155

The Indian flora is extensively utilised as source of many drugs mentioned in the traditional systems of medicine. In traditional literature the morphological description of the drug plant is very meagre so it becomes difficult to identify them. The adequate pharmacognostical description of some genuine drugs are available but our knowledge in this field is very poor. The morphological appearance of many plants are alike leaving scope for the purpose of adulteration and substitution. Another reason for the purpose may be that the medicinal plants are collected by local people who collect them on organoleptic characters and then sell the stock to village dealer who in turn sell them to large scale dealer. The large scale/whole sale dealer thus get the stock from different persons collected from different areas and in order to get higher price get them mixed up. These mixed stocks are ultimately sold in the market. The other important cause of adulteration and substitution is to get higher price for the low grade drug, or even plant material without medicinal properties, for the original drugs. To avoid adulteration and substitution, the pharmacognostical study is intensively required but its practical application is sometimes difficult. Nayar and Chopra (1951) have given brief account of 100 species which are growing in India and are used as substitute. There are about 490 plant species which are either used as substitute or adulterant of medicinal plants mentioned in British Pharmacopoea. Some substitute and adulterant of the drug plants are given in Tables IX and X.

Table IX
Substitute of some medicinal plants

Name of medicinal plant	Name of substitute
Aconitum napellus	*Aconitum chasmanthum*
Areca catechu	*Areca nagensis, Areca triandra*
Atropa belladonna	*Atropa acuminata, Phytolacca acinosa.*
Berberis aristata	*Coscinium fenestratrum*
Butea monosperma	*Butea superba*
Cassia angustifolia	*Pluchea lanceolata, C. obovata*
Cassia fistula	*Cassia javanica*
Cassia occidentalis	*Cassia sophera*
Centella asiatica	*Hydrocotyle javanica*
Cephaelis ipecacuanha	*Viola tricolor, Acalypha indica, Tylophora indica, Randia spinosa Cephaelis acuminata*
Chenopodium ambrosioides	*Chenopodium botrys*
Cinnamomum tamala	*Cinnamomum impressinervium*
Coffea arabica	*Crotalaria mucronata*
Coptis teeta	*Thalictrum foliolosum*
Ephedra gerardiana	*Ephedra intermedia, Ephedra major*
Gentiana kurroo	*Gentiana lutea, Swertia decussata*
Hemidesmus indicus	*Ichnocarpus frutescens*
Holarrhena antidysenterica	*Wrightia tinctoria*
Hydnocarpus kurzii	*Hydnocarpus venenata*
Limnophila indica	*Limnophila gratissima*
Rauvolfia serpentina	*Rauvolfia densiflora, Rauvolfia tetraphylla*

Name of medicinal plant	Name of substitute
Rheum palmatum	*Rheum emodi*
Santalum album	*Ximenia americana*
Saussurea costus	*Euphorbia thomsoniana*
	Inula royleana
Strychnos nux-vomica	*Strychnos acenea, Strychnos colubrina, Strychnos malaccensis, Viscum monoicum.*
Swertia chirayita	*Swertia angustifolia, Swertia decussata, Swertia lawii, Swertia paniculata, Swertia purpurascens*
Terminalia chebula	*Terminalia citrina*
Urginea indica	*Dipcadi erythraeum*
Valeriana officinalis	*Valeriana leschenaultii, Valeriana wallichii*
Veronica beccabunga	*Veronica hederaefolia*
Viola odorata	*Viola serpens*
Withania somnifera	*Withania coagulaus*

Table X
Adulterant of some medicinal plants.

Name of medicinal plant	Adulterant
Acacia catechu	*Senecio jacquemontianus*
Aristolochia indica	*Aristolochia tagala*
Boerhavia diffusa	*Trianthema portulacastrum*
Cassia angustifolia	*Cassia obovata*
Centella asiatica	*Hydrocotyle rotundifolia*
Coptis teeta	*Thalictrum foliolosum*
Digitalis purpurea	*Inula racemosa, Urtica dioica*
Hydnocarpus kurzii	*Hydnocarpus octandra, H. laurifolia*
Saussurea costus	*Inula royleana*

It is evident that the Indian Materia Medica was the basis for the ancient Greek, Roman, Unani and Tibbati practioners because their works included many Indian prescriptions. The evidence of trade between India, Egypt and Rome could be found in Materia Medica as there is mention of Indian species in the ancient work of Egypt and Rome. In the modern age the status of the medicinal plants and their importance have been well understood. Even the most developed countries have inclined towards herbal drugs. Farnsworth and Morris (1976) stated that 25 per cent of prescriptions in USA are based on either plant products or active principles prepared from higher plants. This view was further supported by Farnsworth *et al.* (1985) and Principe (1989). Though it is difficult to assess the exact number of plants used in medicines but it is significant that a fairly good number of plant or plant products have found their way in the treatment of common diseases, like cough, cold, diarrhoea, dysentery, gout and as purgative.

According to an ITC report (1982) about 1,000 plant based laxatives were sold world wide for US $ 500 million in 1982. The allopathic medicines have their prototype in plants and it has been estimated that the member countries of the Organization for Economic Cooperation and Development have sold plant based prescriptions for the worth of US $ 43 billion in 1985. Principe (1991) has predicted that the figure may reach to US $ 500 billion for plant based pharmaceuticals in the next ten years. Huxley (1984) described plants as an "extraordinary chemical factories" which produce complex chemical substances for various purposes and may be classified into primary chemicals, used for self defence against pathogens and predator, and the secondary chemicals which include alkaloids, glycosides, fungicidal and bactericidal compounds. Till world war II either raw plant material or active ingredients were used but with the development of chemistry and the technique for isolating the plant's chemicals and synthesize them in the laboratory, the synthetic drugs have been widely used. But due to several side effects, the synthetic drugs are now gradually getting rejected and are taken over by herbal medicines.

It has been estimatead that 10 per cent, i.e. 600 plants of the 6000 medicinal plants traded world wide are under use in U.K. In USA 75 per cent of plants used in pharmaceutical industries have their origin in foreign countries. In 1988-89 and 1990-91 India exported 1,63,89,528 and 1,66,48,494 kg of Isabgol (*Plantago ovata*) worth Rs. 50,02,52,472 and 60,79,17,573 respectively. The largest five importing countries with quantity and value in terms of rupees are given in table XI.

Table XI
Major importing countries of herbal drugs from India

	Quantity in kg	Value in Rs.
USA	20,22,208	36,92,26,645
France	8,61,621	3,75,07,244
UK	8,48,495	3,43,96,318
Mexico	3,01,560	1,78,20,889
Germany	10,93,616	1,76,54,559

Poppy is the most important medicinal plant and legitimately cultivated in India mainly for opium alkaloid. Till 1986-87 India was the largest legal producer and supplier. About 80 per cent of crude and 45 per cent requirement of world' morphine were fulfilled and exported by India (Gauniyal *et al.*, 1991). But during 1990-91 India imported 1,89,683 kg of opium worth Rs. 2,31,22,658. The reverse condition in trade is due to the non availability of good varieties in international market. However, CIMAP has developed some new varieties and it is expected that this may change the situation in international trade. A critical survey reveals that several crude drugs are exported under the head of Ayurvedic and Unani medicines without any particular specification so it becomes impossible to decide them from botanical point of view. Therefore, to tackle the situation the importer's record should also be checked. In 1988-89 and 1990-91 India exported 2574293 and 2633604 kg of crude drugs worth Rs. 10,12,13,739 and 3,51,32,587 respectively.

The plant drugs exported during 1990-1991 by India to various countries are given in Table XII. The price of some crude drugs is also given in Table XIII.

Hamburg in West Europe is the main centre of trade for crude drugs and medicinal herbs. India and other developing countries, like Indonesia, Zaire, China, etc. are the leaders in marketing crude drugs and their derivatives. An analysis reveals that United States followed by Germany, Switzerland, UK, etc. are the major importers of medicinal plants. In Asia, Japan, Hongkong, China, UAE, etc. are the leading importor of medicinal plants. The finished products are mainly extracted in the industrialised

Table XII
Plant drugs exported during 1990-1991 to various countries

Name of plant	Quantity (Kg)	Amount (Rs.)	Countries
Amomum subulatum	1,307,081	66,080,577	Nepal and Singapore
Aquilaria malaccensis	9,460	42,75,401	France, Japan, Somalia
Atropa belladonna	5,115	16,47,008	Japan and U.K.
Balsamodendron mukul	2,000	45,272	Kenya
Carum carvi	4,37,505	1,02,06,510	China, Iran
Cassia senna	4,36,751	1,41,85,903	China, Indonesia
Cinnamomum zeylanicum	17,246	5,34,031	China
Cuminum cyminum	11,95,451	1,18,36,688	Afghanistan, Iran and Pakistan
Ferula jaeschkeana	10,05,481	6,58,79,893	Bulgaria, China, Germany
Glycyrrhiza glabra	6,33,961	49,44,310	Bulgaria, China, Germany
Glycyrrhiza glabra	16,000	7,16,937	Hongkong
Hemidesmus indicus	2,000	35,087	Mexico
Myristica fragrans	2,20,643	82,86,733	China, Sri Lanka
Panax pseudo-ginseng	79,012	17,15,584	Afghanistan, Bulgaria, China

Name of plant	Quantity (Kg)	Amount (Rs.)	Countries
Plantago ovata	38,950	20,74,988	U.K.
Papaver somniferum	1,89,683	2,31,22,658	
Pimpinella anisum	1,34,558	31,83,720	China, Singapore
Piper longum	4,37,781	31,33,626	Indonesia and Singapore
Piper nigrum	19,12,783	3,21,22,929	Indonesia, Singapore and Sri Lanka
Rhamnus parshiana	22,765	58,06,177	Japan, U.K. and U.S.A.
Strychnos nux-vomica	5,66,076	16,44,353	Sri Lanka
Syzygium caryophyllatum	17,132	7,39,693	China, Indonesia
Zingiber officinale	33,13,729	9,80,60,435	Nepal

countries like Switzerland, Germany, etc. and they are the major suppliers of finished products.

Table XIII
Price of some crude drugs

Name of species	Vernacular name	Rate per kg in Rs.
Mesua ferrea	Nagkeshar	200-250/-
Oroxylum indicum	Arlu or Son	50-80/-
Paeonia emodi	Urd Salem	1000-1200/-
Piper longum	Pipal	250-400/-
Rauvolfia serpentina	Sarpagandha	200-300/-
Rubia cordifolia	Manjistha	50/-
Saussurea costus	Kuth	500-600/-
Swertia chirayita	Chireta	400-500/-
Terminalia arjuna	Arjun	15-20/-
Terminalia bellirica	Bahera	7-20/-
Terminalia chebula	Natuki	30/-
Withania somnifera	Ashwagandha	200-250/-
Zingiber officinalis	Sunth or Sonth	200/-

Diversity in bazar medicinal herbs

It is estimated that about 350-400 species of medicinal plants, plant products are sold in different forms on streat sides or grossary shops. Waring (1897) has mentioned on the uses of some medicinal palnts which are commonly sold in Indian market and such herbs have occupied the valuable position in home remedies. A list of some such plants with their common name and market rate is given in Table XIV.

Table XIV
Some common medicinal herbs of India

Name of species	Vernacular name	Rate per kg in Rs.
Abrus precatorius	Rati	100/-
Acacia concinna	ritha	60/-
Acorus calamus	Bach	80-120/-
Adhatoda zeylanica	Arusha, Vasa	40-60/-
Aegle marmelos	Bel	60/-
Aloe barbadensis	Ghrit kumari or Gheekuar extract	300-350/-
Alpinia galanga	Kulanjan	50-70/-
Abroma auguata	Olat kambal	100/-
Andrographis paniculata	Kalmegh	60/-
Aristolochia bracteolata	Isarmul	120-150/-
Asparagus adscendens and *Chlorophytum arundinaceum*	Safed Musli	1000-1100/-
Asparagus racemosus	Satmul	100-150/-
Bacopa monnieri	Brahmi	80/-
Caesalpinia crista	Nat	120/-
Centella asiatica	Brahmi	100/-
Curcuma aromatica	Ambahaldi	120-150/-
Emblica officinalis	Amla	60-80/-
Glycyrrhiza glabra	Mulethi or Jeysthimadhu	70-80/-
Hemidesmus indicus	Anantamool	80-100/-

However, it is also noticed that some Indian Plants have respectable position in the treatment of various ailments abroad. Some such plants are listed in table XV.

Table XV
Plants growing in India and used in other countries for various treatments

Name of species	Country	Properties/Diseases
Cerastium vulgatum	Spain	Astringent
Chloranthes officinalis	Malay and Peninsula	Stimulative
Chloris virgata	South Affica	Cold and rheumatism
Chlorophora excelsa	Africa	Itch and swelling
Dentella repens	Malaya	Poulticing sores
Desmos cochinchinensis	Malaya	Fever
Ethulia conyzoides	Liberia Africa	Prevents abortion, intestinal parasite, colic and abdominal disorder, headache, constipation
Euchresta horsfieldii	Malaya	Chest, contrapoison, tonic.
Euphorbia rosea	Indo-China	Drastic purgative
Evodia rutaecarpa	China	Stimulative, carminative and stomachache
Grewia carpinifolia	Africa	To remove and prevent lice
Hypericum humifusum	Europe	Sores and eczema
Ixora cuneifolia	Indo-China	Fever
Ixora nigricans	Indo-China	Antidysentric
Limnophila roxburghii	Philippines	Diuretic, tonic and stomachic
Lithospermum officinale	Europe	Diuretic, sedative, and lithotriptic
Lophatherum gracile	China	Antifebrile and diuretic
Lygodium japonicum	China	Expectorant
Polygala glomerata	Indo-China	Inflammation
Polygala sibirica	Japan, China, Malaya, Indo-China	Cold and cough, diuretic, bronchitis, sexual potency and seminal loss.
Saussurea hypoleuca	Indo-China,	Purgative and antiseptic

During the scrutiny of medicinal plants, it is also noticed that some plants which are not growing in India but are sold in Indian market. Following is the list of some medicinal plants which are sold in the Indian market with their trade name and the place of origin (Table XVI).

Table XVI
Plants not growing in India but sold in Indian market

Name of species	Trade name	Country of origin
Achillea santolina	Pushtu	Baluchistan
Aristolochia rotunda	Zarwandi-i-gird	Eastern Europe
Aristolochia longa	Zarwandi-i-tawil	South Europe
Centaurea behen	Safer bahman	Persia
Commiphora planfrons	Meenoharma	Africa
Commiphora stocksiana	Bayisagugul, Malaikluvai	Baluchistan
Cyclamen persicum	Bakhuri-miryan	Europe
Dorema ammoniacum	Ushak	Persia
Doronicum pardalianches	Darunajikanbi	Europe
Ecballium elaterium	Kateri-indrayan	Europe
Euphorbia resinifera	Farfiyum	Morocco
Illicium anisatum	Anasphal, Badoon	Japan
Laurus nobilis	Hab-el-ghar	Europe
Polypodium vulgare	Basfaij	America, Turkey
Trigonella uncata	Iktil-el-malik	Persia, Afghanistan
Zataria multiflora	Sail saatar	Baluchistan
Ziziphora tenuior	Mishkatarelmashih	Baluchistan

It may be mentioned that initially the consistently increasing demand of medicinal herbs in the country were met from the natural sources, thus leading to the depletion in their population in wild. However, with development of improved strains and agrotechnology for many of the medicinal plants, some of these demands are now met from cultivated sources. Central Institute of Medicinal and Aromatic Plants (CIMAP) and the Regional Research Laboratories of CSIR are activity involved in developing the agrotechnology for the medicinal plants and promoting their cultivation in different part of the country. Some of the plants now under cultivation in different parts of India have been described in Table XVII.

Table XVII
Medicinal plants, under cultivation in various parts of the country

Plants	Area
Apium graveolens	Punjab, Haryana, Western Uttar Pradesh
Aristolochia indica	Tropical and subtropical regions of the country
Artemisia maritima	Kashmir, Himachal Pradesh, Uttaranchal
Artemisia pallens	South India
Allium cepa	All over India
Allium sativum	All over India
Abroma augusta	Most of the hotter part of India but commercial supply from West Bengal, Assam, Sikkim
Alpinia galanga	Karnataka, Tamil Nadu
Ammi majus	Jammu, U.P., Punjab, 125 ton
Amomum subulatum	Assam, W. Bengal, Sikkim
Anethum graveolens	All over India
Artemisia annua	Jammu & Kashmir
Artemisia pallens	Jammu & Kashmir
Asparagus officinalis	All over India
Atropa belladona	Jammu & Kashmir, Uttaranchal
Catharanthus roseus	Tamil Nadu, West Bengal
Cephaleis ipecacuanha	Kerala, Tamil Nadu, West Bengal, Sikkim, Assam, Meghalaya
Carica papaya	All over India
Cinchona ledgeriana	West Bengal and Tamil Nadu

Plants	Area
Cinchona officinalis	Tamil nadu
Cinnamomum verum	Kerala, Tamil Nadu.
Citrullus lanatus	Rajasthan
Citrullus colocynthis	Rajasthan
Coptis teeta	Arunachal Pradesh
Coriandrum sativum	Andhra, Bihar, Kerala, Madhya Pradesh Orissa, Rajasthan, Tamil Naud, Uttar Pradesh
Crocus sativus	Himachal Pradesh, Jammu & Kashmir
Cuminum cyminum	Rajasthan, Gujarat, Madhya Pradesh
Curcuma longa	Almost all over India
Elettaria cardamomum	Kerala, Tamil Nadu, Karnataka
Emblica officinalis	All over India
Gloriosa superba	All over India
Glycyrrhiza glabra	Himachal Pradesh, Jammu & Kashmir
Iris germanica	Jammu & Kashmir
Kaempferia galanga	All over India
Manihot arvensis	All over India
Myristica fragrans	Kerala and Tamil Nadu
Nardostachys jatamansi	Jammu & Kashmir
Papaver somniferum	Uttar Pradesh, Madhya Pradesh, Rajasthan
Picrorhiza kurrooa	Jammu & Kashmir
Pimpinella anisum	All over India
Piper longum	All over India
Piper nigrum	Mountains of Western Ghats
Plantago ovata	Gujarat and Rajasthan
Rauvolfia serpentina	All over India
Rheum emodi	Jammu & Kashmir
Syzygium caryophyllus	Tamil Nadu

Plants	Area
Cannabis sativa	Warm valleys of Himachal Pradesh, Jammu & Kashmir, Uttaranchal, Orissa, Assam, Madhya Pradesh
Santalum album	Karnataka, Tamil Nadu and Andhra Pradesh
Saussurea lappa	Jammu & Kashmir, Himachal Pradesh, Uttaranchal

About 80 to 90 per cent of the Indian population depend upon the herbal drugs. There are about 6780 pharmaceutical industries engaged in the production of herbal medicines. About 80-85 per cent of the raw materials utilised for the production of medicines in these pharmaceutical companies are from plants only. Approximately 550 taxa are found to be used by the the manufacturers in different formulations. Some of the plants employed in a number of formulations are given in Table XVIII.

Table XVIII
Number of drug formulations of medicinal plants

Name of the plant	Number of formulations
Abrus precatorius	85
Achyranthes aspera	22
Aconitum heterophyllum	32
Acorus calamus	65
Adhatoda zeylanica	135
Aegle marmelos	115
Aloe barbadensis	55
Abroma augusta	35
Andrographis paniculata	72
Asparagus racemosus	148
Azadirachta indica	35
Berberis aristata	85

Name of the plant	Number of formulations
Bergenia ligulata	24
Boerhavia diffusa	80
Canscora decussata	40
Chlorophytum arundinaceum	32
Commiphora mukul	88
Cyperus rotundus	192
Datura metel	25
Eclipta prostrata	110
Emblica officinalis	240
Evolvulus alsinoides	40
Glycyrrhiza glabra	158
Hemidesmus indicus	40
Holarrhena antidysenterica	70
Ichnocarpus frutescens	65
Melia azedarach	24
Mentha spicata	70
Mesua ferrea	55
Nardostachys grandiflora	56
Ocimum sanctum	77
Pedalium murex	85
Phyllanthus niruri	45
Picrorhiza kurrooa	70
Piper longum	155
Plumbago zeylanica	55
Polyalthia longifolia	65
Raphanus sativus	52
Rubia cordifolia	57
Sapindus trifoliatus	22
Saussurea costus	25
Swertia chirayita	55

Name of the plant	Number of formulations
Terminalia arjuna	86
Terminalia bellirica	240
Terminalia chebula	240
Tinospora cordifolia	160
Tribulus terrestris	68
Trigonella foenum-graecum	52
Vitex negundo	38
Withania somnifera	140

Further, it has been noticed that a single plant is used for different ailments and thus showing diversity in the treatment of diseases. Here some examples are given below as well as in Table XIX.

Abelmoschus esculentus : In bronchitic cough, and intestinal and genito-Urinary organ.

Abrus precatorius : In nervous debility, leucoderma, sciatica, stiff joints, paralysis and cough.

Acacia nilotica ssp. **indica** : In pulmonary and bronchial diseases, diarrhoea, piles, prolapse of rectum, gonorrhoea, typhoid, fever, leucorrhoea and irritability of genito urinary organ.

Achyranthes aspera : In cough, asthma, enlargement of spleen, malaria, painful menstruation, toothache and renal deposits..

Aconitum ferox : In fever, diarrhoea in children, cough, asthma, diabetes, nervous diseases, spermatorrhoea, neuralgia, rheumatism and guinea worms.

Acorus calamus : In gastric and respiratory diseases, dyspepsia, dysentery, epilepsy, wounds, ulcer, vomitting, hysteria, spasmodic complaints and for micturition and labour pain.

Balsamodendron mukul : In dyspepsia, stomatitis, chest complaints, amenorrhoea, and externally in thrush, guinea worm, inflammations and ulcers.

Boerhavia diffusa : In dropsy, asthma, anaemia, inflamatory affectious, hepatic disorder, gout, rheumatism, kala-azar, heart and kidney diseases.

Table XIX
Diversity of medicinal plants in terms of treatment of diseases

Name of species	Number of diseases
Abelmoschus esculentus	10
Acacia nilotica ssp. *indica*	10
Achyranthes aspera	12
Aconitum ferox	11
Aconitum heterophyllum	2
Aconitum napellus	6
Acorus calamus	14
Adhatoda zeylanica	6
Aegle marmelos	12
Andrographis paniculata	10
Asparagus racemosus	9
Atropa belladona	11
Azadirachta indica	23
Bambusa arundinacea	7
Berberis aristata	11
Boerhavia diffusa	11
Sinapis alba	12
Butea monosperma	7
Caesalpinia bonduc	9
Calotropis procera	8
Carica papaya	12
Cassia fistula	10

Name of species	Number of diseases
Cassia sophera	5
Celastrus paniculatus	5
Centella asiatica	16
Cinnamomum camphora	14
Curculigo orchioides	9
Curcuma longa	14
Curcuma zedoaria	12
Datura metel	12
Eclipta prostrata	8
Emblica officinalis	16
Euphorbia antiquorum	22
Ferula asafoetida	17
Ficus bengalensis	10
Ficus racemosa	10
Foeniculum vulgare	12
Gentiana kurroo	9
Glycyrrhiza glabra	10
Hemidesmus indicus	12
Holarrhena antidysenterica	8
Indigofera aspalathoides	17
Jatropha curcas	16
Lawsonia inermis	18
Melanleuca leucadendron	15
Melia azedarach	20
Michelia champaca	11
Mimosa pudica	12
Mimusops elengi	15
Moringa oleifera	21

Name of species	Number of diseases
Myristica fragrans	12
Myrtus communis	13
Nardostachys grandiflora	10
Nelumbo nucifera	13
Nigella sativa	11
Oxalis corniculata	10
Papaver somniferum	35
Picrorhiza kurrooa	9
Pongamia pinnata	23
Piper nigrum	24
Quercus infectoria	11
Rauvolfia serpentina	10
Rheum emodi	6
Ricinus communis	19
Rubia cordifolia	9
Rumex crispus	14
Saccharum officinarum	18
Santalum album	17
Sapindus trifoliatus	14
Saussurea costus	11
Semecarpus anacardium	28
Sida cordifolia	18
Solanum indicum	11
Solanum nigrum	9
Strychnos nux-vomica	38
Tamarindus indica	15

Name of species	Number of diseases
Terminalia arjuna	13
Terminalia bellirica	20
Terminalia chebula	23
Urginea indica	15
Urtica dioica	8
Verbascum thapsus	5
Vernonia anthelmintica	4
Vitex negundo	25
Withania somnifera	18
Zingiber officinale	22

ENDEMISM

The flora of India has great diversity in floral components as well as in distribution pattern. Hooker (1904) has stated that "The country is poor in regards to endemic", and this view can be better understood by his further statement that "whether India is richer in number of genera and species than any other area on the globe of equal dimension is doubtful; it is certainly for poorer in endemic genera and species than many others, especially China, Australia and South Africa". Chatterjee (1940), however contradicted Hooker's (1904) view and stated that undoubtedly country has typical flora of its own. His observations have shown that the Himalaya harbour largest number of endemic species (about 3,169 dicot and about 1000 monocot). South India with about 2,045 dicot and 500 monocot. endemic species stands next. The area between the Himalaya and South India is stated to be the area of high biotic concentration and equable climate, and because of these reasons this area is said to be poor in endemics, and rich in pantropical weeds and other widely distributed species. Nayar (1996) has estimated 5725 taxa endemic to Indian territories. He has listed about 2244 taxa endemic to Hot Spots of which 186 taxa are of medicinal importance. Endemic taxa of different areas and the endemic medicinal taxa are given in Table XX.

Table XX
Endemic taxa and endemic medicinal taxa of different areas of the country

Area	Endemic Medicinal taxa	Endemic taxa
Andaman	4	132
Nicobar	3	45
Agasthayamalai hills	7	189
Anamalai	5	94
Palni hills	2	43
Nilgiris-Silent valley, Wyanad	8	150
Shimoga-Kanara	1	58
Mahabaleshwar Khandala range	10	63
Konkan - Raigad	6	50
Marathwada-Satpura	2	27
Tirupati-Cuddappa-Nallamalai hills	11	49
Jeypore hills	2	30
Southern Deccan	7	50
Chota Nagpur plateau	1	18
Kathiawar-Kutch	1	8
Rajasthan -Aravali hills	3	16
Khasi-Jaintia hills	6	78
Patkoi, Manipur, Lushai hills	8	74
Assam	0	25
Arunachal Pradesh	7	114
Sikkim Himalaya	51	569
Garhwal - Kumaon Himalaya	18	116
Lahaul	5	15
Kashmir	11	224

Endemic Medicinal Plants

Himalaya **:** *Acer molle, Aconitum assamicum, A. falconeri, A. lethale, A. moschatum, A. oblongum* var. *serrulatum, Agalaia eduli,* ***Berberis***

asiatica, B. glaucocarpa, B. huegeliana, B. kashmeriana, B. stewartiana, Caltha palustris var. *purpurea, Capparis pachyphylla, Coptis teeta, Crocus sativus, Curculigo crassifolia, Dioscorea watti, Elaeocarpus ganitrus, Epilobium semiamplexicaule, Ferula jaeschkeana, Garcinia indica, Gentiana harwanensis, Pedicularis canescens, Piper anisotis, P. petiolatum, Podophyllum hexandrum, Saussurea clarkei, S. costus, Strychnos quintriplinervis, Swertia crossoloma, S. grandiflora, S. griffithii, Thalictrum foliolosum, T. saniculaeforme,* etc.

South India : *Andrographis affinis, A. beddomei, A. lawsonii, A. nallamalayana, A. rothii, Boswellia ovalifoliata, Berberis nilghiriensis, B. wightiana, Cinnamomum chemungianum, C. travancoricum, Curcuma cannanorensis, Hydrocotyle conferta, Indigofera pedicellata, Phyllanthus talbotii, Piper crenulatibracteum, Strychnos minor, Swertia corymbosa* var. *grisebachiana, S. trichotoma.*

North-east India : *Aconitum elwesii, A. nagarum, Berberis manipurana, B. micropetala, B. sublevis, B. wardii, Piper gamblei, P. makruense, P. meeboldii, P. nagense, Swertia watii,* etc.

Desert : *Barleria prionitis* var. *dicantha, Cleome gynandra* var. *nana, etc.*

Andaman and Nicobar Islands : *Antidesma andamanicum, Amoora andamanica, Cleistanthes occidentalis, Dioscorea rogerstii, D. vecans, Euphrobia epiphylloides, Mesua manii, Myristica andamanica, Strychnos andamanensis, S. narcoudamensis, Terminalia manii, Tinospora andamanica,* etc.

Rare and threatened medicinal plants

Approximately 90 per cent of the Indian population is dependent upon the plants for their various requirements in their day to day life. Now the people have realised that some of the plants and their habitat are getting threatened due to over exploitation, developmental activities and natural calamities. The Himalaya, one of the most fragile ecosystem which is richest in term of number of plant species, is most disturbed both by human activities and by natural calamities resulting in loss of several gene stocks. The recent landslides in Malpa is still fresh in mind which led to destruction of several habitat of flora and fauna. The South India and North eastern India are next to Himalaya in terms of richness.

Some of the rare or threatened medicinal plants, occurring in different parts of the country are *Aconitum balfouri, A. chasmanthum, A deinorrhzum, A. falconeri* var *latilobum, A. ferox, A. heterophyllum, Acorus gramineus, Allium stracheyi, Angelica glauca, Anogeissus sericea* var. *numularia, Aquillaria mallaccensis, Aristolochia bracteolata, A. indica, Arnebia benthamii, Atropa acuminata, Berberis affinis, B. apiculata, B. aristata, Bergenia stracheyi, Capparis pachyphylla, Carum villosum, Colchicum lurean, Coptis teeta, Coscinium fenestratum, Dactylorhiza hatagirea, Dioscorea deltoidea, Elaeocarpus prunifolius, Ephedra gerardiana, Gentiana kuroo, Gloriosa superba, Hedychium spicatum, Hyoscyamus niger, Hydnocarpus macrocarpa, Iphigenia indica, I. pallida, I. stellata, Kolanchoe roseus, Madhuca insignis, Meconopsis betonicifolia, Nardostachys grandiflora, Panax pseudogingeng, Picrorhiza kurrooa, Podophyllum hexandrum, Pterocarpus santalinus, Rauvolfia serpentina, Rheum emodi, Saussurea bracteata, S. costus, S. gnaphălodes, Swertia chirayita, Taxus wallichiana, Taxocarpus kurzii, Urginea indica, Urginea maritima*, etc.

From time immemorial the plant kingdom is responsible for the survivability of animals. In other words, the animal kingdom directly or indirectly depends upon the plant kingdom. But unfortunately the plant kingdom itself is under threat and struggling for its survival. It is only because of the direct impact of increasing human population and their consumption of biodiversity in unsustainable manner that the world today is forced to think and devise strategies of biodiversity conservation. One may think, why to conserve the biodiversity? Why the world is affraid or worried by the loss of hundreds of component of biodiversity? Infact, loss of one component of the biodiversity affects the survivability of others and finally to the whole ecosystem to which they belong. The biodiversity not only provide food, cloth, fuel, house but also support agricultural resistant and better producing varieties as well as basis for many important medicines. There are 2,50,000 described species of angiosperms, and about 50,000 species are yet to be described. If a species disappears even before coming to the knowledge of Science then it is just like a child who dies after attaining the age of 5-6 years, and this can be realised by the sad feelings of parents. Each and every species has importance of its own which we may not know, but there are some species which possess a minimum of one and maximum of 40 alkaloid or medicinal uses. If these species, are lost or disappeared, it means that we are the loser of that very use which a plant possesses. Sometimes the traditionally mentioned species may not turn true on chemical analysis for the uses mentioned in literature but their wild relatives sometimes provide the needed active principle. One of the largest indirect benefits provided by biodiversity is the development of new medicines. More than half of the medicines in use are derived from plants. It is estimated that there may be as many as 200 new drugs that could be obtained from plant species alone which may be valuable for the worth of between US $ 20-30 billion. Likewise many more reasons can be mentioned to conserve each and every component of the biodiversity. Cruiser states that "If there is a country on earth which can justly claim the honour of having been the cradle of the human race, or at least the scene of primitive civilization, the successive developments of which carried into all parts of the ancient world, and even beyond, the blessings of knowledge, that country is assuredly India". (afer Nadkarni, 1954).

India is one of the twelve megadiversity centres having about 17,500 species of angiosperms, of which about 5725 species are endemic. This rich plant diversity is also associated with the rich cultural and health tradition. It has been estimated that about 7,000 species of angiosperms are used for medicinal purposes. Thus, there is an immediate need for effective conservation and management of medicinal plant diversity. The serious questions are: Which are the important species involved? Where do they grow? What is the native place? Are they collected in wild? And, if so, in what quantities? These questions in most of the cases remain unanswerable as the data on these aspects are either very meager or not available. Thus, there is an urgent need for the monographic work to generate value added data on the medicinal plants.

After 1960 very little interest was shown by the Pharmaceutical companies in the development of drugs from plants and in 1974 only one US company was engaged in investigating the plant derived drugs and in 1980 no company was engaged. After the discovery of Vincristine and Vinblastin from *Catharanthus roseus* the interest has been renewed in plant as a source for new drugs on commercial basis. Fellow (1991) stated that 2618 new structures were derived and by 1990 some 223 companies worldwide were investigating plants as source of new drugs. He also stated that 5 per cent, i.e. 12,500 of the approximately 2,50,000 species of higher plants have been subjected to any kind of chemical study in search of new active chemical. Farnsworth *et al.* (1985) have stated that at least 119 distinct chemical substances, isolated primarily from 91 species of plants, are considered as important drugs used throughout the world. Oldfield (1984) and Fuller (1991) have stated that half of the world's pharmaceutical compounds are derived from plants. Fuller (*l.c.*) also reported that the growth of western European market has gone double in a decade's time. The use of medicinal plants will rise in future and will expose a huge extra burden on wild population of medicinal plants unless effective conservation measures are adopted fast. Nadkarni (1954) states that "In numerous cases, where allopathic treatment fails, indigenous systems of medication succeed." Thus the herbal medicine may or may not cure some of the diseases, but after maximum relief in cases of arthritis, cancer, diabetes, asthma, heart diseases, gout, rheumatism, etc. without any side effects even if used for a longer period invite the increasing utility of herbal medicines. It is all because of the consumers health consciousness which has directed them to look for natural and environment-friendly products.

To overcome the increasing demand of herbal medicine the traders started supplying the materials worldwide besides the internal trade. India with its enormous biodiversity emerged as a major supplier of herbal drugs. Out of the 80,738 tonnes of herbal drugs imported by European countries in 1980, India exported 10,055 tones alone, of which 1061 tonnes and 806 tonnes are shared by Germany and UK respectively. According to an ITC Report (1982) about 500 species of plants are widely used in bulk for medicinal infusion. Fuller (1991) mentioned that according to Seven Foster, a noted expert on medicinal herb, some 600 medicinal herbs are commonly traded in US market. The medicinal plant will not lose their popularity and is likely to expand, and in coming years there will be much more burden over the plant kingdom. However, very little data is available on the trade of medicinal plants. Infact the categories under which the medicinal plants are traded, exported or imported, are very broad and the name of only those plants are given which are traded in larger quantities. In 1990-1991 a large number of medicinal plants under the head of Ayurvedic and Unani medicines, totalling 26,33,604 kg worth Rs. 35,12,35,878 and 11,17,408 kg worth Rs. 76,23,910 respectively, were exported and imported without mention of any plant name. The complexity arises when the plants are used for various other purposes besides medicines. It then becomes really difficult to ascertain the actual category and the real purposes. The plant under this category are usually *Glycyrrhiza glabra, Carica papaya, Lawsonia inermis, Ziziphus* sp., etc. Sometimes the plant material is traded under the different name and in that case it becomes very difficult to decide the exact identity of the materials. It is also difficult to decide the origin (whether the herbs are wild or from cultivated stock) even after examining the traders' stock. So the awareness should be made among traders that they should not encourage the collection of plant materials in wild for those species which are in various stages of threat. Sometimes the traders do not want to show the whole material of trade. In 1997 a consignment of *Strychnos nux-vomica* seeds was ready for export but the exporter was not willing to show the whole consignment for examination (personal observation). In few cases, a mixture of materials is traded under the name of established medicinal plants and it is done willingly to fetch the high price for low grade materials. Sometimes it happens unavoidably where several plants are known under one vernacular name and the plants after collection from different regions ultimately get mixed up when it reaches the ultimate traders.

To overcome all these problems the record of importer must also be taken into account. To avoid such problems, Botanical Survey of India should be appointed as the nodal agency for getting clearance before exporting any plant materials since the organisation is pioneer in the field of taxonomy, and moreover has circle offices in different geographical regions. Though TRAFFIC is in existence and looking after the trade, still they require the supervision from an expert organisation. Based on the threat perceptions from time to time, The Directorate General of Foreign Trade (DGFT), Ministry of Commerce, bans the export of plants and plant products on the advise of Ministry of Environment and Forests, the nodal ministry for conservation of biodiversity of the country. At present 29 plants/groups are included in the Negative List of export of the DGFT.

Serious over-collection of many medicinal plants has already occurred as in case of *Rauvolfia, Dioscorea, Gloriosa, Saussurea, Picrorrhiza* etc. During a survey of Cooch Bihar in 1995 it was observed that the plants of *Rauvolfia serpentina, Aristolochia indica* and *Asparagus recemosus* are very rare in the district. An enquiry from the people revealed that some trader had earlier visited the place, sometimes during 1993-1994 had them collected extensively leading to their depletion in the district. Same is the case with *Hedychium spicatum* (Kapur-kachri) which is endemic to North West and central Himalaya. Now it has become rare due to over demand as it is one of the ingredient of Abin, while the rootstock is used for stomachache, as carminative, tonic, stimulant, emmenagogue, expectorant, liver tonic and in diarrhoea, inflammation and pain.

The discovery of taxol is achieved after sacrificing thousands of trees of *Taxus baccata* which has resulted in near extinction of the species in China. The extract from 35,000 species from higher plants have been tested for anticancer at the National Cancer Institute in America (Douros & Suffuers, 1980). It is interesting to note that about 5000 species of flowering plants have been studied throughout the world as source of new drug. Farnsworth and Soejarto (1985) have, however, estimated that out of 5000 species of angiosperms studied worldwide only 40 species turned out and used as source of drugs in United States. They further predicted that 2067 species or 10 per cent of those occurring in United States will become extinct by 2000 and 16 species of useful medicinal plants will be eliminated from the flora of United States by the end of the year. The use of wild plant materials in the pharmaceutical trade is enormous and only few medicinal plants are subjected to international trade regulations, despite the fact that they are traded in large quantities without knowing the biological impact of such trade. The roots and rhizomes of 685 taxa are used for various purposes so the collection of roots and rhizomes must be avoided and the use of aerial parts after sheding of seeds should be encouraged.

Very few medicinal plants, which are in trade, are under cultivation. Obviously, the pressure is on the wild population for their trade. It is a general belief that a plant collected from the wild is generally more efficacious than the cultivated one and thus this mounts further pressure on the wild populations and some have either disappeared the deforestation and growing commercial exploitation has resulted into the depauperisation of the population of many plants. So, like the agricultural produce, the Government should also fix the prices of several medicinal plants and their parts because the traders offer very less amount for the collected materials. The people living in villages often run short of money and due to the less prices offered they try to collect maximum material and thus destroy lot of plants to fetch the maximum money.

Principe (1991) has stated that the pharmaceutical industries are still unable to synthesize the vast majority of the plant derived drugs due to their complex structure and high cost. It is interesting to note that out of 76 different chemical compounds used in maximum prescriptions, only 7 can be chemically synthesized. They are emetine, caffeine, theobromine, theophylline, Pseudoephedrine, ephedrine and papaverine. However, important drugs, like morphine, codeine, atropine, digoxin, digitoxin can not be commercially synthesized. Further, the cost of synthetic drug is about 10 times more than that obtained from plants, e.g. Reserpine obtained from *Rauvolfia* spp. costs approximately US $ 0.75 per g., whereas the synthesized Reserpine costs US $ 1.25 per g. Thus, due to the increasing demand of herbal medicine in European countries cultivation of medicinal plants will be a buoyant and prosperous opportunity for investment.

In India CIMAP is involved in developing improved varieties of medicinal plants and the technique for their commercial cultivation. The scientists of CIMAP have succeeded in developing several improved varieties of papaver, henna, mentha, belladona, etc. They also provided the technique for the cultivation of medicinal plants on commercial scale. The cultivation technique in case of some rare taxa, like *Gentiana kurroo, Gynocardia odorata, Nardostachys grandiflora, Podophyllum hexandrum,* etc. is still not known. The cultivation technology should also be developed for the threatened species so that the material from cultivation could be obtained for the export of value added formulations which are established after putting a lot of efforts, money and time.

The market for medicinal plant is also unstable and very often the farmers do not get the desired return for their products and, therefore, not willing to invest in the cultivation of medicinal plants. It is worth while to note that India was the largest legal producer of opium since about 80 per cent of the total world production came from India. In 1978-79, the area under cultivation was about 64,000 ha with an annual production of 300-350 tonnes but due to the decline in demand in 1986-87 the area under production reduced to only 22,800 ha with annual production of 150 tonnes. It is mainly because of the fact that good materials were avaiable to the European countries, from some other supplier countries which resulted in the loss of 50 per cent of the market share. So the improved variety of crop is required to compete in the market. The repurchase policy should be devised so that grower should get the proper benefit for their produce even in the worst market scenario. Simultaneously, insurance policy should also be introduced to keep grower secure against the natural calamities.

The vegetation of any country is an important wealth and asset because it controls the economy of that country. The evaluation of a plant on the basis of its utility and wood only will be totally wrong and injustice against the plant kingdom as they provide oxygen and help maintain a balance of N_2, O_2 and CO_2 in the atmosphere. They also protect our earth from being erosed, responsible for rain and keep a balance of temperature and maintain the ecosystem. It is estimated that about 500 species have become rare and threatened and some 50 species have became extinct. It is not only due to over exploitation but also due to deforestation, construction of roads, township, tourism, natural calamities, etc. Therefore, there is an urgent need of effective conservation, which can only be achieved by cultivation, tissue culture, control on collection, trade and smuggling and by declaring the areas rich in medicinal plants as national parks, sanctuaries and biosphere reserves. The conservation may also be done by bringing the plant from their place of occurrence to different botanical gardens already established in different botanical zones.

The awareness among the public regarding the importance of medicinal plants and the threat, along with description of plants, should be made by writing and publishing articles in different news papers in various languages, by giving radio talks, projecting documentary films, and by arranging meetings at village level. Besides, the plantation of some medicinal plants in kitchen garden should also be encouraged. The *Clerodendrum colebrookianum,* which is locally known as "Phuinum", is cultivated and eaten along with food in each and every Mizo family with the belief that the herb will prevent heart aiments. In most of the Hindu families *Ocimum sanctum* is grown and worshiped in the house for the welfare of the family, and used for various ailments. In Orissa *Paederia foetida* is grown near the house by the tribals as it is very effective in diarrhoea. Likewise, *Andrographis paniculata* is grown in the house of villages of West Bengal as it is a good liver tonic. Thus, some of the plants which are frequently used for medicinal purposes are conserved.

Apart from the above discussed solutions, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is also keeping an eye on the endangered plants, and has listed plants in Appendix-I and II to regulate their international trade. The plants of Appendix-I are strictly prohibited from trade. At present only *Saussurea costus* is included in the list as medicinal plant. While the Appendix-II includes medicinal plants, like *Dioscorea deltoidea, Rauvolfia serpentina, Picrorhiza* *kurrooa, Aquillaria malaccensis, Podophyllum hexandrum, Euphorphia* spp. *Aloe* spp., *Taxus wallichiana, Nardostachys, grandiflora,* etc. with restricted trade. Though several species have infact become endangered but could not be included in CITES list because of the non-availability of quantitative data on international trade. Efforts should, therefore, be made to compile trade data on following species so that they could also be listed in different appendices of CITES: *Aconitum deinorrhizum, A. ferox, A heterophyllum, Berberis aristata, Colchicum luteum, Coptis teeta, Gentiana kurroo, Rheum australe,* etc.

There is also a need for organised and co-ordinated research which can bringforth some new medicinal plants as well as pharmaceutical and therapeutical data on the existing medicinal plants. The research should be undertaken in sustainable manner keeping the aspect of conservation in mind. Apart from the medicinal plants, an assessment should also be made on cosmetics, toiletries and other herbal products where plants and or plant products are exploited.

UNESCO has sponsored two regional networks for promoting co-operation among research institutions concerned with the chemistry of medicinal and aromatic plants in South and South East Asia. Recently it has also launched the Asian and Pacific Information Network on medicinal and aromatic plants. WHO is also encouraging the research on medicinal plants so that traditional and new herbal medicine could be put to a better use.

REFERENCES

Caius, J.F. 1986. *The Medicinal and Poisonous Plants of India.* Scientific Publishers, Jodhpur.

Chatterjee, A. and S.C. Pakrashi 1991. The *Treatise on Indian Medicinal Plants.* PID-CSIR, New Delhi.

Chatterjee, D. 1940. Studies on the endemic flora of India and Burma. *J. Roy. Asiat. Soc. Beng.* **5**: 19-67.

Chatterjee, D. 1947. Influence of east Mediterranean region flora on that of India. *Sci. and Cult.* **13**: 9-11.

Chatterjee, D. 1960. Floristic Pattern of Indian Vegetation. In: Maheshwari, P., B.M. Johri and I.K. Vasil (eds.) *Proceedings of the Summer School of Botany.* pp. 32-42.

Chopra, R.N. 1933. *Indigenous Drugs of India.* Calcutta.

Chopra, R.N., I.C. Chopra and B.S. Verma 1969. *Supplement to Glossary of Indian Medicinal Plants.* CSIR, New Delhi.

Chopra, R.N., S.L. Nayar and I.C. Chopra 1956. *Glossary of Indian Medicinal Plants.* CSIR, New Delhi.

Dey, A.C. 1980. *Indian Medicinal plants used in Ayurvedic preparations.* Bishen Singh Mahendra Pal Singh, Dehra Dun.

Douros, J.D. and M. Suffuer. 1980. The National Cancer Institute's natural Products antineoplastic development programme. *Recent Results Cancer Res.* **70**: 21-24.

Dymock, W. 1883. *Vegetable Materia Medica of Western India.*

Dymock, W.C., J.H. Warden and D. Hooper 1890-99. *Pharmacographia India.* 3 Vols.

Farnsworth, N.R. and D.D. Soejarto. 1985. Potential consequences of plant extinction in the United States on the current and future availability of prescription drugs. *Econ. Bot.* **39**: 231-240.

Farnsworth, N.R. and R.W. Morris. 1976. Higher plants : The sleeping giants of drug development. *Ameican J. Pharm.* **148**: 46-52.

Farnsworth, N.R., O. Akerela and A.S. Bingel. 1985. Medicinal Plants in therapy in *Bull. World Health Organisation* **6**: 965-981.

Fellow, L.E. 1991. Pharmaceuticals from traditional Medicinal Plants: Future prospects. A paper presented at the sympsoium *New Drugs from Natural Sources*. Sponsored by I.B.C. Technical service Ltd. London, June 13th-14th 1991. Royle Botanic Garden, Kew.

Fuller, D. 1991. *Medicine from the wild.* TRAFFIC, USA, Washington DC.

Gauniyal, A.K., A.K. Singh and O.P. Vimani. 1991. Major medicinal plants as foreign exchange earner. Yojana **35**(13): 14-18.

Hooker, J.D. 1904. *A sketch of the flora of British India.* Calcutta.

Huxley, A. 1984. *Green Inheritacne.* Gaia Books Ltd., London.

ITC 1982.*Market for selected medicinal plants and their derivatives.* International Trade centre/UNCTAD/GTT, Geneva.

Jain, S.K. and R.A. De Filipps 1991. *Medicinal Plants of India.* Vol. 1-2. Reference Publ., Michigan.

Kirtikar, K.R. and B.D. Basu. 1935. *Indian Medicinal Plants.* Vol. I-III. (Repr. ed. 1984).

Maheshwari, J.K. 1960. Studies on the Naturalised Flora of India. In: Maheshwari, P., B.M. Johri and I.K. Vasil (eds.) *Proceedings of the Summer School of Botany.* pp. 156-170.

Nadkarni, K.M. 1954. *Indian Materia Medica. Revised and Enlarged by A.K. Nadkarni.* Vol. I and II.

Nayar, M.P. 1996. *Hot spots of endemic plants of India, Nepal and Bhutan.*TBGRI, Thiruvananthpuram.

Nayar, S.L. and I.C. Chopra. 1951. *Distribution of British Pharmacopoeial Drug plants and their substitutes growing in India.* CSIR, New Delhi.

Oldfield, M. 1984. *The value of conserving Genetic Resources.* U.S. Department of Interior, Wahington DC.

Principe, P.P. 1989. The economic significance of plants and their constituents as drug. In: Wagner, H., H. Hikino and N.R. Farnsworth (eds.) *Economic and Medicinal Plant Research.*

Principe, P.P. 1991. Valuing Diversity of Medicinal Plants. In Akerela, O., W. Heywood and H. Synge (eds.) *Conservation of medicinal plants.* Cambridge University press, Cambridge.

Rastogi, R.P. and B.N. Mehrotra 1960-89. *Compendium of Indian Medicinal Plants.* Vols. I-IV. CDRI, Lucknow & PID, New Delhi.

Waring, E.J. 1897. *Remarks on the uses of some of the bazar medicines and common medicinal palnts of India.* 5th ed. London.

Warrier, P.K., V.P.K. Nambiar and C. Ramankutty (eds.) 1993-1995. *Indian Medicinal Plants. A compendium of 500 species.* Orient Longman Limited, Madras.

Watt, G. 1889-1904. *A Dictionary of the Economic products of India.* Vols. I-IV.

ETHNOBOTANY

V. Mudgal
K.K. Khanna
D.C. Pal
A.K. Sahoo
M.K. Pathak

Man came into being empty handed on this planet. He had to create his own means to satisfy his necessaties using only what nature had provided around him. Here came the first effort of using plants, soil, water and air to achieve the desired needs.

Man did not come to this world equipped with knowledge as to what was harmful and what was good. He had to gain this by his talent and experiences. Obviously, they must have tried to learn from animals cohabiting with them. Simultaneously, they must have tested the plant resources of the earth by trial and error method and the knowledge thus gained must have been retained by his clans or faithful fellows.

Infact, the knowledge of different products obtained from plants, *viz.* food products, medicines, chemicals, dyes, wood products, cotton fibres, etc. actually came to us from ancient men, whom the so called civilized world terms as backward, underdeveloped and barbarians, but the facts are otherwise. Fortunately in our country there are 550 ethnic communities (population *ca* 55 million) who speak 227 dialects of 106 languages. Many of these communities follow primitive pattern of life which they have inherited from their ancestors. Studies on these ethnic communities were initiated in India by Dr. E.K. Janaki Ammal as an official programme in the Economic Botany section of Botanical Survey of India since its reorganisation in 1954. Few years later, the work was well elaborated by Dr. S.K. Jain and subsequently by a number of other workers. These studies (Jain, 1963, 1963b, 1964, 1964a, 1967, 1975; Jain & Tarafdar, 1963, 1970; Jain & Pal, 1982; Jain & Borthakur, 1980; Jain & De, 1964; Jain *et al.*, 1976; Maheswari *et al.*, 1981, 1986; Rao, 1981, Rao & Jamir, 1982, 1982a, Rao & Neogi, 1980; Pal, 1973, 1980; Pal & Banerjee, 1971; Goel *et al.*., 1984; Joshi *et al.*, 1980; Mudgal & Pal, 1980; Khanna *et al.*, 1993, 1993a, 1994, 1996) have revealed the fact that the knowledge and use of many plants which the tribal people possess are new to the today's civilized world and scientists. In other words, these forest dwelling ethnic communities are much ahead than the scientists in knowledge and sustainable use of plant diversity. The study of relationship between the ethnic community and plants, and the search of newer uses and applications of plants is kept under the branch of science which is popularly known as Ethnobotany. The plants identified on this basis are called Ethnic plants.

Now it is well established that the tribal people are well versed with the plants of their locality. They are able to distinguish the minute differences among closely related plants, which is sometimes difficult even for the trained botanists. Besides, their traditions and beliefs have made a valuable contribution for many centuries as regards the conservation of plant diversity in the country. They protect the rapidly disappearing useful (including medicinal) plants of their area in several ways. One of the best way of conservation of the plant diversity of their locality is in the form of sacred groves which are well protected by their religious belief.

Ethnic people

From the evolutionary point of view the ethnic communities of India belong to Austreloids, Kokecides, Mongoloids and Nigro groups. They are further divided into three language groups.

I. Austro-Asian Language Group:

Munda, Santal, Oraon, Lodha, Mech, Rabha, Asur, Birhor, Bhumij, Kharia and Nicobarese.

II. Dravidian Language Group:

Ethnic communities of central and South India.

III. Tibeto-Burmese Language Group:

All ethnic communities of Assam and the eastern Himalaya.

The selected ethnic communities of India are listed in Table I.

Some of these communities, viz. Onge, Jarawa and Shompen of Andaman & Nicobar Islands, Toda of Nilgiris, Asur of Chota Nagpur, Lodha of Midnapur and Toto of Jalpaiguri are confined to restricted areas with small populations.

Table I
Selected ethnic communities of India

Australo-Asiatic	Dravidian	Tibeto-Burmese
Munda, Oraon, Santal, Lodha, Gond, Rabha, Asur, Birhor, Saora, Bhumij, Kharia, Nicobarese, etc.	Chenchu, Irul, Malayar, Kurchya, Toda, Nayadis, Gadabia, Reddi etc.	Bhotai, Miri, Mikir, Garo, Khasi, Borokachari, Jaintia, Lepcha, Nepali, Mech, Rabha, etc.

Useful Plants

An analysis of the plants used by ethnc communites has revealed some interesting facts. *Ocimum sanctum* (Tulsi) is used in more than 300 ways among various ethnic communteis. Similarly *Andrographis paniculata* (Kalmegh) is used in more than 100 ways. If we list the use of 500 medicinal plants the number of uses will cross 20000. Further, the same plant has different uses at different places and by different communities. *Dendrocalamus falcata* is used as antifertility (family planning) drug in Mayurbhanj (Orissa), while it is used against stomach disorders in Santal Pargana (Bihar). On the contrary, many plants are used by different ethnic communities for same ailments. Example of such plants are listed in Table II-IV.

Table II
Different uses of same plant by different ethnic communiities

Name of the plant	Ethnic community and place	Uses
Abrus precatorius	Gov (Uttaranchal)	Eczema
	Khond (Orissa)	Antihelmintic
	Munda and Oraon (Bihar)	Abortion
	Santal (Bihar)	Blood purifier
	Lepcha (Sikkim)	Pneumonia
	Bhil (Rajasthan)	Veterinary medicne
Acalypha indica	Andh (Maharashtra)	Laxative
	Gond (Madhya Pradesh)	Asthma
	Santal and Oraon (Bihar)	Reduces obesity

Name of the plant	Ethnic community species	Uses and place
Achyranthes aspera	Bodo and Chakma (Assam)	Antifertility
	Gond (Madhya Pradesh)	Abortifacient
	Konda-Kapus, Koya (Andhra Pradesh)	Piles
	Kathouria (Rajasthan)	Hydrophodia
	Santal and Oraon (Bihar)	Bleeding during delivery
	Naga (Nagaland)	Germicidal
Aconitum heterophyllum	Agariya (Andhra Pradesh)	Antipyretic
	Gujjar (Lahaul)	Stone in gall bladder.
	Naga (Nagaland)	Antihelmintic
	Bhoxa and Jaunsari (Uttaranchal)	Stomachache
Boerhavia diffusa	Garasia (Rajasthan)	Painless delivery
	Santal (Bihar)	Epilepsy
	Kharia (Andhra Pradesh) and people of Kurukshetra area.	Regulation of menstrual cycle
	Bhoxa (Uttaranchal)	Heart diseases
Andrographis paniculata	Khond (Orissa)	Blood purifier
	Santal (Bihar)	Antihelmintic
	Oraon (Bihar)	Liver diseases
	Lodha (West Bengal)	Skin diseases
	Konda-Reddis (Andhra Pradesh)	Filaria
Abelmoschus esculentus	Rabha (West Bengal)	Irregular
	Mech (West Bengal)	Laxative
	Munda (Bihar)	Veneral diseases
	Lodha (West Bengal)	Body cooling
	Khond (Orissa)	Remittent fever
	Bhil (Rajasthan)	Veterinary medicine
Barleria cristata	Santal (Bihar)	Fever
	Birhor (West Bengal)	Anaemia
	Asur (Bihar)	Gum inflammation
	Lodha (West Bengal)	Septic wounds
	Oraon (Bihar)	Washing mouthsores

Name of the plant	Ethnic community species	Uses and place
Celastrus paniculatus	Ho (Bihar, West Bengal, Orissa)	Skin diseases
	Santal (Bihar)	Leprotic wounds
	Lodha (West Bengal)	Strengthen the skul
	Bhil (Rajasthan)	Gout
Cryptolepis buchanani	Mammara (Andhra Pradesh)	Rickets in children
	Santal (Bihar)	Eczema
	Khond (Orissa)	Leprosy
	Bhumij (Orissa and Bihar)	Rheumatic swelling
	Toto (West Bengal)	Bone fracture
Ehretia laevis	Santal (Bihar)	Washing tongue sores
	Lodha (West Bengal)	Ringworm
	Oraon (Bihar and West Bengal)	Skin diseases
	Bhumij (Orissa and West Bengal)	Whitlow
Holarrhena pubescens	Bodo (Assam)	Leucoderma
	Santal (Bihar)	Dysentery
	Lodha (West Bengal)	Rheumatic fever
	Rabha (West Bengal)	Healing wounds
	Vasavas (Gujarat)	Gout
Schleichera oleosa	Santal (Bihar)	Rheumatic massage
	Oraon (Bihar)	Skin diseases
	Lodha (West Bengal)	Hair growth
	Munda (Bihar)	Septic wounds
	Tharu (Uttar Pradesh)	Veterinary medicine
Soymida febrifuga	Khond (Orissa)	Malaria
	Santal (Bihar)	Post natal care
	Saora (Orissa)	Skin eruption
Strychnos nux-vomica	Oraon (Bihar)	Dysentery
	Kharia (Orissa and West Bengal)	Dyspepsia

Name of the plant	Ethnic community species	Uses and place
	Lodha (West Bengal)	Bone fracture
	Munda (Bihar)	Skin diseases
	Khond (Orissa)	Veterinary medicine
Ventilago denticulata	Khond (Orissa)	Rheumatic
	Saora (Orissa)	Swelling
	Lodha (West Bengal)	Skin diseases
	Santal (Bihar)	Dysuria
	Kol (Uttar Pradesh)	Night blindness
Hyoscyamus niger	Gov (Uttar Pradesh)	Hysteria, muscle pain
	Aamchi (Jammu & Kashmir)	Sedative, Whooping cough, astringent
Adhatoda zeylanica	Nayadis (Kerala)	Asthma
	Santal (Bihar)	Cough and cold
	Bhil (Rajasthan)	Eczema
	Naga (Nagaland)	Malaria
Kalanchoe pinnata	Borokachari (Assam)	Amoebic dysentery
	Khond (Orissa)	Dyspepsia
	Tharu (Uttar Pradesh)	Antihelmintic
	Santal (Bihar)	Skin diseases
	Karbi (Assam)	Influenza
Gloriosa superba	Santal, Munda, Oraon (Bihar)	Abortifacient
	Kharia (West Bengal)	Intermittent fever
	Tharu (Uttar Pradesh)	Gout
	Birhor (West Bengal)	Veterinary medicine, small pox

Table III
Different plants used by various ethnic communities for Kidney trouble

Plant species	Parts used	Ethnic community and place
Abelmoschus esculentus	Petiole	Birhor (West Bengal)
Hygrophila auriculata	Whole plant	Kharia (Orissa)
Bacopa monnieri	Whole plant	Khond, Saora (Orissa)
Delphinium kashmirianum	Root	Aamchi (Ladakh, Jammu & Kashmir)
Macrotyloma uniflorum	Seed	Lodha and Munda (West Bengal)
Euphorbia hirta	Whole plant	Hill Reddis (Andhra Pradesh)
Indigofera tinctoria	Leaves	Baiga (Madhya Pradesh)
Peperomia pellucida	Whole plant	Munda, Santal (Bihar)
Phyllanthus fraternus	Whole plant	Chenchu and Reddi (Andhra Pradesh)
Terminalia chebula	Fruit	Santal (Bihar)
Tridax procumbens	Whole plant	Lodha (West Bengal)
Swertia chirayita	Whole plant	Aamchi (Ladakh, Jammu & Kashmir)
Tanacetum tenuifolium	Root	Aamchi (Ladakh, Jammu & Kashmir)
Taraxacum officinale	Root	Aamchi (Ladakh, Jammu & Kashmir)
Thlaspi arvense	Whole plant	Aamchi (Ladakh, Jammu & Kashmiir)
Trianthema portulacastrum	Leaf	Yerukulas (Andhra Pradesh)
Moringa oleifera	Leaf	Santal (Bihar)

Table IV
Different plants used by various ethnic communities for diabetes

Plant species	Parts used	Ethnic community and place
Acalypha indica	Leaf juice	Santal (Bihar)
Aegle marmelos	Leaf oil	Kharia (West Bengal)
Asparagus racemosus	Boiled root	Santal, Munda, Oraon (Bihar and West Bengal)
Azadirachta indica	Leaf paste	Khond (Orissa)
Bacopa monnieri	Leaf juice	Santal (Bihar)
Bambusa monnieri	Leaf juice	Santal (Bihar)
Bambusa vulgaris	Leaf paste	Rabha (West Bengal)
Cajanus cajan	Leaf juice	Santal and Munda (Orissa)
Catharanthus roseus	Leaf and plant juice	Lodha, Oraon, Bhumij (West Bengal, Bihar)
Centella asiatica	Leaf juice	Santal and Oraon (Bihar)
Clitoria ternatea	Leaf of white flowered plant	Lodha, Kharia (West Bengal, Bihar)
Coccinia grandis	Root, Leaf mucilage from young plant.	Lepcha (West Bengal) Ho, Bhumij, Birhor (Bihar)
Ficus benghalensis	Bark	Santal (Bihar), Khond (Orissa)
Glycosmis pentaphylla	Leaf oil	Lodha and Toto (West Bengal)
Gymnema sylvestre	Leaf and fruit	Santal, Munda, Oraon, Saora, Khond (Bihar, Orissa)
Pterocarpus marsupium	Bark and heart wood	Santal, Munda, Oraon (Bihar)
Syzygium cumini	Seeds	Oraon, Munda (Bihar and Orissa), Mikir (Meghalaya)
Terminalia chebula	Fruit	Santal, Oraon (Bihar)
Tragia involucrata	Root	Munda, Asur (Bihar)

On the basis of survey made on plants used by different ethnic communities, there are over 4000 medicinal plant species, over 3000 edible plants, over 700 plants are used in different religious ceremonies, over 500 plants yield fibre, over 400 plants are used as fodders, over 400 plants are insecticidal, over 300 plants are used as a source for dyes and resins and over 100 plants are aromatic in India.

The actual number of plants whose knowledge of usage is credited to the ethnic people has always been a matter of conjecture amongst the ethnobotansts. However, Jain (1991) has compiled ethnobotanical data of taxa, 2532 taxa from India. An analysis of this data indicates that Fabaceae is the most dominant family of plant group (Jain, 1991) since its 158 taxa are exploited for ethnobotanical purposes. This is followed by Asteraceae (141), Euphorbiaceae (90), Poaceae (84), Rubiaceae (69), Rosaceae (59), Acanthaceae (51) and Cucurbitaceae (40).

Traditional Methods of Conservation

In our country, a number of plants, like *Ficus religiosa* (Peepal), *Ficus benghalensis* (Bargad) and *Aegle marmelos* (Bel) are grown everywhere including the tribal villages and not removed/destroyed due to certain belief. Many such beliefs have been brought to light by a number of ethnbobotanists including Jain (1963a, 1971); Chaudhuri and Pal (1990); Hajra, (1993) (Table V).

Table V
Sacred trees and related deities

Plant and common name	Related Deities
Aegle marmelos (Bel)	Shiva, Durga, Laxmi, Surya, Ghost and Souls
Anthocephalus chinensis (Kadam)	Krishna, Indra, Yakshini, for securing future generation
Azadirachta indica (Neem)	Shitala, Mansa, Ghosts, Patgoshwami, Vansh Vradhi Upasana.
Bombax ceiba (Semal)	For securing future generation
Butea monosperma (Palas)	Gandharva, Apsaras.

Plant and common name	Related Deities
Cinnamomum camphora (Karpur)	Moon
Dendrocalamus strictus (Bans)	Krishna, Yagyopavit Sanskar, Ancestors
Emblica officinalis (*Phyllanthus emblica*)	Laxmi, Kartia, Vishnu, Gandhrav, for securing future generation
Euphorbia ligularia (Sij)	Mansa, Sirla
Ficus benghalensis (Bat, Bargad)	Brahma, Vishnu, Mahesh, Hari, Krishna, Panchanan, Kuber Laxmi, Makhadmpir
Ficus religiosa (Peepal)	Vishnu, Budha, Krishan, Brahma, Laxmi, Sun, Durga, Apsaras, Gandharva
Madhuca longifolia var. *latifolia* (Mahua)	For securing future generation
Mangifera indica (Mango)	Laxmi, Govardhan, Dhanki, Budha, Gandharva, and for securing future generation
Musa paradisiaca (*Musa spaientum*) (Banana)	Laxmi, Shakambhari, Navpatrika, Ancestor's worship, for securing future generation
Ocimum sanctum (Sacred Basil, holy basil)	Krishna, Vishnu, Ram, Narayan, Shree Hari, Jagannath, Brindavati, Chand, Laxmi
Phoenix sylvestris (Date palm)	Souls, Ghosts, Budha, Yakshini
Polyalthia longifolia (Ashoka)	Buddha, Indra, Vishnu, Gandharva, Aaditya, Apsara, Yasipi
Sarcostemma acidum (Seem)	Chand
Shorea robusta (Sal)	Laxmi, Ghosts, Vayadurga, Bahu Thakurani, etc.
Tamarindus indica (Imli)	Souls, Ghosts
Ziziphus mauritiana	Liukumar, Vansh Vridhi Upasana

It is believed that the name of a family or clan of certain ethnic community is associated with a particular plant species and they are supposed to save that plant species. BHAKTA tribe of West Bengal is believed to be associated with *Dioscorea* species (popularly known as chirka). The members of this clan never dare to harm this plant.

A number of studies (Campbell, 1916; Jain, 1963a; Jain & Borthakur, 1980; Jain *et al.*, 1979; Jain & De, 1966; Billore & Bhatt, 1978; Maheshwari *et al.*, 1981, 1986) have shown that ethnic people living in certain areas have strict rules governing cutting of trees, peeling off bark, pluckng of flowers and fruits, uprooting the whole plant. It has been observed that peeling off of the bark of *Bauhinia vahlii* from main stem is prohibited. The bark is peeled off only from the secondary branches for making ropes and the main branch is left intact and untouched. In some places of West Bengal (Jain & De, 1966; Pal & Mudgal, 1985) it has been seen that cutting of living branches of *Haldinia cordifolia* is strictly prohibited. Only dried branches are used for fuel purpose. *Madhuca longifolia* is generally protected because its flowers are used as food during scarcity and famine. Branches of *Terminalia tomentosa* and *Gardenia gummifera* are cut only once in a year. In many places only the leaves of *Shorea robusta* are used for thatching and the remainng plant is left undamaged.

Some communities believe that the medicinal plants attain the medicinal property only after fruiting or vice versa. In certain, cases peeling of bark is permitted from one side only for medicinal uses. In the areas where population of *Dipteracanthus fruticosus* (Ranured) and *Asparagus racemosus* (Shatmul) is low, its use for medicinal purpose is prohibited.

Further, juvenile plants are not selected for resin and gum collection and only mature ones, up to 20 plants at a time, are selected for this purpose. This helps in the protection of significant number of trees. The plants of *Lagerstroemia parviflora, Shorea robusta* and *Emblica officinalis* are worshipped. Its shade is used for various ceremonies and this leads to the preservation of these plants in and around the villages.

Some communities consider *Dillenia aurea* and *Streblus asper* as mysterious trees. They believe that some super natural power has its abode on this tree. Any harm to this tree will cause incurable illness and even death. As a result of this belief, some large trees are seen in many tribal villages which favour the population growth of other plants and animals. Cutting of trees at the junction of two tracks is prohibited. In some forests of West Bengal vegetation at the junction of 3 or 5 tracts is protected. This vegetaton is known as *Bounga*. Such place presents a unique picture of plant diversity. Bushes and climbers look like a miniature of forest.

Sacred Groves

Sacred groves are the patches of climax vegetation present in their original state for thousands of years on the basis of religious faith and belief. These patches of vegetation are considered sacred and worshiped by the local people. Each of these groves has its own presiding deity and it is believed that doing any harm will bring the curse on the wrong doer (Gadgil & Vartak, 1973). These sacred groves harbour many rare flora and fauna (Gadgil & Vartak, 1996, 1981; Hajra, 1990; Vartak & Gadgil, 1990). They also serve as shelter for many birds, insects and animals.

In India sacred groves are found in the states of Bihar, Karnataka, Kerala, Madhya Pradesh, Meghalaya, Maharashtra, Orissa, Rajasthan, West Bengal etc. In West Bengal there are some sacred groves known as *"Banbebitala"* (Pal & Mudgal, 1985). From biodiversity point of view, best type of groves are found in Surjuga district of Madhya Pradesh where almost all the villages have their own grove. The area of these groves varies according to place and time. Generally it ranges from few trees to 50-60 hectares. They show the glimpses of the vegetaton of the past. So they can be cited as the living museums of the species of plants and animals. Regarding survey and conservation of these groves, the work has been taken up by the Botanical Survey of India on top prioity. Some appreciable work has been done in Meghalaya, Maharashtra, Tamil Nadu, etc.

It has been observed that in such groves there is no temple, mosque or shrine. Instead, the tribal people paste vermilion (Sindur) on the stone or some tree, especially *Ficus religiosa*, *F. benghalensis* considering them as their deities. It is said that the red colour denotes the furious temperament and sacrifical nature of the deity. The fear of this nature of the deity prevents the cutting of trees from the groves and thus saves the diversity of the grove from any damage by any offender. On the other hand simultaneous cutting of plants from graveyard and funeral places is prohibited. No doubt many of these beliefs are based on traditions and are unscientific, but they serve a lot for the conservation of plant diversty. However, due to expansion of education and modernisation, the belief is slowly disappearing. As a result, the sacred groves are facing a strong threat and some of them are on the verge of extinction. Small sacred grooves, however, can still be traced in many areas. In fact they are remnants of the ancient network. For example, the chance of gettng the rare species from Western Ghats is now confined to these groves only. One such rare species, viz. *Kunsteleria keralensis* has recently been discovered by the Botanical Survey of Inda from an urban grove of Kerala.

Some areas of prioritisation in 21st century

It has been regarded that Ethnobotany is actually the reciprocal and dynamic aspects of human interactions with plants. But as per more recent concept Ethnobotany is more applicable for solving the problems of modern world problems. Very recently it has been realised that Ethnobotany is the vital discipline for ecological studies and hence its ecological perspectives are important for both research and policy decisons.

In these perspectives following are major areas for prioritisation.

1. Scientific confirmation of the ethnobotanical information already compiled.
2. Field studies on the basis of geographical and tribal groups.
3. Museum and Herbarium studies.
4. Studies of folklore and folk taxonomy.
5. Studies of total ethnobotany covering all aspects of the subject into a single species of genus or family.
6. Comparative analysis of information already gathered.
7. Study of ancient and medieval literature.
8. Role of tribal participation in forest management.
9. Role of tribal participation in environmental management and conservation of nature.

10. Study of folk medicine, tribal medicine, household remedies and veterinary medicine.

11. Study of ethnobotany in respect of lower groups of plants, like algae, fungi, lichen, bryophytes, pteridophytes, etc.

12. The cultural cognition of plants.

REFERENCES

Billore, K.V. and G.K. Bhatt 1978. Ethnobotanical lores from Ajmer forest division (Rajasthan). *Sachitra Ayurveda* **30:** 960-966.

Campbell, A. 1916. The traditions of the Santals *J. Bihar and Orissa Res. Soc..* **2:** 15-21.

Chaudhuri, Rai, H.N. and D.C. Pal. 1990. Plants in folk religion and mythology. In: Jain, S.K. (ed.) *Contributiion to Indian Ethnobotany.* pp. 19-28. Scientific Publishers, Jodhpur.

Gadgil, M. and V.D. Vartak 1973. Groves dedicated to Gods. *Illustrated Weekly of India* **35:** 19-21.

Gadgil, M. and V.D. Vartak 1976. The sacred Groves of Western Ghats in India. *Econ. Bot.* **30:** 152-160.

Gadgil, M. and V.D. Vartak 1981. Sacred groves of Maharashtra- An inventory. In: Jain, S.K. (ed.) *Glimpses of Indian Ethnobotany.* pp. 279-294. Oxford & IBH Publishing Co., New Delhi.

Goel, A.K., A.K. Sahoo and V. Mudgal 1984. *A contribution to the ethnobotany of Santal Pargana.* BSI, Howrah.

Hajra, P.K. 1990. Nature conservation in Khasi folk beliefs and taboos. In: Jain, S.K. (ed.) *Contribution to Indian Ethnobotany.* pp. 317-320. Scientific Publishers, Jodhpur.

Hajra, P.K. 1993. Plants in magico-religious beliefs and in Sanskrit literature. In: Jain, S.K. (ed.) *A Manual of Ethnobotany.* pp. 117-124. Scientific Publishers, Jodhpur.

Jain, S.K. 1963. Studies in Indian ethnobotany Less known uses of 50 common plants from tribal areas of Madhya Pradesh. *Bull. Bot. Surv. India* **5:** 223-226.

Jain, S.K. 1963a. Magico-religious beliefs about plants among the adivasis of Bastar. *Q. J. Myth. Soc.* **54**(3): 73-94.

Jain, S.K. 1963b. Observatons on ethnobotany of the tribals of Madhya Pradesh. *Vanyajat* **11**(4): 177-183.

Jain, S.K. 1964. Wild plant foods of the tribals of Bastar (Madhya Pradesh). *Proc. Nat. Inst. Sci. India* **30** B (2): 56-80.

Jain, S.K. 1964a. Plant resources in tribal areas of Bastar. *Khadi Gramodyog* **10:** 557-561 & *Vanyajati* **12:** 147-173.

Jain, S.K. 1967. Plants in Indian medicine and folk-lore associated wth healing of bones. *Indian J. Orthopaedics* **1:** 95-104.

Jain, S.K. 1975. Search for new herbal medicine. *Magnolia* **1**(2): 26-31.

Jain, S.K. and J.N. De 1964. Some less known plant foods among the tribals of Purulia (West Bengal). *Sci. & Cult.* **30:** 285-286.

Jain, S.K. and J.N. De 1966. Observations on Ethnobotany of Purulia dist. West Bengal. *Bull. Bot. Surv. India* **8:** 237-251.

Jain, S.K. and D.C. Pal 1982. Ethnobotanical research on less known medicinal plants in India. In: Atal, C.K. and B.M. Kapur (eds.). *Cultivaton and Utilization of Medicinal Plants*. pp. 538-557. RRL (CSIR), Jammu.

Jain, S.K. and C.R. Tarafdar 1963. Studies in Indian Ethnobotany - Native Plant remedies for snake-bite among the Adibasis of Central India. *Indian Med. J.* **57:** 307-309.

Jain, S.K. and C.R. Tarafdar 1970. Medicinal plant lore of the Santals. A revival of P.O. Bodding's work. *Econ. Bot.* **24:** 241-278.

Jain, S.K. and S.K. Borthakur 1980. Ethnobotany of the Mikirs of India. *Econ. Bot.* **34:** 264-272.

Jain, S.K., D.K. Banerjee and D.C. Pal 1976. Medicinal plants among certain Adibasis in India. *Bull. Bot. Surv. India* **15:** 85-91.

Jain, S.K., S.K. Borthakur and N. Dam 1979. Some ethnobotanical notes from northeastern India. *Econ. Bot.* **33:** 56.

Joshi, M.C., M.B. Patel and P.J. Mehta 1980. Some folk medicines of Dangs, Gujrat State. *Econ. Bot.* **1:** 8-24.

Khanna, K.K., P.K. Srivastava, G. Shukla and V. Mudgal 1993a. Unknown traditional uses of plants as veterinary medicines from Uttar Pradesh, India. *Proc. Nat. Acad. Sci. India* **63**(B): 407-411.

Khanna, K.K., V. Mudgal, G. Shukla and P.K. Srivastava 1993. New medicinal plant uses recorded from tribal and rural folk-lores of Bahraich district, Uttar Pradesh. *Proc. Nat. Acad. Sci. India* **63**(B): 213-218.

Khanna, K.K., V. Mudgal, G. Shukla and P.K. Srivastava 1994. Unreported ethnomedicinal uses of plants as aphrodisiac from the folk-lores of Uttar Pradesh plains, India. *Bull. Bot. Surv. India* **36:** 91-94.

Khanna, K.K., V. Mudgal, G. Shukla and P.K. Srivastava 1996. Unreported ethnomedicinal uses of plants from Mirzapur district, Uttar Pradesh. *J. Econ. Tax. Bot.* Additional Ser. **12.** 112-117.

Maheshwari, J.K., K.K. Singh and S. Saha 1981. *Ethnobotany of the Tharus of Kheri district, Uttar Pradesh.* NBRI, Lucknow.

Maheshwari, J.K., K.K. Singh and S. Saha 1986. *Ethnobotany of tribals of Mirzapur district, Uttar Pradesh.* NBRI, Lucknow.

Mudgal, V. and D.C. Pal. 1980. Medicinal plants used by tribals of Mayurbhanj (Orissa). *Bull. Bot. Surv. India* **22:** 59-62.

Pal, D.C. 1973. Tribal folk lore about some plants associated with eye treatment. *Bull. Bot. Surv. India* **14**(12): 446-447.

Pal, D.C. and D.K. Banerjee 1971. Some less known plant foods among the Tribals of Andhra Pradesh and Orissa State. *Bull. Bot. Surv. India* **13:** 221-223.

Pal, D.C. and V. Mudgal 1985. Conservational practices of tribals of Purulia and their relevance in ecodevelopment programmes. *Proc. Eco-development Camp, Baghmundi (Purulia).* pp. 37-42. Calcutta School of Fundamental Research.

Rao, R.R. 1981. Ethnobotany of Meghalaya- plants used by Khasi and Garo tribes. *Econ. Bot.* **35:** 4-9.

Rao, R.R. and N.S. Jamir 1982. Ethnobotanical studies in Nagaland I: Medicinal Plants. *Econ. Bot.* **36:** 176-181.

Rao, R.R. and N.S. Jamir 1982a. Ethnobotanical studies in Nagaland II: 54 medicinal plants used by Nagas. *J. Econ. Taxon. Bot.* **3:** 11-17.

Rao, R.R. and B. Neogi 1980. Observation on the ethnobotany of the Khasi and Garo tribes in Meghalaya. *J. Econ. Taxon. Bot.* **1:** 157-162.

Vartak, V.D. and M. Gadgil 1990. Studies on sacred groves along Western Ghats in Maharashtra and Goa: Role of Belief and Folk lores: In: Jain, S.K. (ed.) *Contribution to Indian Ethnobotany*. pp. 329-335. Scientific Publishers, Jodhpur.