Special Habitats and Threatened Plants of India

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Envis
Wildlife and Protected Areas

This issue
Special Habitats and Threatened Plants of India

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Environmental Information System
INDIA

The Environmental Information System (ENVIS) Centre at the Wildlife Institute of India, set up in September 1997, is part of the ENVIS setup of the Ministry of Environment and Forests, Government of India. It deals with general matters concerning 'wildlife' and specifically those related to 'protected areas'. Its objectives are to:

- Establish a data bank on information related to wildlife and wildlife protected areas, and thereby build up a repository and dissemination centre for information on wildlife science;
- Promote national and international cooperation, and exchange of wildlife related information;
- Provide decision makers at the apex level with information related to conservation and development

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Wildlife and Protected Areas

Special Habitats and Threatened Plants of India

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Mail Bag

ENVIS Bulletin Vol. 10 No. 1, 2007: Galliformes of India

It was most kind and thoughtful of you to send me the formidable and beautifully brought out copy of the ENVIS publication and CD on the 'Galliformes of India'. I have been much enjoying the past month rummaging through the stupendous mine of information, with lovely illustrations of a species in those early years over two decades ago when we feared their rapid extinction. It is so reassuring to see so much research since done to show that these so-called 'game birds' are secure and largely in good health.

I am really happy to have a copy of this splendid labour of love, put together with such meticulous care skill and professionalism, and feel short of words in praise of a monumental work by so many dedicated contributors. Dr. Sathyakumar's editing, as always, in the Nanda Devi tradition if I may say so, along with Dr. K. Sivakumar, has been superb. I am particularly delighted that you focused among avian species on the Galliformes, which includes on the cover our National bird, the dancing Peacock!

My warmest congratulations to your WII team - I feel so privileged and proud to have been closely associated with the creation almost three decades ago of a great institution doing such splendid work in building knowledge and thus helping to save our natural world.

N.D. Jayal, Former Secretary
Ministry of Agriculture, Govt. of India, Vasanth Vihar, Dehradun, India

It looks like an excellent publication and my compliments to WII in this regard. My only comment is that the publication would have had an added more value if the sub-species and their distribution had also been mentioned in brief. This would particularly apply to a species like the Kalij Pheasant.

Dr. M.K. Ranjitsinh
Wildlife Trust of India, New Delhi, India

This document provides a brilliant reference for those seeking to conserve the Galliformes of India as it summarizes the work carried out so far and gives guidance and ideas of what should be done to conserve this important group of birds in India in the future. I congratulate you for this great achievement and look forward to receive copies of further series that hopefully will be published in the future.

Dr Francis Buner, Grey Partridge Ecologist
Game & Wildlife Conservation Trust
Fordingbridge, Hants, SP6 1EF, United Kingdom

It is a wonderful work that will be useful to many conservationists not only in India but also over the world. I'm preparing a book about Partridge, Quails and Francolins and I found already new information in this CD. Our century will be probably the conservation century for the threatened species and I'm pleased to see that now the conservationists originate from the countries where these species live. Congratulations to you and to all participants in this work. I wish you a Happy New Year with many successes in the conservation of the Indian Galliformes.

Alain Hennache, Chair EAZA Galliformes TAG
EEP Coordinator for the Edwards' Pheasant, European Studbookeeper for the Crestless Fireback
Muséum National Histoire Naturelle, Parc de Clères, 76690 Clères, France

Many thanks for the wonderful overview on Galliformes of India. I was very impressed. My best wishes for your future work.

Dr. Siegfried Klaus
Lindenhöhe 5, D-07749 Jena, Germany

I have gone through the CD on the 'Galliformes of India' that has depicted your excellent country's beautiful birds. It has been nicely prepared and the information in the bulletin is very helpful for our study. But I wonder why the information on the incubation period of Chukar (Alectoris chukar) has been mentioned as 'unknown' in the bulletin. I wish to inform you that we have been studying Chukar and Rock partridge since 1995 and have found that the incubation period for Chukar is 23-24 days. The results of our study are available in the internet now and the same may be included in the bulletin.

Dr. Alper Yilmaz,
University of Selcuk, Turkey.

This is a path breaking effort and I am sure there will be many more additions to the series in time to come. Congratulations! This one that I have received will find a pride of place in my small library once I am through.

D. Datta Roy, Former Chief Wildlife Warden,
Tripura, Bagdogra, West Bengal, India

I can not resist complimenting you and your dedicated team to have produced such a valuable book on 'Galliformes of India'. Your project leader Sh. P.R. Sinha deserves "kudos" for encouraging and inspiring the scientists to bring out such scientific literature. The get up and design of the bulletin is attractive in addition to almost errorless printing. I appreciate the really exhaustive bibliography, so strenuously prepared. The color pictures of birds and their distribution maps are nicely depicted.

V.S. Saxena, IFS (R)
Member Appellate Authority Pollution Control, Government of Rajasthan, India

It is an excellent document. I want to congratulate all your staff for bringing out this valuable document. It is a rich source of reference for researchers like me. I think it should be widely distributed to Institutes and Universities.

Dr. Asad Rahmani
Director, Bombay Natural History Society, Mumbai, India

We found 'Galliformes of India' to be extremely useful. We would like to congratulate you and your team for bringing out this bulletin.

Manoj Kumar Misra, Executive Director,
PEACE Institute Charitable Trust, Delhi, India

My congratulations to you and your team in WII-ENVIS, Dr. S. Sathyakumar and Dr. K. Sivakumar on producing a great volume on 'Galliformes of India'. It speaks greatly about the planning and hard work that has been put in. The design, color plates and layout of the printed volume as well as the CD is superb.

Dr. Rajiv S. Kalsi, Head, Department of Zoology
M.L.N. College, Yamuna Nagar, Haryana, India

It is a nice review of the status and distribution of the group in the country. Congratulations to you, Dr. S. Sathyakumar and Dr. K.Sivakumar and the reviewers for putting this together.

Dr. Salim Javed, Deputy Manager,
Bird Conservation Environment Agency, Abu Dhabi, United Arab Emirates

The publication is extremely informative and beautifully done.

Ajai Saxena, Conservator of Forests (Wildlife)
Van Sadan Haddo, Port Blair, Andaman & Nicobar Islands, India

I am very pleased to receive the well-produced and useful ENVIS Bulletin entitled "Galliformes of India" brought out by the Wildlife Institute of India.

Dr. Raghavendra Gadagkar, Professor and JC Bose National Fellow
Centre for Ecological Sciences, Indian Institute of Science, Bangalore, 560012, India.

Many thanks for sending me the ENVIS Bulletin on 'Galliformes of India'. It appears very nicely done and I will read it with interest.

Dr. Ullas Karanth, Director,
Centre for Wildlife Studies, Bangalore, India

Please accept my heartiest congratulations for an excellent publication brought out by the Wildlife Institute of India. I look forward to going through this wonderful compilation.

Vasant Saberwal, Program Officer,
Environment and Development, Ford Foundation, New Delhi, India

Congratulations for the Herculian Task achieved by bringing out the book: 'Galliformes of India'

Harsh Vardhan,
TWSI, C 158-A, Dayanad Marg, Tilak Nagar, Jaipur, India

We are sure that the information provided in 'Galliformes of India' will be useful to our readers.

Atish Chatterjee, Chief, Acquisitions Division
United States Library of Congress, Field Office, American Center, New Delhi, India

'Galliformes of India' is a valuable document in our library collection.

Yashwant G Kanade,
Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India

'Galliformes of India' is very useful to us in our environment and awareness activities in Mumbai and Maharashtra.

Dr. Goldin Quadros
Education Officer & Interim State Director, WWF-India, MSO.

This is another remarkable and extraordinary contribution from the scientists of Wildlife Institute of India towards the scientific research. This book will not only be helpful to the researchers and academicians but is equally beneficial and important for the layman.

Kuldip Shiva, Honorary Director,
NAVDANYA, Rajpur Road, Dehradun, India

Thank you for making the Galliformes Bulletin release function such an intellectually stimulating one.

Vijai Sharma
Secretary (E & F), MoEF, New Delhi

Thank you all for your valuable comments and suggestions which will help us to improve the quality of our ENVIS publications. We will incorporate these as appropriate in the online edition of this issue.

- Dr. V.B. Mathur, *Project Coordinator*

DIRECTOR'S NOTE

Wildlife Institute of India is one of the ENVIS Centres of Ministry of Environment & Forests, Government of India for publication and dissemination of researched information in the subject area of Wildlife and Protected Areas. So far, it has brought out 10 thematic ENVIS bulletins. These bulletins are available as hardcopies and CDs, and are also hosted on Institute's website http:wii.gov.in/envis/publications.html. Considering the importance of the floral wealth of the country, this publication on "Special Habitats and Threatened Plants of India" covering various Biogeographic zones of the country has been compiled. It is an attempt to make its readers aware about the varied and unique floral wealth of our country and draw their attention towards the threat to their long term persistence as part of our natural ecosystem.

It is hoped that nature lovers and protected area managers would find the information contained in this publication very useful. It would also help policy makers and professional managers in developing appropriate strategies for conservation and monitoring of the plants species and their habitats.

P.R. Sinha

Director

Dr. M. Sanjappa
Director

भारत सरकार
पर्यावरण एवं वन मंत्रालय
भारतीय वनस्पति सर्वेक्षण
Government of India
Ministry of Environment & Forests
BOTANICAL SURVEY OF INDIA

FOREWORD

India with vast geographical expanse and amazing diversity in climate, soil and topography support almost all types of ecosystems found anywhere in the world. The varied ecosystems span from the alpine grasslands of Himalayas to coastal mangroves of Sundarbans; hot deserts of Rajasthan to tropical evergreen and semi evergreen forests of North-East and Western Ghats; the flood plains of Gangetic belt to coral reefs of Andaman sea; the cold deserts of Ladakh and Lahaul -Spiti to tropical Island ecosystems Andaman & Nicobar Islands, and so on. In each of these ecozones there are hundreds of biotopes- each supporting its distinctive floristic components. The confluence of three major biogeographical realms (Eurasian, Afro-tropical and Indo-Malayan) has further enhanced the intermingling of floristic elements of these regions in Indian flora. Though the country constitutes merely 2% of the world's geographical area, it harbors ca 45000 species, nearly 11% of the known world flora, and thus ranking third in Asia and eleventh among the top mega-diversity countries of the world. Studies undertaken so far on floras in several parts of the world have shown that many plant species are in danger of extinction while some have turned extinct. On a global basis, the IUCN have estimated that about 10% of world's vascular plant species are under varying degrees of threat and started publication of Red Data Books on animals and plants to include data on threatened species and facilitate their conservation.

In India, the problem on threatened plants was first discussed in the 11th Technical Meeting of the IUCN in 1969 in which important papers were presented on the subject. Subsequently, the Botanical Survey of India published a small book-let: Threatened plants of India- A State-of-the Art Report, in 1980. Concerted efforts were made on the subject and valuable base-line data on nearly 1000 threatened species gathered, all this data had given impetus for writing up of Red Data Books by the Botanical Survey. Endemicity and

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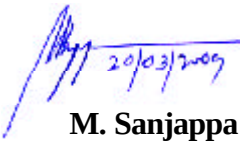
usefulness leading to overexploitation are essentially two reasons for a species to come under threat. Apart from it, rapid changes in land use have resulted in degradation of specialized natural habitats and along with it rapid depletion of plants confined to these habitats.

Specialized habitats and threatened plants undeniably deserve exceptional concern for endured conservation and sustained monitoring in different phytogeographic regions in the country. Shared collaboration, coordination and harmonization among institutions and also among naturalists, plant taxonomists, forest and protected area managers and volunteers possibly give the essential boost to realize this objective. I am happy to know that the Wildlife Institute of India has taken an initiative to bring out a special issue focusing on the theme 'Specialized Habitats and Threatened Plants. The articles in this issue are contributed by professional taxonomists as well as amateur naturalists in the country and covered Western Himalayas, North East India and also Western and Eastern Ghats. Thar Desert, Ran of Kachchh, and some semi arid regions of Deccan are also covered. Many threatened species and their habitats are discussed. Undeniably, this is a beginning for a focused documentation on specialized habitats and threatened species but certainly not an exhaustive account in view of the vastness and diversity of the country. This will act as a stimulant to similar such publications.

I am sure, this publication would prompt personnel manning forest and protected areas to take up follow up measures recommended for different biogeographic zones and also specific to species to strengthen plant conservation efforts in the country.



M. Sanjappa

Monitoring Threatened Plants and Their Habitats: Way Forward

- Editorial

Conscious of current conservation crisis, a number of leading institutions and individuals are currently engaged in the systematic study of flora and fauna including threatened species. The responsibility of implementing*in situ* conservation of biodiversity is primarily vested with the State Forest Departments (SFDs) which have the backing of several policy documents including recently notified Biodiversity Act (2002) and technical support of research institutions. Though a considerable effort has been made to strengthen the protected area network (PAN) in the country (4.8% of the geographical area), all habitats, threatened plants and ecologically sensitive areas cannot be contained within the PAN. The PA boundaries in the past were decided based on administrative convenience rather than ecological considerations. As a result, several macro and microhabitats which harbour unique assemblages of plants remain outside the current PAN and continue to face anthropogenic pressures.

Generally, well managed parks ensure conservation of major ecosystems and representative biota. However, conservation of rare and threatened plants requires concerted efforts and baseline information. As part of conservation planning and habitat management activities the PA managers are required to know about the plants of high conservation value but this is not taken into consideration in all the parks due to lack of floral inventory and paucity of information on rare endemic species. Conservation of gene pool and native crop varieties are often recommended in the Biosphere Reserves but precious little has been achieved in this direction so far. Very few PAs have been set aside exclusively for the conservation of floral diversity. Even prioritized areas lack trained manpower and adequate ecological information on rare and vulnerable species. More often than not, interested staff do not get involved in the search and protection of such plants due to lack of incentives, initiatives and relevant literature. Therefore, despite having enormous conservation potential, most of the PAs and other forests are unable to play an active role in the restoration and conservation of threatened, rare and endemic plants, which could be of local, regional or global interest.

In order to promote practical plant conservation and monitoring in various Biogeographic zones of India, it is high time that we initiate an all India coordinated programme on monitoring and restoration of highly threatened plants. The programme would need the involvement of leading institutions and taxonomists, SFDs, Universities and Volunteers. This would help in the following ways: (i)

Establishment of linkages between the Field Botanists and frontline staff of SFDs; (ii) Restoration, habitat improvement, protection and monitoring of threatened taxa on priority basis; and (iii) Strengthening biodiversity conservation in various Biogeographic zones of the country. At the outset, such an initiative would require identification of rare and threatened species and habitats and major threats to such species, priority listing for *in-situ* conservation, and restoration. Following this, the participants or the collaborating agencies will need to carry out status surveys of selected taxa within and outside the PAs, identification of the restoration sites in consultation with the SFDs and identified botanists. The third and most important step would be to evolve appropriate monitoring protocols for various species through a series of training workshops in the field involving SFDs (Range Officers or equivalent staff) in which identity of species, survey methods, restoration of microsites, and baseline data collection for future monitoring can be ascertained. Preparation of distribution maps and information on the micro-habitats for various areas and further analysis in GIS domain may be achieved within a stipulated time.

In this issue of ENVIS Bulletin, we have made an attempt to collate information on special habitats and threatened plants needing further monitoring and restoration in different Biogeographic zones of India. Altogether, there are thirty three articles covering various biogeographic regions of the country. In addition, there are two short notes (Box items) and a compendium of selected references on threatened and endangered plants of India. The contributors range from amateur naturalists to senior foresters and professional botanists. It is hoped that this volume would enthuse naturalists and amateur botanists to take up further monitoring and documentation of threatened plants in their respective regions and this will serve as a much needed baseline information for the field staff of SFDs.

G. S. Rawat
Editor

G. S. Bhardwaj

Section I:
Trans-Himalaya

1.0 Special Habitats and Threatened Plants of Ladakh

G.S. Rawat

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Introduction

Located in the rain shadow of the Great Himalayan massif, Ladakh forms a major portion of the Indian Trans-Himalaya. Also known as 'Little Tibet', this region is spread over some 96,700 km^2 area in the state of Jammu & Kashmir. The region exhibits typical biophysical features of cold deserts having low precipitation and mean annual temperature, short growing season, low primary productivity and sparse vegetation cover. Biogeographically, it is divisible into two provinces *viz*., Ladakh Mountains and Eastern Plateau (Rodgers & Panwar 1988). The former includes rugged mountain ranges and valleys while the latter is gently undulating elevated landscape that forms the western extension of Tibetan Plateau (Plate 1). Floristically, Ladakh is not as rich as comparable altitudes of Greater Himalaya, but it supports a unique assemblage of flora having close affinity with Central Asia and Tibetan plateau. The region has an enormous variation in altitude (2600 to >6500 m asl). Snowline in the Trans-Himalaya is located at much higher altitude (5800 – 6000 m) as compared to Greater Himalaya where it is usually around 5500 m. This provides adequate area for the plants of high alpine and sub-nival zone. The interface between the moist alpine zone of Greater Himalaya and the cold arid region is generally sharp. Mean annual precipitation varies from 50 to 150mm and it increases at higher altitudes, while deep river valleys such as lower Nubra and Zanskar are particularly dry. The arid landscape is interspersed with glacial streams, rivers and lake basins which form crucial Life -Support System for all living forms and provide ecosystem services. Geologically, Ladakh is quite diverse and divisible into several zones, each comprising a series of formations and sedimentary sequences ranging in age from recent to Cretaceous period which have undergone complex tectonic evolution (Frank *et al.* 1977, Thakur & Rawat 1992). In the extreme west there are basaltic formations (Dras volcanics), while in the north-eastern parts one comes across the remnant Tethyan sea beds.

Based on extensive floristic surveys, Kachroo *et al.* (1977) have reported 611 species of flowering plants from Ladakh. However, recent estimates suggest that the number may be much higher. Dickore & Miehe (2002) estimate that for most of the ladakh the richness of vascular plants may be about 500-1000 species per 10,000 km^2, while in Karakoram and north-eastern Ladakh the plant species richness is much lower *i.e.*, <300 species per 10,000 km^2. In recent surveys of south-eastern Ladakh, Klimes (2003) recorded 404 species of vascular plants in about 10,207 km^2 area. The life-forms of the plants exhibit high adaptability to extreme climatic conditions and biotic pressures (Klimes 2003, Rawat & Adhikari 2005). The dominant families of angiosperms are Asteraceae, Poaceae, Rosaceae and Brassicaceae having about 135, 130, 60 and 57 species respectively. The prominent genera are *Saussurea*, *Astragalus*, *Oxytropis*, *Potentilla*, *Carex* and *Polygonum*, each having more than 20 species. The area is diverse in wild legumes (11 genera and 45 species) which enrich the alpine steppe habitat. Despite numerous floristic surveys by various organizations, a comprehensive flora giving updated nomenclature, site specific distribution of species, patterns of rarity and endemism is still lacking for the region.

Special Habitats

Extreme fluctuation of daily temperature, strong winds, sandy soil, solifluction at the higher altitudes and high salinity in the pan shaped lake basins have given rise to a number of unique landforms, micro-habitats and plant communities. In the absence of detailed geo-botanical surveys, it is difficult to paint a complete picture of plant communities and their

distribution across all the habitats. Here, only a few examples of special landforms and corresponding vegetation types have been described. These 'Special Habitats' reflect peculiar ecological settings and harbour unique plant assemblages including some of the rare and threatened species (Plate 1).

i. *Moist meadows Zanskar Ranges*

The areas immediately north of Greater Himalaya, especially in the moist pockets of Zanskar range and northern slopes of Nun Kun, Kolahoi and Zoji La are characterized by the presence of moist meadows rich in herbaceous flora. The basins of larger mountains *e.g.*, Surru, Kargil and Dras, especially towards higher slopes receive higher snow during winter which support extensive grassy slopes dominated by *Festuca kashmeriana*, *Oryzopsis munroi* and *Melica persica*. Moist slopes harbour a rich array of medicinal and aromatic plants including *Ephedra gerardiana*, *Podophyllum hexandrum*, *Inula rhizocephala*, *Iris ensata*, *Swertia speciosa*, *Arnebia euchroma*, *Bistota affinis*, *Cicer microphyllum*, *Geranium grevilleanum*, *Allium carolinianum* and *Rheum australe* to name a few. *Pulsatilla wallichiana*, one of the little known anemones, can be seen occasionally on these slopes. *Colchicum luteum*, a valuable medicinal herb is found in moist meadows around Dras.

ii. *Marsh meadows of Changthang*

Several lake basins and seasonally inundated banks of Indus in Changthang have given rise to lush green marsh meadows which are patchy but rich in plant life. Pools of shallow water support a number of aquatic species such as *Potamogeton pectinatus*, *Myriophyllum verticillatum*, *Hippuris vulgaris*, *Ranunculus natans* and *R. trichophyllus.* The marsh meadows are dominated by sedges (species of *Carex*, *Blysmus*, *Kobresia* and *Eleocharis*) and a few grasses *e.g.*, *Calamogrostis holciformis*, *Poa* spp., *Puccinellia* spp. Typical herbaceous elements in marsh meadows include species of *Ranunculus*, *Pedicularis*, *Gentiana*, *Gentianella* and *Primula*. Some of the species, typical of saline marshes (halophytes) are *Atriplex tatarica*, *Pucinellia himalaica*, *Suaeda olufsenii*, *Triglochin maritimum* and *Glaux maritima.* Rawat & Adhikari (2005) have identified several communities along moisture gradients in Tso Kar basin, Changthang.

iii. *Craggy Rock Surfaces in Zanskar*

A few pockets in the Zanskar range exhibit special lithological features making them unique. For example, higher slopes of Naki La, adjacent to Lachung La that rise abruptly above Yunam River consist of monotonous, phyllitic, olive coloured shales with fine graded sandstones intermingled with 'exotic' limestone. Geologically such areas correspond with Namik La Flysch. Floristically such areas are quite diverse and interesting. Among the rocky crags of Naki La (eastern Zanskar) the plant communities comprise dwarf *Isopyrum anemonoides*, *Silene viscosa*, *Minuarta biflora*, *Valeriana himalayana*, *Rhodiola fastigiata*, *Saxifraga* spp., *Biebersteinia odora* and *Festuca kashmiriana* to name a few.

iv. *Scree bases*

Scree bases (colluvial deposits) and tallus along valley bottoms in Zanskar and other parts of Western Ladakh represent yet another special habitat. Such areas, usually parallel to stream or river courses, harbour several characteristic species *e.g.*, *Lamium rhomboideum*, *Corydalis crassifolia*, *C. moorcroftiana*, *Astragalus nivalis*, *Oxytropis tatarica*, *Rheum tibeticum*, *Elymus nutans*, *Aquilegia fragrans*, *Thermopsis inflata* and *Silene hispida*. It appears that most of these species are dispersed mechanically along with loose cobbles and are well adapted to grow in such habitats. Some of the species *viz.*, *C. crassifolia*, *T. inflata* and *A. nivalis* have typically swollen or inflated fruits to aid wind dispersal along valley bottoms.

v. *Riverine Scrub*

Two species of *Hippophae*, *viz.*, *H. rhamnoides* ssp. *turkistanica* and *H. tibetana* form major constituents of riverine scrub in Ladakh. While the former is much taller (>1 m) and forms dense thickets along the banks of Indus, Shyok and Nubra rivers, the latter, a dwarf (<50 cm) shrub, forms extensive patches in flat terminal moraines and alluvial areas in Zanskar and Surru valleys. Common associates of *H. rhamnoides* are *Myricaria germanica* and *Phragmites australis.* Along the hill streams *M. elegans* forms gregarious and pure stands of riverine scrub. In Nubra valley, in addition to these species *Tamarix gallica* and *Rosa webbiana* are common elements of riverine scrub. *Salix flabellaris* and *S. pycnostachya* are the common willows which can be seen along riverine areas in the Zanskar and much of the lower Ladakh (<4000 m). The riverine scrub in Nubra and other parts of Ladakh serve as most important habitats for critically endangered species of mammals such as lynx (*Felis lynx*) and Nubra pika (*Ochotona nubrica*) which are confined to only a few localities in Ladakh and Nubra respectively (Chundawat & Rawat 1994).

vi. *Scrub Steppe*

Well drained, relatively moist slopes in Changthang support typical scrub steppe dominated by *Cargagana versicolor*, a key-stone species in the region. The mosaics of *Caragana* sp. scrub on gelifluction lobes give a peculiar appearance to the landscape which can be seen on eastern slopes of Taklang La and other parts of Rupshu. Depending upon the micro-topography and soil depth several scrub communities have been identified in Changthang area *e.g.*, *Caragana – Artemisia*, *Artemisia – Eurotia* and *Artemisia – Tanacetum* (Rawat & Adhikari 2005). Towards inner dry ranges especially wind blown slopes of Khardung La and Chang La, patches of *Acantholomon lycopodioides* form pure stands, while dry alluvial fans, flat terraces and valley bottoms (*ca*. 4000 m) in Nubra valley are frequented by *Ephedra gerardiana.* The latter is also found in association with other shrubs in Nubra valley *e.g.*, *Lycium ruthinicum* and *Tamarix gallica*.

vii. *Fell-fields and sub-nival zones*

The sub-nival zone that lies usually above 5000 m asl, is characterized by very short (1-2 months) growing season and extremely harsh climatic conditions. Such areas are usually unstable due to snow and avalanche action and hence support very low vegetation cover. The stable and sheltered areas with higher moisture support mosses and lichens. Some of the typical angiosperms in these areas are *Carex nivalis*, *Saussurea gnaphaloides*, *S. medusa*, *S. glacialis*, *S. werneroides*, *S. nana*, *Draba altaica*, *Saxifraga hirculoides*, *Androsace tapete*, *Rhodiola tibetica* and *Leontopodium alpinum*. At such heights, especially on gentle slopes one can often see the fell-field and cushion forming communities of *Thylacospermum – Arenaria* and *Androsace* species.

viii. *Remnant woodlands*

Palaeobotanical evidences suggest that several parts of Zanskar and Lower Ladakh had much more extensive patches of natural woodlands in the past which have declined rapidly due to combined action of anthropogenic pressures and increasing aridity. Some of the remnant patches of natural woodland, especially of birch (*Betula utilis*), juniper (*Juniperus semiglobosa*), elm (*Ulmus wallichiana*) and some poplars (*Populus euphratica*, *P. ciliata*, *P. alba*) can be seen in Western Ladakh and Nubra Valley. No efforts have been made to delineate or notify such patches for further conservation. In some of the valleys natural woodlands have been replaced by plantations of willow and exotic poplars (*Salix* spp, *Populus nigra*, *P. balsamifera*). Junipers as well as birch are mainly harvested for religious ceremonies and fuel. As a result, they have disappeared from much of their range in Nubra, Khaltse and Chilling-Zanskar road area.

Threatened Plants

Ladakh lies at the cross roads of floral migration between Central Asia and Greater Himalaya. Therefore, the level of endemism in the flora of Ladakh is relatively low (<6%). Several species which exhibit range extension into Ladakh from adjoining floristic regions such as Tibetan plateau, Greater Himalaya or Mediterranean region may have small and fragmented populations within this area. Other species are sparsely distributed owing to limited habitats available to them. The high value medicinal and aromatic plants having narrow distribution range and low populations are particularly threatened in the region. Some of the threatened plants of Ladakh, their brief description, distribution and causes of threat are given below:

1. *Colchicum luteum* Baker (Liliaceae)
English Name : Golden Collyrium

An annual herb. Stem-base below the ground, thickened into a solid, thick, fleshy, gibbously-ovoid corm with dark-brown scales and a longitudinal groove on one side, having 2 daughter-corms, one at the base and other at the top, 15-30 x 8-15 mm. Leaves few, all radical, 3-5, dark green, linear-oblong or oblanceolate obtuse, appearing with or after flowering. Flowers golden yellow, 1-2, on a very short stalk or scape among leaf-sheaths. Fruits 2.5-3.8cm long capsules with long recurved beake, having numerous seeds. Seeds are brownish-white, globose or irregularly globular, 2-3mm in diameter.

Found on moist slopes – sparsely distributed in parts of Dras. Also found at higher alpine meadows of Kashmir Valley. Corms are used widely as medicine in the treatment of gout (seed and corm) and also as alterative, aphrodisiac, carminative and laxative. Seeds contain 'colchicine', a valuable alkaloid used widely in cytological studies and it is known to induce polyploidy. Major threats include over exploitation and habitat degradation.

2. *Inula rhizocephala* Schrenk. (Asteraceae)
Local Name : *Turzit*

Dwarf, stemless herbs. Leaves in rosettes, ad-pressed to the ground, 3-5 cm long, bristly hairy. Heads yellow, 1.6-2.5 cm across, collected at the centre of the rosette. Involucral bracts narrow, outer green, inner purplish. Whole plant (including roots) is used in the treatment of chest pains and common cold. This plant is locally used in the treatment of constipation, intestinal infections and ulcers.

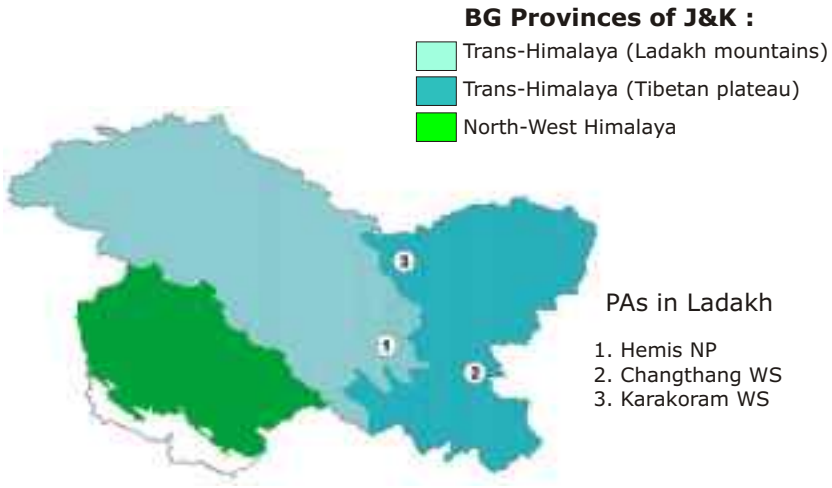
Occasional in moist meadows between 3500-4000 m asl in Western Ladakh especially Nun-kun basin, Kargil and Surru valleys. Over exploitation and habitat degradation are the major causes of population decline.

3. *Saussurea medusa* Maxim (Asteraceae)
English Name : Snow Lotus

Woolly herbs. Stem short, elongates up to 10 cm with age. Basal leaves rosette shaped, obovate or rhomboid, apex of upper leaves dentate. Flower heads embedded in woolly hairs, rarely exposed outside the hairs. Composite heads 5-8 cm in diameter.

Restricted to morainic and stable scree slopes in Karakoram range especially Marsmik La (5400 m). So far known from Karakoram range (India), Tibet and Nepal. Past and present populations have not been assessed. The species is naturally sparse in the region. No immediate threat is perceived except over collection for botanical curiosity.

Plate 1
Landforms and Little Known Taxa from Ladakh



Ladakh & Zanskar Ranges

Changthang Plateau

Marsh meadow, Ladakh

Rajender Sharma

A. *Caloplaca flavorubescens*: An orange lichen with Buddhist inscriptions
1. *Colchicum luteum*
2. *Inula rhizocephala*
3. *Saussurea medusa*
4. *Allium przewalskianum*
5. *Arnebia euchroma*

4. *Allium przewalskianum* Regel (Alliaceae)
Local Name : *Skotze*

A perennial bulbous herb. Leaves shorter than scape, cylindrical hollow. Scape 10-40 cm, cylindrical, covered with leaf sheaths only at base. Umbels globose, densely many flowered. Perianth pink to red or dark purple. Filaments equal, 1.5 -2 times as long as perianth segments, connate at base and adnate to perianth segments. Ovary globose, without concave nectaries at base. Style much longer than ovary, exserted. Fls. and Frs. June – September.

Dry, open scrub and rock crevices between 4000 - 4800 m. Leaves collected locally to prepare condiments and also used medicinally. Distributed in Pakistan, India (Karakoram and Ladakh ranges), Nepal and China (Tibet). The species is locally collected but also protected in agricultural fields in Durbuk and Nubra Valleys.

5. *Arnebia euchroma* (Royle) Johnston (Boraginaceae)
Local Name : *Dimmok*, *Aambokh*

Perennial herbs with dense stiff hairs and thick root stock. Basal leaves long, linear. Upper leaves shorter and broader. Flowers pink or purplish white in terminal dense (globular) racemes. Occasional on dry sandy / stony slopes 3500 – 4500 m asl. Roots yield purple dye which is mixed with oil and used as hair tonic. The roots are also used as ingredient of *Amchi* medicine for the treatment of cough, backache and several other ailments.

Rocky and gravelly slopes. Distributed in Afghanistan, NW India, Kazakhstan, Kyrgyzstan, Nepal, Pakistan, Russia, Tajikistan, Turkmenistan and Uzbekistan. Over extraction for local as well as commercial use is the major cause of its decline.

Conservation Measures

Most of the high value and threatened species of Ladakh including those listed above, can best be conserved with the help of local institutions such as Amchi Association of Ladakh, Women's Alliance of Ladakh and other Self Help Groups. The Department of Forest and Wildlife needs to initiate dialogues with such organizations to identify and set aside a few localities in different watersheds where natural habitats can be protected and restored in order to promote natural regeneration of high value medicinal plants. Amchis and their collectors would be the best judges to set the limits of harvest for various species on a sustainable basis. A network of medicinal plant conservation areas (MPCAs) needs to be established across Ladakh so as to ensure the in-situ conservation of medicinal and associated threatened plants.

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2.0 Nilang : A Little Known Trans-Himalayan Valley in Uttarakhand and its Floral Wealth

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Introduction

The landscape immediately north of main central thrust (MCT) in the state of Uttarakhand represents a unique cold arid ecosystem that has largely escaped the attention of the ecologists, geographers and natural resource managers, owing to the remoteness, inaccessibility and harsh climatic conditions. This area forms a narrow strip (50 – 80 km wide) between the crest of Greater Himalaya and water divide between Satluj and Yarlung-Tsangpo that also forms the international boundary between India and Tibet (Valdiya 2001, Mazari 2007). One of such valleys in the state is Nilang (31° 00 44.1" to 31° 27' 06.26" N latitudes and 78° 53' 39" to 79° 15" E longitudes), located in Uttarkashi District. It is spread over an area of about 1100 km^2 and forms the entire catchment of the river Jahnavi or Jad Ganga and its tributaries. Biogeographically, the Nilang Valley exhibits close affinities with the Tibetan Plateau both in terms of proximity and species composition. Although, Rodgers and Panwar (1988) had categorized the entire region of Uttarakhand (erstwhile Uttar Pradesh) under Western Himalaya (2B), this area can safely be categorized into Trans-Himalaya (Zone 1). However, owing to rapid transition between the Greater Himalaya (2B) and juxtaposition of valleys and varied topography it is rather difficult to mark sub-division and characteristics of any provinces within zone A. Presence of snow leopard (*Uncia uncia*), blue sheep (*Pseudois nayaur*), historical presence of wild yak (*Bos grunniens*), seasonal movement of great Tibetan sheep (*Ovis ammon*), characteristic cold arid steppe vegetation and dominance of floral elements similar to Ladakh and Tibetan Plateau qualifies this area to be classified under Indian Trans-Himalaya.

Historical account of Nilang Valley is given by Atkinson (1981 *Rep*.). The original inhabitants of this valley (Jadhs) were resettled at lower altitudes *viz.*, Harsil and Dunda following Chinese aggression in north India in 1962. Presently this area forms a part of Gangotri National Park .

This article highlights the botanical wealth and a few species of high conservation significance from Nilang Valley.

The Landscape and Vegetation Characteristics

The area is dissected broadly by snow fed tributary streams of the Jadh Ganga that drain the area to meet the Bhagirathi River at Bhaironghati. These tributaries are arranged in almost parallel lines where the mountain slopes are steep in the area of the central crystalline granites closer to Bhaironghati towards the southern portion of the Jadh Ganga valley but assume a dendritic pattern towards the north where slopes are comparatively gentler and the gradient of the Jadh Ganga is also less severe due to the plateau like formation proximal to Tibet. At some points on the Jadh Ganga more than one tributaries confluence to form an important drainage plexus, as at Tirpani, where the southerly flowing Jadh Ganga is met by the Rangmanch Gad from the west and the East Nala from the east. The lower portion of the valley is

extremely rugged and steep in the form of a canyon formed by the river Jadh Ganga. Visually, the study area is divisible into glacial and periglacial types of landforms. The valley gradually widens as one goes for about 10 -15 kms from Bhaironghati. The areas close to MCT are highly broken and unstable owing to regular avalanches and enormous glacial erosion. On the right flank of Jad ganga between Gartang and Nilang there are deep gorges, visually impenetrable. One of such gorges leads to Sangla Valley in Himachal Pradesh, traditionally used by Gaddis for annual movement between Nilang Valley and their homeland with their domestic livestock. Nilang (3400 m asl) is the first traditional village that has been abandoned subsequent to Chinese aggression. The mountain slopes around Nilang and beyond up to Tipani, Jadung and Neelapani Gad are extremely broken, at places with extensive scree slopes, colluvial deposits and lateral moraines. The morainic deposits are prone to wind erosion giving rise to typical barnacles at several places. The areas around Rangmanch Gad, Plumsumdo (PDA) and beyond are gentle and stable (Plates 2A, 2B).

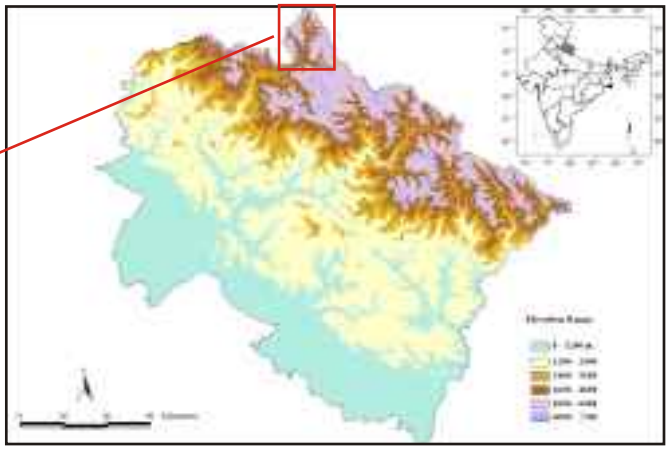
The lower parts of Jadh Ganga (Jahnavi) especially around Bhaironghati support Dry Temperate Deodar forests (Champion & Seth 1968) with open canopy and stunted growths. *Pinus wallichiana* occurs as a common associate. Second storey generally consists of *Ribes alpestre*, *Rosa macrophylla*, *Abelia triflora, Viburnum cotinifolium, Jasminum humile, Berberis aristata, B. pseudumbellata, Artemisia japonica,* etc. Broad-leaved species occurring in the shallow depressions are *Populus ciliata, Acer acuminatum, Sorbaria tomentosa, Rubus niveus* and *Salix karelinii*. Ground vegetation consists of *Thalictrum foetidum, T. minus, Mirabilis himalaica, Veronica stewartii, Impatiens scabrida, I. brachycentra, Arenaria serpyllifolia, Arabidopsis himalaica, Arisaema flavum* and *Salvia nubicola*. Between Karchha and Nilang the vegetation undergoes rapid transition from Deodar mixed blue pine to open juniper woodland and alpine scrub. Commonly associated tree species including *Prunus cornuta* and *Euonymus fimbriatus, Artemisia dracunculus, A. santolinifolia, A. dubia*, *Abelia triflora, Viburnum cotinifolium, Juniperus communis, J. indica, Cotoneaster roseus, Berberis umbellata, B. pachyacantha* and *Lonicera hypoleuca* are the common shrubs and the ground vegetation consists of *Arenaria serpyllifolia, A. neelgherensis, Erigeron acer* var. *multicaulis, Asparagus filicinus* and a few grasses such as *Phaceleurus speciosus, Piptatherum munroi* etc.

Along the side stream courses near Karcha and on opposite slopes a few remnant patches of birch / Bhoj Patra (*Betula utilis*) can be seen. Ground vegetation of scattered birch patches consists of *Anaphalis royleana, Astragalus maddenianus, Danthonia schneideri, Erigeron multiradiatus* and *Solidago virga-aurea*. Beyond Nilang – on way to Naga, Nilapani and Sonam the vegetation is rather sparse and in the form of scattered scrub. Characteristic species include *Rhamnus prostrata, Ephedra gerardiana, Rosa webbiana, Spiraea canescens, Hyssopus officinale,* and *Astragalus candolleanus*. Stream courses and river banks are often dominated by *Myricaria elegans* and *Salix flabellaris.* The past camping sites and nitrogen rich areas are frequented by the high altitude nettle *Urtica hyperborea, Chenopodium tibeticum, Rumex patentia* and *Atriplex hybrida*.

The interior valleys and undulating slopes exhibit characteristic steppe vegetation dominated by *Lonicera spinosa* and *Caragana versicolor* and at places by *Eurotia ceratoides*. Here the unstable scree slopes harbour a distinct community characterized by *Aconogonum tortuosum, Lamium rhomboideum, Cicer microphyllum* and *Rubia tibetica*. Gregarious patches of *Aconogonum tortuosum* on scree slopes turn reddish pink during autumn making the hill slopes picturesque. The seemingly barren rock surfaces have luxuriant growth of colourful lichens *e.g., Xanthoria elegans* (orange red) and *Acarospora chlorophoea* (lemon yellow). The valley bottoms and moist places with clayey soil support patches of sedge meadows dominated by *Kobresia schoenoides, Kobresia royleana* and various species of *Carex.* Towards Shankar glacier and Thag La (above 4500 m) the vegetation reflects the characteristic features of arctic tundra dominated by a few cushion forming dwarf herbs such as *Thylacospermum caespitosum, Arenaria festucoides, Androsace globifera* and *Rhodiola tibetica.* Thus the flora of the Nilang Valley typically reflects the prevalence of Trans-Himalayan elements.

Plate 2A
Location and Landforms of Nilang Valley, Uttarakhand

FCC of Nilang Valley



Location of Nilang in Uttarakhand

Vegetation and Landforms

Riverine Scrub and Scree Slopes

Plate 2B
Unique Plants of Nilang Valley

Allium carolinianum

Arnebia euchroma

Dictamnus albus

Malus baccata

Acarospora chlorophoea

Biebersteinia odora

Hyssopus officinalis

Ephedra gerardiana

Floral Wealth and Plants of High Conservation Significance

Naithani (1988) gave the first botanical account of this Valley in which he reported about 170 species of flowering plants from this valley. The authors have been conducting regular floristic surveys in the valley since past 3-4 summers. Our latest estimate reveals that this valley harbours about 221 genera and 421 species of vascular plants distributed over 69 families. A detailed break up of the general flora is given below :

Groups	Families	Genera	Species
Pteridophytes	3	6	9
Gymnosperms	4	4	7
Dicotyledons	53	174	341
Monocotyledons	9	37	64
Total	**69**	**221**	**421**

Some of the little known species of high conservation value in this area are briefly described below :

1. *Allium carolianum* DC. (Amaryllidaceae)
Local Name: *Rogba; Rukba*

Bulbous, delicate herbs. Leaves 5-6, flat, linear, strongly aromatic. Flowering scape up to 30 cm. Flowers pink in many flowered umbels. Frequent in alpine moist meadows 3000 – 4500 m asl. Bulbs and leaves of this herb are used in the treatment of constipation.

2. *Arnebia euchroma* (Royle) Johnston (Boraginaceae)
Local Name: *Khami*

Perennial herbs with dense stiff hairs and thick root stock that yields purplish – red dye. Basal leaves long, linear. Upper leaves shorter and broader. Flowers pink or purplish white in terminal dense (globular) racemes. Occasional on dry sandy / stony slopes 3500 – 4500 m asl. Roots yield purple dye which is mixed with oil and used as hair tonic. The roots are also used as ingredient in Tibetan medicine especially for the treatment of cough, back-ache and several other ailments.

3. *Biebersteinia odora* Steph. (Geraniaceae)
Local Name: *Taksha*

Strongly aromatic, glandular-pubescent herb. Rootstocks densely tufted. Leaves pinnately compound with irregularly lobed leaflets. Flowers yellow in short terminal racemes. Occasional in tussocks on rocky slopes between 4500-5000 m asl. Whole plant is used in the treatment of cuts, wounds and peptic ulcer. It is also used in the treatment of diarrhoea.

4. *Cicer microphyllum* Benth. (Fabaceae)
Local Name: *Chhel*; English Name: Wild Gram

A low spreading glandular-hairy herb. Leaves pinnate, ending in a coiled trendril. Flowers solitary or paired, purple to white. Pod 2-3 cm, inflated, explosive, beaked and densely hairy. Occasional on dry sandy river beds and stable scree slopes between 3500-4500 m asl. It is also a source of vitamin C and used as ingredient in various medicines.

5. *Ephedra gerardiana* Wall. (Ephedraceae)
Local Name : *Chesna;* Trade Name: *Som Lata*

A low rigid tufted shrub up to 60 cm tall. Branches slender, numerous and jointed. Joints covered with scales. Fruits ovoid 7-10 mm, with freshy red succulent bracts enclosing the 1-2 seeds. Frequent on alluvial fans, gravel terraces and rocky slopes between 3000-5000 m asl. Young branches used for the extraction of ephedrine which is used for instantaneous cure of asthma, rheumatism and as heart stimulant. It is also used in preparation of nasal sprays to cure sinusitis and inflammation of mucous membrane.

6. *Dictamnus albus* L. (Rutaceae)
English Name : Burning Bush

Strongly aromatic herb up to 50 cm. Stem and leaves clothed with glandular hairs. Leaves pinnate 20-30 cm long. Flowers 2.5-4 cm in erect racemes. Petals pink, easily falling. Sparse in inner dry ranges 2800 – 3300 m among bouldery scrub vegetation. Not in much local use but its potential as aromatic herb needs to be explored.

7. *Hyssopus officinalis* L. (Lamiaceae)
Local Name : *Chhabra*

Perennial much branched and tufted herbs. Stem and leaves rough in texture, highly aromatic. Flowers bluish – purple. Frequent on inner dry ranges, especially on dry gravelly soil between 3400 – 4000 m asl. Leaves are used for extraction of certain oils by Ayurvedic industries. Tea of Hyssop flower tops are highly useful in the treatment of respiratory problems and for easing cough, sore throat and for loosening phlegm.

8. *Lillium polyphyllum* Don. (Liliaceae)
Local Name : *Kakoli*, *Kashir Kakoli*

Perennial, erect herbs upto 50 cm tall. Leaves sessile, alternate or nearly opposite or whorled, narrowly lanceolate or linear, 8-12 x 1 – 2 cm. Bracts leaf-like, often whorled. Flower solitary or whorled with 4 – 10 long stalk. Perianth 5 – 8 cm long, greenish white with purple dots inside, segments obtuse, recurved when fully expanded. Stigma obscurely 3-lobed. Capsule 2.5 to 3.5cm long.

Rather sparse in a few patches upto Karcha under open deodar forests. Tubers are said to be highly medicinal. One of the rare lilies of higher Himalaya.

The Jadh Ganga valley has hosted large scale grazing for millennia and an estimated 30,000 sheep, goats and mules graze these pastures intensively even today, entering from Bhaironghati in May and branching out into various micro-catchments to spend the summer. *Lonicera* and *Caragana* are heavily browsed during onward passage while *Eurotia* is favoured on the return journey with the onset of autumn. The plant diversity of Nilang is seriously threatened by heavy grazing even as the inclemency of the climate leaves a very short period for its revival. It is imperative that the Forest Department should involve the local communities and evolve a practical strategy of rotational grazing, allowing sufficient rest to grazed valleys to restore their diversity.

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3.0 Cold Deserts of Himachal Pradesh: Unique Habitats and Threatened Plants

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Introduction

The northern flank of Himachal Pradesh (HP), separated by the Great Himalayan range and partly by the Pir Panjal (to the west), forms the southern extension of Indian Cold Desert. A major portion of this land mass has been categorized under the Biogeographic zone 1 *i.e.*, Indian Trans-Himalaya by Rodgers and Panwar (1988), and administratively this area falls under Lahaul & Spiti district of HP. Far from being barren wasteland, as has been erroneously referred in some texts, this region represents a unique ecosystem hosting an array of specialized plants and animals adapted to the harsh conditions prevailing here. This tract is among the sub-continent's last remaining citadels of total wilderness. Along with the unique floral elements several birds and mammals exhibit seasonal migrations up and down the steep mountain slopes and depend on contiguous habitat for their movement. If any of the habitat layers are lost or degraded, numerous biological processes are disrupted. Therefore, conservation of this ecoregion is critical for the conservation of biodiversity not confined here but extending afar of its boundary limits.

This article gives an overview of biophysical features, habitat and vegetation characteristics within cold deserts of HP. A few species of angiosperms, representing these habitats have been appended along with their uses, distribution and threat status.

Biophysical Features

The cold deserts in the HP lie extending between 31° 44' 34" N to 32° 59' 57" N latitudes and 76° 46' 29" E to 78° 41' 34" E longitudes, covering Lahaul & Spiti district and part of Pooh Sub-division in Kinnaur. The altitude ranges from 2400 to 6400m above mean sea level and the area above 5600m remains perpetually under snow. The region exhibits typical alpine characteristics with low vegetation cover and primary productivity and stark seasonality. The region forms an integral part of the Himalayan ecosystem, with interconnected processes that extend from the riparian scrub along the river and stream courses to the high alpine meadows and boulder-strewn scree that spreads over the vast landscape. However, to overcome these environmental stresses, both plants and animals have adapted themselves in many ways. Typical Trans-Himalayan faunal elements include the elusive snow leopard, brown bear, Tibetan wolf, majestic ibex and blue sheep (Plate 3A).

Despite harsh climatic conditions, the cold deserts have been occupied by human beings since the dawn of civilization. Secluded in selected pockets, the indigenous people have managed to eke out their living by adapting themselves to the harshness of their chosen habitat with tradition. The unpleasant face of development and the increasing biotic pressure in recent years along with the lack of appropriate technologies has led to the overuse and degradation of the natural resources of the region. The scarce vegetation cover is steadily getting degraded, and the limited water resources are getting depleted and polluted. Waste accumulation and poor sanitation and hygiene are new problems

of the region, and are leading to health problems among the local people. Firewood is scarce and power inadequate and unreliable for both domestic and occupational use. Very little research interest and technology development has been focused on these regions. Moreover few technologies that have been transferred have frequently not been aligned to the special needs and conditions of the region. Agriculture is done on terraced fields. One of the major features in the region is agro-forestry, under which local people have adopted willows and poplars which are planted along the margins of the agricultural fields. In the Patton sub-valley, however, fruit trees, such as walnut, plum, and peach, are also cultivated. Seabuckthorn (*Hippophae* spp.) is found in smaller patches on the interspaces of the terraces, particularly in those parts of the fields through which the irrigation channels pass (Rawat *et al.* 2006).

Habitat and Vegetation Characteristics

The evolutionary history of landscape features and habitat characteristics in the cold deserts of Western Himalaya is beyond the scope of this article. However, current physical features and eco-climatic conditions reflect a mosaic of numerous habitats and corridors for dispersal of the floral and faunal elements thereby resulting in high degree of biodiversity. Though this particular region does not harbor a spectacularly rich flora like many other biomes of the world in terms of species diversity yet their morphological, ecological and behavioral adaptations are necessarily unique. The region has several focal species of immense conservation importance (Plates 3A & 3B). Some of the interesting features of natural habitats and corresponding vegetation have been described below:

i. *The Moist Meadows of Pir Panjal*

The areas along and immediately north of Pir Panjal range, especially towards Lahaul exhibits characteristic features of alpine moist meadows similar to Greater Himalaya. It forms a transition zone between the moist temperate and alpine habitats. One of the most accessible and typical sites where this habitat can be seen is around Rohtang Pass that forms the beginning of Pir Panjal range. The meadows are dominated by species of *Poa*, *Festuca* and a large number of herbaceous species. A few species of high conservation significance in these habitats include *Primula rosea*, *Meconopsis aculeata*, *Rheum australe*, *Lagotis* spp., and *Bistorta affinis*. The lush green meadows around Rohtang slopes harbor the summer grazing grounds for herds of sheep, goats and mules. These grazing grounds over the years have become vulnerable to unpalatable native species in the company of some ever-increasing invasive elements, belonging mainly to the *Polygonaceae* and *Brassicaceae* family. The unpalatable plant species include *Bistorta vaccinifolia*, *Primula denticulata*, *Meconopsis aculeata*, *Geranium wallichianum*, *Bistorta affinis*, *Geum elatum*, *Impatiens thomsonii*, *Salvia glutinosa*, *Senecio chrysanthemoides* and *Urtica hyperborea*. Some other species like *Anemone rivularis*, *Iris kemaonensis*, *Morina longifolia*, *Potentilla argyrophylla*, *Taraxacum officinale* and *Thermopsis barbata* thrive under these stressed conditions and can be seen in gregarious formations.

ii. *Riverine scrub of Bhaga Valley*

The riverine scrub along Bhaga river is dominated by *Hippophae rhamnoides*, *Salix alba*, *Myricaria elegans* and *Rosa webbiana*. Regions where the adjoining glacial streams meet the river, glacial moraines and scree are covered with good *Juniperus* regeneration, *e.g.*, the area opposite Jispa. At higher altitudes, the snow on the north facing slopes lasts longer into the summers. This results in the formation of special habitats which show a prominent effect on the composition of the flora. *Betula utilis* formation can be observed in moist gulleys among craggy cliffs and slopes, while the adjacent sun facing slopes have drier conditions favouring arid floristic elements like *Juniperus* spp. with undergrowth of *Rosa webbiana*, *Ribes alpestre* and *Lonicera myrtillus*. A good formation of Juniperus forest is found around Stingri near Keylong.

iii. *Juniper woodland and sub-alpine Scrub of Miyar Valley*

Miyar forms the North-Western part of Lahaul. This remote fascinating valley of Lahaul is hidden behind the lofty Udaipur Range and remains snow bound for over half the year and is amongst the most inaccessible areas in the region. During the short summer months, however, the alpine passes, mountain slopes, meadows and moraines present a spectacular display of colours as the vegetation bursts into life. Quite a few patches of juniper tree (*Juniperus semiglobosa* Regel) can be seen here, which represents sub-alpine forests in the region. This is one of the featured species of high conservation and religious importance in the valley. In the moist valley area along Miyar rivulet, the cool temperate and sub-alpine zones are dominated by dry zone *Cedrus deodara* in association with gnarled trees of *Juniperus* spp. Other prominent taxa in this zone are stunted associations of *Juglans regia*, *Pyrus baccata*, *Prunus cornuta*, *Berberis* spp., *Rosa webbiana*, *Rosa eglanteria*, *Ribes grossularia*, *Cotoneaster bacillaris*, *Crataegus songarica*, *Populus balsamifera* and *Betula utilis.* The mouth of the valley has a dominant presence of *Datisca cannabina* along the steep river valley and further into the valley the slopes are dotted with a dominance of beautiful flowered *Eremurus himalaica* ('Praey') during the onset of summer (Kapoor & Jishtu 2008).

iv. *Alpine Dry Scrub of Spiti*

Spiti valley, in general is characterized by sloppy mountain deserts with the growing season of 5 – 6 months (April to September). The annual snowfall varies from 150-200 cm with very negligible rainfall. The minimum average temperature during winters touches as low as -30^{o}C. Sub zero temperature prevails from December to February, whereas, around 0.5^{0}C temperature is experienced during winter months. The air is very dry particularly in the summer months. Very high wind velocity in the afternoon and night hours results in heavy soil erosion and soil moisture losses. This area harbours typical alpine dry scrub dominated by *Caragana versicolor*, *Lonicera spinosa*, *Rheum* spp., and *Kraschenninikovia ceratoides*. In riverine / moist areas gregarious patches of *Hippophae tibetana* can be seen, especially around Losar upstream of Kaza.

v. *Alpine Mixed Communities of Pin Valley*

Pin Valley, located to the south of Spiti river adjacent to Great Himalayan range, is peculiar in many ways. The vegetation exhibits characteristics of both the Greater and Trans-Himalaya. Common shrubs in the valley are *Rosa webbiana*, *Hippophae rhamnoides* subsp. *turkistanica* ('Charma') and *Salix elegans* ('Changma'). The herbaceous vegetation turns to be profuse during the summers and is predominantly constituted of grasses and sedges. Here, the flora is remarkably rich, prominent taxa being species of *Aquilegia*, *Allium*, *Corydalis*, *Iris*, *Ranunculus*, *Potentilla*, *Pedicularis*, *Saxifraga*, *Sedum* and *Primula*. Numerous plant species thrive in the area, among them many varieties of medicinal plants. In summer, wild flowers create a riot of colours in some areas. One of the important woody species *Juniperus semiglobosa* (~ *J. macropoda auct.*) is reported to have become almost extinct in the valley due to over-exploitation.

vi. *Riverine Scrub of Lingti Valley*

It is the longest side valley in Spiti and is a living geological museum famous for shale's and fossils in a geological history dating back 250 million years. Gya (6794m), the highest peak in HP, stands above the northern head of the valley and present a stupendous monolith where the boundaries of Ladakh, Spiti and Tibet meet. *Hippophae rhamnoides* subsp. *turkistanica* ('Charma') forms the major constituent of riverine scrub in the valley. Common associates are *Myricaria elegans* ('Humbok'), *Rosa webbiana* and *Clematis orientalis.* At places dwarf *Juniper* can be seen lower down in the valley.

Some Taxa of High Conservation Significance

First comprehensive documentation of the flora for Lahaul & Spiti was by Aswal and Mehrotra (1994) who reported 79 families, 353 genera and 985 species of seed plants (Angiosperms and Gymnosperms) from the district. Many of the taxa listed in this work are rare and threatened. Others are extremely valuable for their medicinal properties, *e.g.*, *Allium carolinianum* ('Loadh'), *Artemisia brevifolia* ('Nyurcha'), *Ephedra gerardiana* ('Chhe'), *Heracleum candicans* ('Raswal'), *Meconopsis aculeata* ('Charr-Bongcha'), *Podophyllum hexandrum* ('Omo-Shey'), *Physochlaina praealta* ('Lang Tang') and *Saussurea costus* ('Koonth'). Populations of many of these plants have suffered high depletion rates in the last decade or so. Species of *Arnebia*, *Betula*, *Dactylorhiza*, *Juniperus* and *Podophyllum* are on the threatened list of plants. What is also critical is that some of the plants are endemic to the region and extinction from the region would imply a loss in global biodiversity. Over harvesting for use and trade, destructive forms of harvesting, overgrazing, are some of the causes leading to depletion and fragmentation of the species populations. Very little of the supply of plant material, which constantly falls short of the escalating demand, is from regenerative sources, and much of the harvesting is through destructive collection methods. Collectors' earnings are limited, much of the returns from the sale of the herbs going to middlemen and traders. This also makes them uncaring of the regeneration and long-term survival aspect of the plants. Some of the taxa of high conservation significance in the region are given below:

1. *Podophyllum hexandrum* Royle (Podophyllaceae)

Syn : *Podophyllum emodi* Wall. *ex* Honig.

Local Name : *Omo-Shey*, *Bankakri*

Erect perennial herb; Stem smooth, fleshy; rhizome short, horizontally creeping, scaly above. Leaves palmate, deeply 3 (5) lobed; sharp toothed, acute, sessile. Flowers white - pink, terminal in bud, supra axillary later. Sepals 3, caducous, petaloid. Petals (4-) 6, obovate-oblong. Berry oblong-ovoid to ellipsoid, scarlet or red, pulpy, many seeded.

Habitat : It is a shade loving plant growing in rich humus; 2000 – 4500 m. Miyar Valley.

***Fl. & Fr.* :** April - May.

***Distribution* :** Throughout Himalayas, Pakistan, India, Afghanistan and China.

***Uses* :** The plant is poisonous but when processed have medicinal properties. Powdered roots in chronic constipation. Ripe fruit edible and also used in tuberculosis and cough.

***Threat Status* :** Listed as Critically Endangered in Appendix II of CITES. Endangered in Uttaranchal, Himachal Pradesh and Jammu & Kashmir as per CAMP Workshop, Shimla.

2. *Capparis himalayensis* Jafri (Capparidaceae)

Syn: *Capparis spinosa* L. var. *himalayensis* (Jafri) Jacobs (Plate 3B)

Local Name: *Rohtokpa – Martopka*

Perennial straggling shrub; branches white pubescent, becoming glabrescent. Stipular spines pale yellow, apex recurved. Leaf blade ovate/ suborbicular, as long as wide, fleshy when fresh, later leathery. Flowers in upper axils, solitary. Petals dimorphic, anterior 2 white; posterior 2 yellowish green. Fruit dark green, ellipsoid, with vertical ridges, dehiscent; mesocarp red. Seeds numerous, red brown, reniform, smooth.

Habitat : Plains, desert flats, open drier areas; More common in Spiti valley (Tabo, Hurling, Kaza, Pin valley).

Fl. & Fr. : June - September.

Distribution : NW India, Nepal, NE Pakistan, Tajikistan; SW Asia, Iran Afghanistan, Kazakhstan and China.

Uses : Ripe fruits edible and pickled. Medicinally used for urinary and liver problems.

Threat Status : Data Deficient (DD). Fruit collection has limited its regeneration as most of the fruits are collected for domestic uses. Medicinal.

3. *Colutea nepalensis* Sims (Fabaceae)
Syn : *Colutea arborescens* var. *nepalensis* (Sims) Baker

Shrublet up to 3m tall; Stems pilose, red brown, shining. Leaves stipulate leaflets 7-13, elliptic to ovate, pubescent. Inflorescence 3-5 flowered raceme; flowers yellow. Fruit oblong, distinctively inflated with curved fruit stalk, beaked and pubescent; seed smooth, flat, black to dark brown.
Habitat : Found on scree slopes on the mountains, roadside /riverside gravel; 2600-3300 m; Hurling.
Fl. & Fr. : July - September.
Distribution: Afghanistan, Pakistan, India (J & K, HP, Uttarakhand), Tibet, Nepal.
Uses: Used for making household articles as well as agricultural implements. Fuelwood.
Threat Status: Data Deficient (DD). Having limited distribution mainly in the Spiti Valley.

4. *Crataegus songarica* K. Koch. (Rosaceae)
Syn : *Crataegus oxycantha* auct. non L.
Local Name : *Ramiya*, *Ramjagh*

Small Tree; Branchlets purplish brown to grayish brown when old. Leaf blade broadly ovate, glabrescent, base cuneate, margin remotely serrate with 2-3 pairs of deep lobes; lobes oblong, apex acute. Corymbs many flowered, white. Fruit a pome; reddish black, pulp yellow, globose to ellipsoid, glabrous; sepals persistent; seeds 2 - 3, smooth.
Habitat : Valleys, field boundaries, thickets; 2800—3600 m. Miyar, Trilokinath.
Fl. & Fr. : May - August.
Distribution : Afghanistan, Kazakhstan; SW Asia (Iran).
Uses : Fruit edible and considered cardiac tonic. Wood used for making handles, walking sticks and for engraving (Anonymous 1986).
Threat Status : Data Deficient (DD). Populations have dwindled considerably and only individual trees are found sporadically in the vicinity of Udaipur in Lahaul.

5. *Rosa webbiana* Wallich *ex* Royle (Rosaceae)
Local Name : *Shaybala*, *Chuaa*, *Sia*

Spinescent Shrub; Branchlets purple-brown; prickles present, yellow, terete, straight. Leaves 3–4 cm; stipules adnate; leaflets 5–9, suborbicular, glabrous, margin serrate at upper part, entire near base, apex rounded. Flowers solitary, red or rose, rarely 2-3, fasciculate. Fruit a nodding hip, bright-red, subglobose or ovoid, glabrous, with persistent, spreading sepals.
Habitat : Forests, scrub, meadows, valleys, slopes, fields; 2200 - 4200 m. Common across the region.
Fl. & Fr. : June - September.
Distribution : Afghanistan, NW India, Kashmir, Mongolia, W Nepal.
Uses : Peeled young stems and ripe fruits edible. Finds use in religious customs to ward away evil spirits. Thorny stems used as bio fence. Dried stems used as firewood. Flowers offered in gompas and used as stomachic in Lahaul (Koelz 1979).
Threat Status : Data Deficient (DD).

6. *Onosma hispida* Wall. *ex* G. Don (Boraginaceae)
Syn : *Onosma hispida* var. *kashmiricum* (I.M. Johnston) I. M. Johnston
Local Name : *Khomig*, *Ratanjot*

Perennial Herb; Stems many, hollow, and densely hairy. Basal leaves linear to oblanceolate, middle cauline leaves often larger uppermost smaller. Inflorescence a terminal cyme. Bracts lanceolate, leaf-like, but smaller. Calyx densely

hairy; lobes lanceolate. Corolla creamish-white to light yellow, tubular-campanulate, puberulous outside, deflexed. Nutlets shiny.

Habitat : Usually occurs near glacial moraines and drier slopes; 3200 – 4200 m. It is mainly distributed in western areas of Lahaul bordering Pangi area of Chamba and is occasionally met in drier parts of Kinnaur.

Fl. & Fr. : May - September.

Distribution : Kashmir, parts of Himachal Pradesh, Pakistan, Afghanistan, Iran, westward to Syria, Turkey and Europe.

Uses : Medicinally, the plant has cooling, laxative, anthelmintic, and alexipharmic effects and is also used in treating diseases of the eye, disorders of the blood, bronchitis, and abdominal pain (George 1972). The plant is also used as a dye (Supiriya 1994) and root mixed with mustard oil as a hair tonic (Rawat & Pangtey 1987).

Threat Status : Data Deficient (DD). Limited and specific distribution.

7. *Rheum australe* D. Don (Polygonaceae)

Syn : *Rheum emodi* Wallich *ex* Meisner

Local Name : *Archo*, *Tuksu*, *Goggul*

Stout Perennial Herb; Stem sulcate, glabrous, pubescent at nodes. Petiole of basal leaf equal to blade or slightly longer, pubescent; leaf blade broadly ovate, basal veins 5-7, base cordate, margin entire, apex obtuse. Stem leaves ovate, narrow; ocrea large. Panicle large, branched; perianth purple-red. Fruit ovoid-ellipsoid, base subcordate; wings purple-red. Seeds ovoid.

Habitat : Grassy slopes; 3000-4300 m. Miyar, Jispa, Lingti valley.

Fl. & Fr. : August - October.

Distribution : China, India, Myanmar, Nepal, Pakistan, Sikkim.

Uses : Stems and petioles chewed to avoid high altitude uneasiness and also to quench thirst. Root as dye for woolen products (Sood *et al.* 2001)

Threat Status : Endangered in Uttaranchal, Himachal Pradesh and Jammu & Kashmir as per CAMP Workshop, Shimla.

8. *Ephedra intermedia* Schrenk *ex* C. A. Meyer (Ephedraceae)

Syn : *Ephedra intermedia* var. *tibetica* Stapf.

Local Name : *Chhee*, *Somlata*, *Tse*

Dwarf Shrublet; Stems dense branched, erect to spreading. Branches yellowish or bluish green, pruinose. Leaves in whorls of 3. Male cones up to 8, whorled, usually clustered at nodes, often sessile; bracts in 3-4 pairs/ whorls. Seed cones ellipsoid to oblong-ovoid, globose, red, fleshy. Berry ovoid, red. Seeds 2-3, ovoid/elongate-ovoid, concealed by bracts.

Habitat : Found in grasslands, deserts, river valleys, floodplains, sandy beaches, cliffs, and other dry, sandy or rocky places; 2800-4600 m; Hul, Gue.

Fl. & Fr. : May - September.

Distribution : Afghanistan; Kazakstan; Kyrgyzstan; Mongolia; Pakistan; NW India; Russia; Tajikistan; Turkmenistan; Uzbekistan; SW Asia and China.

Uses : Fresh twigs as toothbrush and burnt twigs ash as snuff (Koelz 1979). Medicinally to cure liver disorders and for cardiac ailments. Uprooted to burn as fuelwood.

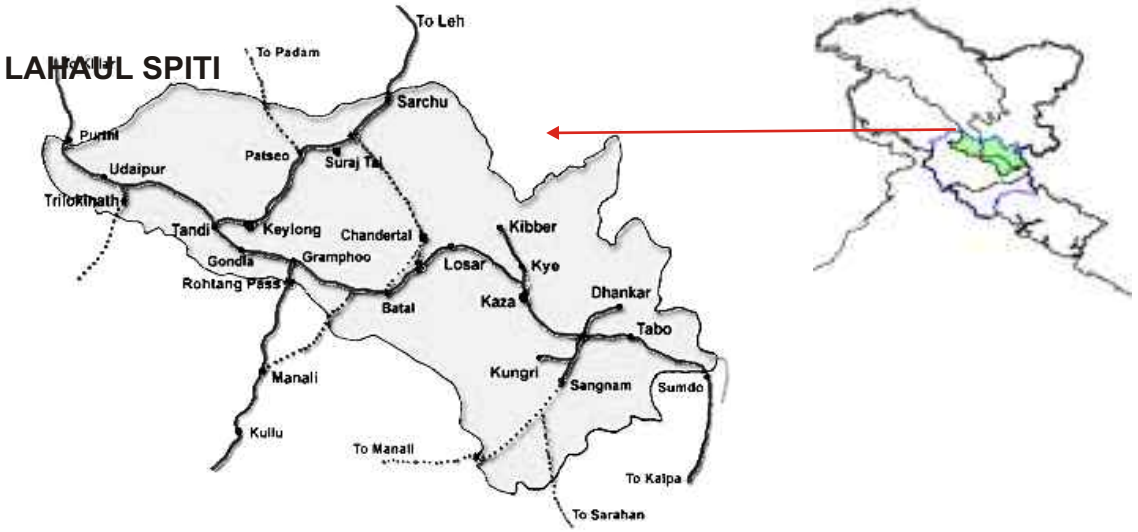
Threat Status : Data Deficient (DD). Not very common having limited distribution.

9. *Betula utilis* D. Don (Betulaceae)

Syn : *Juniperus macropoda* auct. Boiss.

Local Name : *Shiag*, *Bhojpatra*

Plate 3A
Lahaul-Spiti: Important Localities and Habitats



Alpine pastures of Gete (Kibber)

Asiatic Ibex in its habitat

Miyar Valley (Lahaul)

Plate 3B
Threatened Plants of Lahaul-Spiti

Capparis himalayensis

Ephedra intermedia

Colutea nepalensis

Crataegus songarica

Dactylorhiza hatagirea

Rheum australe

Onosma hispidum

Medium sized to small deciduous trees; Bark whitish, papery, peeling off in layers. Leaves ovate, base rounded, margins irregularly serrated, woolly haired below when young. Male flowers in reddish catkins; female spikes solitary. Fruiting bracts 3 lobed; Nutlets winged.

Habitat : Drier mountainous regions in shaded moist pockets; near the river basin of Mudgram area; 2800 4300 m. Ghandal, Pomerang, Mudgram, Khanzar.

Fl. & Fr. : July – October.

Distribution : Pakistan, NW Himalaya, Nepal, SW China.

Uses : Bark used as aromatic and for wrapping food, lighting fire and in religious functions. Twigs as brooms and in roof thatching of houses. Medicinally used as antiseptic, carminative and as contraceptive. Also used in hysteria and jaundice.

Threat Status **:** Critically Endangered (CR) in J&K; Endangered (EN) in Himachal Pradesh and Near Threatened (NT) in Uttaranchal as per CAMP Workshop, Shimla.

10. *Juniperus semiglobosa* Regel. (Cupressaceae)

Syn : *Juniperus macropoda* auct. Boiss.

Local Name : *Shukpa*, *Shur*

Monoecious medium sized trees; Stem gnarled. Leaves on upper branches scale like, opposite, decussate, broadly ovate, closely appressed, on the lower branches subulate, pungent. Male cones terminal on branchlets, scales imbricate. Berries subglobose, blue black when ripe. Seeds 3 5, brownish yellow, testa thick.

Habitat : Forming forests in Lahaul (Stingri) and sporadic in the inner drier valleys of the Lahaul and Spiti; 2000 4200 m. Stingri, Poh, Pattan Valley, Miyar Valley.

Fl. & Fr. : May – October.

Distribution: S.W. Europe, Caucasus, Iran, Arabia, Afghanistan, Baluchistan, NW Himalaya, Nepal.

Uses : Used as Incense and to cleanse the house. It finds use in all religious and cultural ceremonies as it is sacred to the community.

Threat Status : Endangered in Uttarakhand, Himachal Pradesh and Jammu & Kashmir as per CAMP Workshop, Shimla (Polunin & Stainton 1984, Aswal & Mehrotra 1994, Kapoor & Jishtu 2008).

The *taxon*, according to IUCN red list categories is Data Deficient (DD), *i.e.* when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution (IUCN 1993). Therefore these plant taxa may be well studied, and its biology may be well known, with appropriate data on abundance and distribution. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that a threatened classification is appropriate. Basic knowledge of these threatened habitats and their floristic composition is of fundamental importance to biodiversity conservation (Arkadiusz & Sylwia 2006). It will be especially helpful in active management of rare plant communities, estimation of restoration possibilities and to assess their effective conservation. Floristic surveys are indispensable in analysing the environmental conditions of threatened habitats and the flora thriving there.

Major Threats and Conservation Strategies

i. *NTFP Collection* **:** Traditionally, people of the region are engaged in little mountain farming and animal husbandry. Collecting medicinal plants from various mountain ecosystems is an important part of their traditional medicine system, but only trained medicine men or *Amchis* do this. However, some people are engaged in collection of medicinal plants for augmenting their income. Large-scale collection of the fodder and fuelwood from this ecoregion by the local people for storage and use during the prolonged cold winters is a substantial threat, especially because the floral

species in the region are very slow to regenerate. Some plants like *Myricaria elegans*, *Colutea nepalensis*, *Rosa webbiana* and species of *Caragana* are destructively harvested for fuel wood and other domestic uses by the local inhabitants. There is no exact figure to show how many and how much of the plants are collected from different habitats in the region. In recent years, due to increased domestic market demand, over harvesting of wild plants is a common problem world-over resulting in the threat to some of these species.

ii. *Habitat Alteration* : Land use change is seen as the main factor to cause the habitat loss for native flora in the region. The loss of habitat is being seen as one of the major causes of threats to biodiversity, and there are numerous threatened species of plants distributed in the region, *e.g. Betula utilis*, *Juniperus* spp., *Arnebia euchroma*, *Allium* spp., *Saussurea* spp., *etc.* Like in other parts of the state the people in the cold deserts too are directly engaged in animal husbandry, agriculture and horticulture. The cattle and sheep population is almost three times the humans, coupled with hordes of additional sheep and goats of the nomadic graziers coming to the alpine regions each summer. Moreover, the wild populations of wild sheep and goats have increased over the years due to complete ban on hunting. Protected areas that overlap the region are Pin Valley National Park, Rupi Bhabha Wildlife Sanctuary and Kibber Wildlife Sanctuary. Therefore, there seems to be a great pressure on the alpine pastures of the cold deserts. Indiscriminate use of the grazing areas has therefore resulted in critically low biomass availability along with the emergence of weeds that have threatened the native species. Pastures Meadow steppe and scrub ecosystems are the special habitats for some rare medicinal flora in the region. Due to overgrazing, vegetation degradation occurs in many areas of this region.

Distinct plant assemblages can be identified in the moist alpine vegetation that is strongly aggregated by altitudinal variations suggesting the presence of distinct zones of the alpine flora. Elevation and specific locations are the dominant environmental gradients underlying the species composition in these specific habitats. Hence, the alpine pasture habitat in the cold deserts is not only a group of grasses but is an ecosystem in itself. Here, the survival of this habitat is directly related to the survival of native flora, fauna and the inhabitants of the region. All the three components therefore, interact with each other and maintain the dynamic equilibrium within an ecosystem. Some of the strategies for long term conservation of threatened taxa in the region include enhanced monitoring of the effects of exploitation for species, particularly for the species under trade.

Conservation in such areas can not be achieved without the involvement of local communities, who are directly dependent on these resources for their livelihood. Their involvement in management would certainly help in conservation. These communities could be encouraged to set aside some habitats for *in situ* conservation of high value medicinal plants. Efforts are needed to establish cold desert conservatorium / medicinal plant gardens, MPCA's in the region. There is a need to focus on the development of packages for cultivation of economically important medicinal plants with modern techniques including tissue culture and genetic engineering.

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Glechoma nivalis (Benth.) Press: An Interesting Plant of Alpine Scree Slopes from Spiti

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While posted as Director, Pin Valley National Park, located in Spiti Sub-Division of Himachal Pradesh (HP) during 1994, I frequently visited parts of Kibber WS. During one of such visits to Kibber, I came across an interesting, strongly aromatic plant on dry steep scree slopes near Komik village (4300m), which was identified by Dr. G.S. Rawat of WII Dehradun as *Glechoma nivalis* (Benth.) Press (Lamiaceae). This species had only a few individuals and it was restricted to loose scree slopes. Aswal & Mehrotra (1994) in the 'Flora of Lahaul – Spiti' have stated that there are no specimens of *G. nivalis* from HP in the Indian Herbaria. Hence this note is being sent herewith along with a photograph (from Kibber WS) to authenticate the presence of *G. nivalis* in Spiti.

G. S. Rawat

Section II:
North-West and Western Himalaya

4.0 Special Habitats and Threatened Plants of Kashmir Himalaya

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Introduction

Kashmir, commonly called the Kashmir Valley, the 'paradise on earth', is situated in the Northwest Himalayan biogeographic zone in India between $33^0.20'$ -$34^0.54'$ N latitudes and $73^0.55'$ -$75^0.35'$ E longitudes, covering an area of 15,948 km^2. Topographically, it is a deep elliptical bowl-shaped valley bounded by lofty mountains of the Pir Panjal in the south and southwest and by the Great Himalayan range in the north and east, with 64% of the total area being mountainous. The Valley is asymmetrical, with 187 km diagonal length (from southeast to northwest corner), and considerably varying breadth, being 115.6 km along the latitude of Srinagar (Kaul 1977). The altitude of the Valley basin at Srinagar is 1,600 m and rises to 5, 420 m at Kolahoi or "Gwashibror', the highest peak among its surrounding mountains. Traversing the Valley is the river Jhelum and its tributaries, which feed many lakes for which Kashmir is famous. The Valley is divided into six administrative districts: Srinagar, Budgam, Pulwama, Anantnag, Baramulla and Kupwara.

Owing to great heterogeneity in its topography, altitude and climate, Kashmir harbours diverse habitats which support a rich floristic wealth that has been used as a resource-base by its people since times immemorial. No wonder, the region has been called a "biomass State" (Khoshoo 1997). Indeed Kashmir has ever been known for its economically-valued plants and their products, such as food, fodder, fibre, medicinal and aromatic plants, spices, perfumes, ornamentals, timber, small wood, and variety of other non-wood timber produce.

The written records of floristic studies in Kashmir date back to 1822 when William Moorcroft first collected plants from this Valley, followed by other western explorers, namely Victor Jacquemont, Royle, von Huegel and Vigne. Royle, for the first time published illustrations and taxonomic diagnoses of many plants from Kashmir. J. D. Hooker, in his *Flora of British India* (1872-1897), cited plant material from this area with a large number of taxa. This was followed by important contributions to the flora of Kashmir by three botanists: Coventry (1923-1930), Blatter (1928-1929), and Stewart (1972).

The floristic studies in this region received a great boost with the establishment of the Jammu & Kashmir University at Srinagar in 1961. The same year, a Botanical Garden was laid down adjacent to the Department of Botany. Many a local students and teachers started research on various floristic aspects, including monographs, and with the plant material collected during the course of these studies was established a herbarium, the KASH, in 1972. The establishment of the Centre of Plant Taxonomy (COPT) in 1981, as an adjunct of the Department of Botany, was yet another milestone in the onward progress of floristic research in this area. This Centre has paved the way for publication of numerous research papers and some important books on the Kashmir Himalayan flora (*e.g.*, Singh & Kachroo 1976, Dhar & Kachroo 1983, Munshi & Javeid 1986, Sharma & Jamwal 1988, 1998, Singh & Kachroo 1994, Navchoo & Kachroo 1995, Dar *et al.*, 2002, and Nasreen *et al.* 2003).

The ancient flora of Kashmir is said to have been tropical, having changed to subtropical and temperate types during glacial phase of the Pleistocene era (Puri 1943, 1947; Vishnu-Mittre 1963). Thereafter, plants from various floristic

regions have entered the Valley through normal dispersal and anthropogenic interventions, rendering its present flora as Holarctic, and mostly a confluence of various floristic elements from many adjacent regions. A vivid vegetation pattern is seen along the gradient of altitudinal climatic belts. Beginning from somewhat subtropical formations, one finds in the temperate Valley domesticated plant systems and wetland and aquatic formations, followed higher up in the mountains by forests, sub-alpine and alpine meadowlands, alpine scrubs, *etc.*

The wild-growing gymnosperms comprise not more than a dozen conifers, yet they dominate the forests. Dar & Naqshi (2002) and Dar *et al.* (2002) have reported 2,000 species of flowering plants from the Kashmir region; these are distributed over 710 genera in 132 families. Asteraceae, Poaceae, Brassicaceae, Rosaceae, and Lamiaceae are the first five larger families with regard to number of species; while *Carex*, *Polygonum* (sensu lato), *Potentilla*, *Artemisia* and *Nepeta* are the larger genera. Presence of a large number of grasses and sedges is significant. In all, about 20% angiosperm species occur as weeds [Kaul (1986) recorded 401 species as weeds in 251 genera and 56 families]; 15% species comprise indigenous and exotic trees and shrubs [Ara *et al.* (1995) listed 295 arboreal species in 120 genera and 60 families]; the aquatic and wetland flora is also rich [Kak (1990) listed 196 species in 82 genera and 44 families]; some 8% species are exclusively endemic to Kashmir (Dar *et al.* 2008), which is significant considering the fact that this region forms only 0.48 % land mass of India.

Special Habitats

For the purpose of habitat study, Kashmir may be divided into two broad ecological zones: the main valley zone, and the surrounding montane zone. Mostly under human habitation and cultivation, the main valley is beset with varied habitats; besides it possesses the following special habitats with interesting attendant vegetation types.

1. Swamps and marshes

Kashmir Valley is very rich in freshwater swamps and marshes. The swamps are water logged areas with water level above the soil surface. These support reed-swamp vegetation dominated by reeds (*Phragmites australis*), rushes (*Juncus* spp.), and sedges (*Scirpus* spp.); other tall plants, such as *Butomus umbellatus* and species of *Typha*, *Equisetum*, and *Alisma*, also occur occasionally. The marshes are like swamps but with the water level not rising above the surface. These support a luxuriant helophytic vegetation comprising rushes and sedges (species of *Scirpus*, *Carex*, *Cyperus* and *Fimbristylis*), with occasional hygrophilous associates such as *Lythrum salicaria*, *Galium palustre*, *Bidens tripartita*, *Prunella vulgaris*, *Triglochin palustre*, *Ranunculus sceleratus*, *Spiranthes sinensis* and *Persicaria hydropiper*.

2. Floating gardens

Kashmir Valley abounds in lakes, which are home to a varied hydrophytic vegetation, both benthon and pleuston. Within and along the lakes occur stabilized islands that have been formed ingeniously by local boat men -'Hanjis' using willow trees (*Salix* spp.) as tent poles along margins and being used for growing a rich variety of local vegetables. Some common weeds associated with these island farms are *Bidens cernua*, *Persicaria hydropiper*, *Mentha arvensis*, *Rorippa sylvestris*, *Sium latijigum*, *Lythrum salicaria*, *Galium palustre*, *Myosotis palustris*, *Veronica anagallis-aquatica*, *Plantago major* and *Cyperus difformis*.

3. Graveyard sites

Every village/habitation site in Kashmir has a graveyard, which is rich in nutrients. The graveyards are frequently planted with a few trees of *Celtis australis* and *Morus alba* and harbor a distinct vegetation. It is customary to grow some bulbous geophytes, such as species of *Sternbergia*, *Narcissus* and *Iris* on and around fresh graves. After some time these get

naturalized and grow profusely on such sites. *Sternbergia fischeriana* and *Narcissus tazetta* are the first to bloom in February-March, while species of *Iris*, such as *I. germanica*, *I. kashmiriana* and *I. ensata* bloom in April-May, rendering a colorful look to these sites.

4. Mud wall and masonry wall sites

The mud walls are raised to cover the kitchen gardens, orchards and lawns. They form a characteristic habitat for vegetation which shows more or less a seasonal rhythm. During spring, under moderate temperature and high moisture content of the substratum, a luxuriant growth of plants, such as *Veronica persica*, *V. biloba*, *Poa annua*, *Cardamine hirsuta* and *Stellaria media* is seen. The summer, exhibiting an increase in temperature with a corresponding decrease in moisture content of the substratum, shows a decline in the number of plant species and the main taxa colonizing mud walls during this season include *Anthemis cotula*, *Galinsoga parviflora*, *Sisymbrium loesellii*, and *Eragrostis minor*. During autumn the substratum becomes almost dry and only some hardy species, such as *Artemisia tournefortiana*, *Ipomoea eriocarpa* and *Urtica dioica* are able to bloom. Dar & Kachroo (1983) recorded 68 species of flowering plants, belonging to 27 families, growing on the mud walls of Ganderbal in Srinagar, all of which are herbaceous with 75% being annual, revealing predominance of therophytic life forms on these walls.

Masonry walls are frequently raised as bounds along water courses. They support species such as *Oxalis corniculta*, *Arenaria serpyllifolia*, *Stellaria media*, *Campanula pallida*, *Plantago lanceolata*, *Capsella bursa-pastoris*, *Veronica persica* and *Epilobium* spp., together with many composites (*Taraxacum* spp., *Gnaphalium affine* and *Lactuca dissecta*) and grasses (*Poa annua*, *P. bulbosa* and *Calamagrostis pseudophragmites*).

5. Rocky gorges

These are narrow passages of rocks, rocky slopes and rocky banks through which flow the nallahs and streams in the montane terrain. The vegetation along these sites is mainly lithophytic, including characteristic scrubs of *Isodon rugosus*, *Viburnum foetens* and *Clemaris* spp., together with herbaceous elements such as *Arisaema jacquemontii*, *Campanula cashmeriana*, *Cirsium falconeri*, *Gentiana cachemirica*, *Leonurus cardiaca*, *Minuartia kashmirica*, *Oxyria digyna*, *Rumex hastatus*, *Dictamnus albus*, *Stachys sericea*, and species of *Corydalis*, *Epilobium*, *Nepeta*, *Sedum*, *Thalictrum*, and *Swertia*.

6. Moist alpine meadows

Kashmir is known for its beautiful alpine valleys, locally known as 'margs / bahaks'. These are used as summer pastures by graziers and harbor open grassland communities, comprising colorful species of *Aconitum*, *Aquilegia*, *Delphinium*, *Callianthemum*, *Aster*, *Inula*, *Salvia*, *Phlomis*, *Campanula*, *Geranium*, *Barbarea*, *Potentilla*, *Geum*, *Chaerophyllum*, *Selinum* and *Fritillaria*.

Certain stretches within alpine meadows have mostly a frozen and poorly-drained soil surface, resulting in damper or marshy depression-like situations. This moor-like habitat is covered by mossy mats and its vegetation is dominated by hygrophytic sedges such as *Juncus sphaceluros*, *Luzula spicata*, *Kobresia nitens*, *Carex* spp., and grasses such as *Poa alpina*, *P. versicolor*, *Phleum alpinum*, *Alopecurus himalaicus*, *etc.* A few ground-hugging herb-like shrubs (*Salix flabellaris* and *Gaultheria trichophylla*) with the hygrophilous herbaceous species of *Pedicularis*, *Primula*, *Anemone*, *Aconitum*, *Ranunculus*, *Epilobium*, *Gentiana*, *Jaeschkea*, *Lomatogonium*, and *Swertia* are also common here.

7. Alpine rocky and scree slopes

These comprise bare rock and scree with interstitial gravel above the alpine scrubs. This special habitat shows a rich growth of epilythic lichens and numerous xerophilous plants. Dwarf patches of *Ephedra gerardiana* and *Cassiope*

fastigiata manage to grow on these slopes, together with a number of hardy rosette and other lithophytes, such as *Corydalis crassissima*, *Papaver nudicaule*, *Paraquilegia anemonoides*, *Anemone rupicola*, *Potentilla curviseta*, *Arnebia benthamii*, *Minuartia foliosa*, *Sedum crassipes*, *Bistorta vivipara*, *Dolomiaea baltalensis*, *Jurinea ceratocarpa*, *Lactuca laevigata*, *Waldheimia tomentosa*, *Arabis* spp., *Chorispora sabulosa*, *Draba* spp., *Ermania kashmiriana*, *Saussurea gossypiphora* and *S. sacra*.

8. Glacial moraines

Glaciers usually occur in gulleys, criques and coles along high alpine mountains in Kashmir, though at some places they descend to elevations of 3,300m. They comprise huge masses of ice and provide inimical conditions for vascular-plant growth. However, the fringes of glaciers melt during summer, providing melt water to the substratum throughout the growing season. This moist habitat along melting glaciers supports distinctive vegetation represented by species such as *Adonis chrysocyathus*, *Trollius acaulis*, *Oxygraphis polypetala*, *Aquilegia nivalis*, *Anemome polyanthes*, *Ranunculus munroanus*, *Thlaspi cochlearioides*, *Bergenia stracheyi*, *Saxifraga sibirica*, *Pedicularis* spp., *Swertia petiolata*, *Aster diplostephioides*, *Lloydia serotina*, *Milium effusum*, and *Juncus leucomelas*. Occasionally, species of *Rhododendron* are also seen growing along glaciers.

Threatened Plants

A century ago, Kashmir would have been a naturalist's paradise. Dense forests in Kashmir descended up to the interior of present-day city and towns, the wood was easily and abundantly available from these forests and formed the main item of the timber and fuel, and that the preponderant medicinal plants were the main source of the local Hakim (Unani) system of medicine. Over the decades, however, a large number of species have been rendered threatened due to various anthropogenic causes, such as habitat loss or modification (particularly deforestation and expanding urbanization), over-exploitation of economically important plants, alien species invasion, unchecked grazing, unplanned development, and great tourist influx. Dar & Naqshi (2002) have reported 356 plant taxa (346 species + 3 subspecies + 7 varieties) as threatened in Kashmir and Ladakh phytogeographical region. Some critically endangered plants of Kashmir (Plate 4) are given as follows:

1. *Aquilegia nivalis* Falc. *ex* Jackson (Ranunculaceae)
English Name : Columbine

A small perennial herb with few ternate leaves divided into kidney-shaped 3-lobed leaflets, and deep purple flowers. Growing on moist, shady or open alpine slopes, screes or rocks, in slightly hard, pebbled soil, between 3000-4000 m.
Threats : Shrunk populations, fragile habitats, grazing pressures.

2. *Aconitum kashmiricum* Stapf. *ex* Coventry (Ranunculaceae)
Local Name : *Pevak*

A smaller plant than *A. heterophyllum*, with coarsely-toothed entire leaves, and smaller dark-purplish flowers. Growing in loose soils, less-pebbled, moist and open alpine slopes, between 3000-4000 m.
Threats : Harsh and fragile habitats, squeezed populations and restricted distribution, extensive herbivory of flowering portions, exploitation of tubers for medicinal purposes.

3. *Artemisia amygdalina* Decne. (Asteraceae)
Local Name : *Veri tethvan*.

A robust perennial herb, with simple leaves resembling those of a willow, and yellowish-green flowers. Growing in moderately moist, relatively hard, open or partially shaded sub-alpine situations, between 2600-3200 m.

Threats : Shrunk populations and restricted distribution, extensive herbivory of flowering tops.

4. *Gentiana cachemirica* Decne. (Gentianaceae)
English Name : Rock Gentian

A tufted perennial herb with many leafy stems, each with few or solitary pale-blue funnel-shaped terminal flowers. Growing always on rocks, in their crevices and ledges, between 3200-4000 m.
Threats: Extremely harsh and fragile alpine habitats, with highly specific and very narrow ecological niche.

5. *Lagotis cashmeriana* (Royle) Rupr. (Scrophulariaceae)
English Name : Hare's ear.

A small plant with oblong to elliptic rounded-toothed leaves, and dense cylindrical spikes of dark blue tubular flowers. Growing in wet places (usually glacier-fed) in open or shady, loose-soiled and less-pebbled patches in typical alpine situations, between 3000-3800 m.
Threats : Narrow and fragile habitats, patchy distribution, extensive herbivory (especially of flowering spikes), very small number of flowering individuals, and very low seed set. A very important medicinal plant. The paste of leaves is applied for wound-healing in cattle; rhizome is used as adulterant in place of *Picrorhiza kurrooa.*

6. *Hedysarum cachemirianum* Benth. *ex* Baker (Fabaceae)
English Name : Kashmir Hedysarum

A nearly hairless erect perennial herb, with pinnate leaves having numerous leaflets, and dense clusters of numerous large drooping red-purple flowers. Growing on moderately moist, rocky alpine slopes, between 3200-4000 m.
Threats: Small populations, very restricted distribution in a few alpine areas, very low number of flowering individuals, and scanty seed production.

7. *Meconopsis latifolia* Prain (Papaveraceae)
English Name : Blue Poppy

A perennial erect bristly-spiny herb, with long-stalked basal leaves, sessile upper leaves, and large beautiful blue flowers. Growing in dry rock crevices with thin soil, under rocks or among big boulders in sandy soils, between 2800-4200 m.
Threats: Extremely fragile habitats, very narrow ecological niche, highly shrunk populations, fragile nature of root-stock affecting vegetative propagation, very small number of flowering individuals, grazing pressures. Roots are dried, powdered and taken with water as stomachic.

8. *Megacarpaea polyandra* Benth. (Brassicaceae)
Local Name : *Chatter*

A robust perennial herb with a stout stem, large deeply pinnately-lobed basal leaves, and a large terminal dense cluster of small flowers. Growing on moderately moist, less pebbled open alpine slopes between 3200-4200 m.
Threats: Extremely shrunk and restricted populations, small number of reproductive individuals, harsh alpine habitats, and over-exploitation. The fleshy roots are relished as pot herb or eaten raw; young leaves are locally cooked as vegetable.

9. *Saussurea costus* (Falc.) Lipsch. (Asteraceae)
Local Name: *Kuth*

A tall robust perennial herb, with triangular long-stalked basal leaves and large clasping upper leaves.

Plate 4
Kashmir Himalaya: Landscape and Threatened Species

Y.V. Bhatnagar

A. Landscape of Gurej Valley; 1. *Saussurea costus*; 2. *Artemisia amygdalina;* 3. *Aconitum kashmiricum;* 4. *Lagotis cashmeriana;* 5. *Aquilegia nivalis;* 6. *Meconopsis latifolia*

Growing on moist, shady slopes among juniper shrubs or in open places, between 2800-3800 m.
Threats : Reduced, restricted populations, less sexual reproductive effort, over-exploitation for medicinal purposes, illicit trade. Rhizome is used as spasmodic in asthma, cough and cholera, in skin disease and rheumatism, also as insect repellent.

10. *Ulmus wallichiana* Planchon (Ulmaceae)
English Name : Himalayan Elm

A large tree with rough grey bark and elliptic to obovate, long-pointed, double-toothed leaves. Growing in broad-leaved deciduous forests and moist ravines, between 1700- 2600 m.
Threats: Over-exploitation for its wood and lopping pressure. Bark contains a strong fibre used locally for rope and sandals.

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5.0 Threatened Plants of Jammu Region, North-West Himalaya and Strategies for Their Conservation

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Introduction

Jammu region in the North-West Himalaya is characterized by a rapid transition from sub-tropical to alpine eco-climatic conditions as one moves from south (Kathua) to north (Kishtwar). The region harbours a rich array of flora and fauna manifested by diverse habitat conditions. However, the region is subjected to enormous anthropogenic pressures such as over exploitation of timber as well as non-timber forest products especially wild medicinal plants, livestock grazing, ill planned developmental activities and deforestation. As a result, natural forests and grasslands have degraded and top soil has eroded from most of the mountain slopes. The soil erosion is particularly severe in the Shiwaliks.

The floristics and distribution of rare and threatened plants of Jammu region has been worked out by several authors *e.g.*, Sharma & Kachroo (1981), Singh & Kachroo (1983, 1994), Swami & Gupta (1998), Singh *et al.* (2002), Choudhary & Rao (2002), Kapoor *et al*. (1964) to name a few. The forest types recorded in the state range from thorn scrub to temperate and alpine types (Champion & Seth 1968). However, there have been marked and perceptible changes in flora as well as vegetation of the region since the publication of above works. Distribution and abundance of many species has drastically reduced. For example, shady moist ravines and semi-evergreen forests along the foot-hills are extremely rare now. In such habitats species such as *Myrica esculenta* (Myricaceae), *Bischofia javanica*, vern Chiuntar, Cheentar or Paniala (Euphorbiaceae), and *Cinnamomum tamala* (Lauraceae) used to grow profusely 2 – 3 decades ago but these trees have become extremely rare. Presently, *Myrica esculenta* can be seen growing only at two localities, one in Kardoh Nala (Basohli-Bani) and second in Saamna banj (Ram Nagar Forest Division). *Buxus wallichiana* (Buxaceae), an evergreen tree of temperate forests seen growing at Pancheri-Laander (Udhampur Forest Division), Saamna banj (Ram Nagar Forest Division), Budhal and Thannamandi (Rajouri Forest Division). It prefers well drained soil having pH range from 5.5 to 7.4. Its crocodilian fissured bark looks elegant. Fruit set is low and as a result regeneration is poor. It is called Chikhri in Dogri and Pahari languages and is in great demand by the handicraft artisans who use it for making variety of articles like snuff boxes, combs, forks, spoons, toys & decoration pieces. The wood sustains a whole cottage industry in Rajouri – Poonch area of Jammu. On account of its overexploitation, its populations are dwindling day by day. Other taxa of high conservation significance in the region include *Holmskioldia sanguinea* (Verbenaceae), *Pittosporum eriocarpum* (Pittosporaceae), *Taxus wallichiana* (Taxaxeae), *Litsea glutinosa* (Lauraceae), *Corylus jacquemontii* (Corylaceae).

In this article, a few rare and threatened species (Plate 5) of Jammu region have been appended along with their dwindling status and strategies for long term conservation.

1. ***Eremurus himalaicus* Baker (Liliaceae) :** Wild ornamental and edible herb of dry temperate region. Recorded from Padder area of Kishtwar where it has declined drastically during last two decades. Locally known as Kaihloon, Dharshaag, Chhil haak, Bulkutor Yalun. It is overexploited for its edible leaves and roots. It also grazed by the cattle and seed formation is hampered in the natural habitat. Edible young leaves are also sold in the Kishtwar market during March-April. This herb grows under the canopy of *Pinus gerardiana* in the open blanks. Soil in its natural habitat is usually prone to avalanches during winter and early spring.

2. ***Eremostachys superba*** **Royle *ex* Benth. (Lamiaceae) :** Wild ornamental herb of sub-tropical areas *viz.* Nandni Wildlife Sanctuary, Sunderbani, Channi Paraat area of Rajouri and Pauni Bharkh area of Reasi Forest Division. The last area is under stress due to overexploitation by nomadic Gujjars who feed its tuberous roots to the milch cattle for enhancing milk yield. Digging of roots and plucking of handsome golden yellow spikes leaves this herb without adequate seed formation. As the plant is pollinated by insects, non-availability of pollinators in sufficient number is likely to be a major factor causing its depletion in the wild. Dr. Susheel Verma, Scientist, Centre for Biodiversity Studies, Baba Ghulam Shah Badshah University, Rajouri has carried out detailed study on its floral biology and *ex situ* conservation. Habitat of this magnificent herb is under anthropogenic pressure due to soil erosion, soil compaction and loss of moisture in the ground soil of forests in the Shiwaliks.

3. ***Gentiana kurroo*** **Royle (Gentianaceae) :** A very handsome gentian of temperate Chir pine and oak forests which flowers during September-October. It is declining at an alarming rate in the state. Once, abundant around Termain, Kalounta (Ram Nagar Forest Division), Pancheri, Maungri Basnot (Udhampur Forest Division), Banjal, Jouriyan Mata, Baikan, Lohai Malhar (Billawar Forest Division), this herb has sufferred due to habitat loss, dam building, over-exploitation, forest fires and illegal trade under the name Karu booti. It is also called as Ram Vaan because of its effective healing properties. It is mixed and traded with true Karu or Kaur, *Picrorrhiza kurrooa* which stands almost wiped out in the sub-alpine meadows in the Jammu region and is seen only in areas like Marwah Dachhan in Kishtwar and Seoj Dhar in Ram Nagar.

4. ***Arnebia benthamii*** **(Wall. *ex* G. Don) Johns. (Boraginaceae) :** A rare species of higher altitudes especially in dry temperate slopes *e.g.*, Marwah-Dachhan and Kishtwar mountains. It is locally dwindling due to overexploitation for its medicinal roots under the name 'Ratanjot' or 'Rattmundi'. Flowering spikes are useful for cardiac ailments. It's allied species, *A. euchroma* is reported from Trikuta hills, around Hathi Matha and Bhairoo Ghati in the Reasi Forest Division.

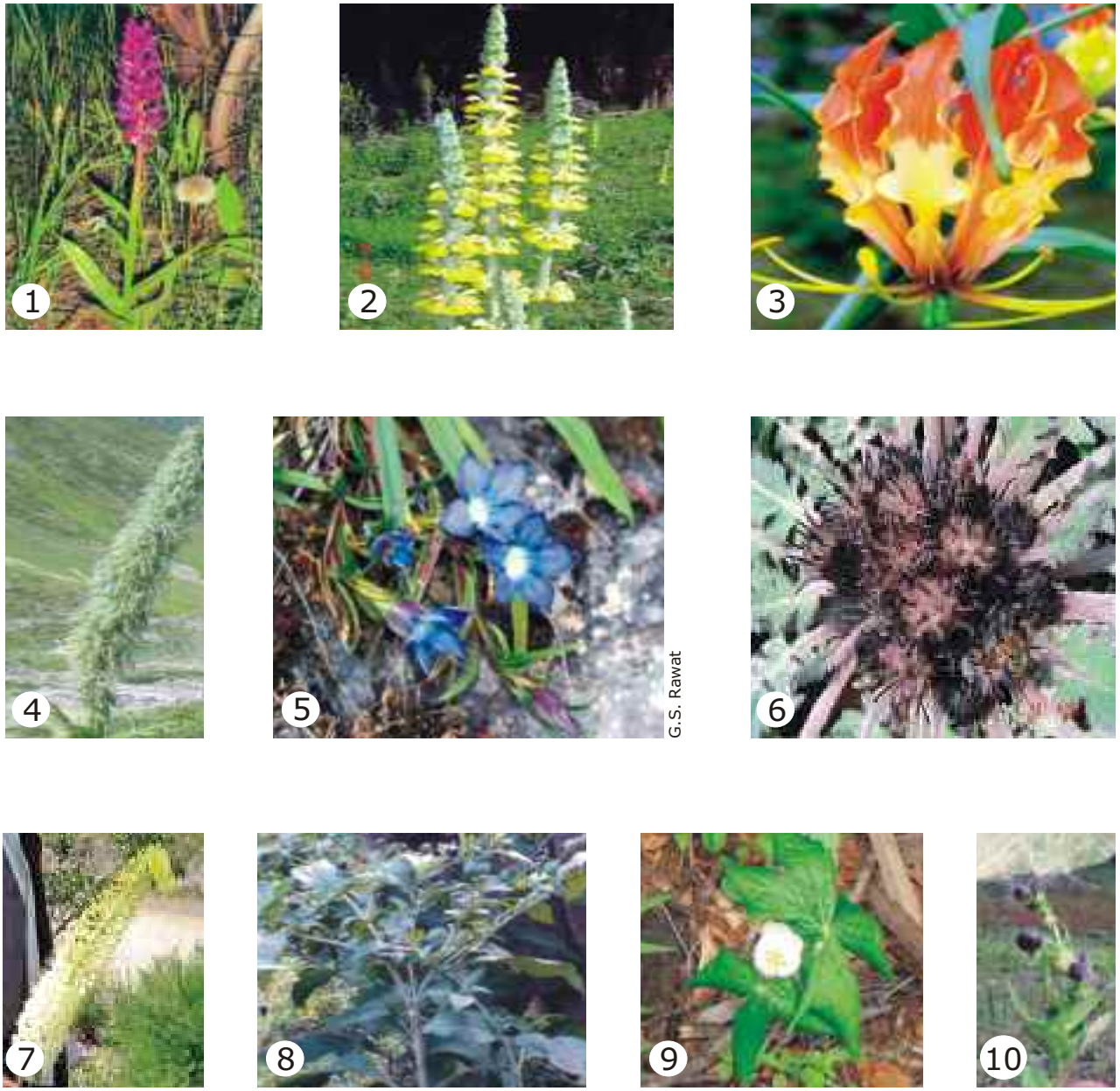
5. ***Meconopsis aculeata*** **Royle (Papaveraceae) :** Also known as 'Queen of Himalayan Flowers', this Himalayan Blue Poppy can be seen growing naturally in the Simthan pass, Margan Top, Wadwan and Marwah area of Kishtwar in the Jammu region. It usually prefers dry temperate stony habitats near mountain streams and forest edges. It is locally called Gul-Neelmi because of its sky blue flowers. Degradation of soil due to over grazing, deforestation in the fir-spruce forest areas, multiple dam building over the river Chenab and large scale deforestation in the upper mountains are the major causes of its decline. It grows sporadically and shows poor seeding. It needs to be put under cultivation in the hill stations as wild ornamental plant.

6. ***Habenaria intermedia*** **D. Don (Orchidaceae) :** A handsome orchid found in temperate forest fringes and grassy meadows. Tuberous roots are harvested for medicine. It is very sensitive to changes in habitat and restricted to a few localities like Marta (Ram Nagar), Chew (Billawar) and Moungri Basnot (Udhampur). Despite repeated search the author could not relocate its populations in the areas where it used to occur in the past.

7. ***Balanophora involucrata*** **Hook. f. (Balanaphoraceae) :** A saprophytic angiosperm, usually seen growing under bushes of *Viburnum grandiflorum* (Vern. Guchh, Teldi) and *Rhododendron campanulatum* (Vern. Sarangar) in the temperate forests of Rajouri-Poonch where it is collected by Gujjars and used as tea substitute. Soil erosion, loss of habitat due to landslides and deforestation are the main threats. It is called 'Mastaani Booti' by the local people in Kashmir.

8. ***Ceropegia bulbosa*** **Roxb. (Asclepiadaceae) :** Slender climber of sub-tropical deciduous forests of Rajouri and Udhampur Forest Divisions. Because of deforestation of Khair trees, its habitat has been disturbed in recent decades. Widespread invasion of weeds such as *Parthenium hysterophorus* has also suppressed its growth in the

Plate 5
Some Threatened Plants of Jammu Region, NW Himalaya



1. *Dactylorhiza hatagirea;* 2. *Eremostachys superba;* 3. *Gloriosa superba;*
4. *Arnebia benthamii;* 5. *Gentiana kurroo;* 6. *Jurinea dolomiaea;*
7. *Eremerus himalaicus;* 8. *Atropa belladona;* 9. *Podophyllum hexandrum;*
10. *Aconitum heterophyllum*

wild. Tubers are eaten by locals. It used to be abundant in Khadakpanjaah area of Kalakote and Tikri in Udhampur but is quite rare these days.

9. ***Atropa acuminata* Royle *ex* Lindley (Solanaceae) :** Deadly poisonous mountain perennial found growing in wild especially around Loran, Bufliaz of Poonchh Forest Division and Gool-sangaldaan area of Ramban Forest Division. It also grows along the fringes of Kail, Fir and oak forests. It is called Bisraal, Braand and Tookan Sool by the locals.

10. ***Notholirion thomsonianum* (Royle) Stapf. (Liliaceae) :** Fragrant flowering bulbous herb which grows in rocky places along the Ban-Ganga. It is quite an attractive plant of Jammu region but quite rare in the area. Author collected this herb for the first time during March, 2008 from a hillock along the side of Ban-Ganga at Katra. This species is recommended for cultivation in the gardens.

For the conservation of above mentioned species and also for all other threatened taxa of the region both *in situ* and *ex situ* measures would be essential. Forest Department needs to raise the nurseries of high value medicinal and aromatic trees and execute population recovery programmes in various reserved forests. Volunteers and non-government organizations can also be motivated to grow such species along the fringes of forests and cultivated fields. The Centre for Biodiversity Studies, Baba Ghulam Shah Budshah University Rajouri has taken an initiative of raising the seedlings of *Buxus wallichiana* in the nurseries for its rehabilitation in the Pir Panjal Biodiversity Park of Rajouri. Such efforts need to be upscaled and replicated in other parts of the state. The Horticulture Department can take up a few species for *ex situ* conservation and genetic improvement. For example, the hedgel nut (*Corylus jacquemontii*), locally called Thaangi, Urmuni in Pahadi and Pogli dialects, is sold in the local market but it has poor regeneration in the forests. It needs to be grown as a horticultural crop. Superior grafting with Turkish varieties is desirable for enhancing yield of its nuts. Likewise, State Forest Department can include several woody and herbaceous species for afforestation and reforestation programmes under Clean Development Mechanism to serve the dual purpose of biodiversity conservation and carbon sequestration.

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6.0 Rare and Little Known Plants from Lower Himachal Pradesh

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The Shivaliks and outer Himalayan ranges in Himachal Pradesh have received relatively less attention of plant explorers and phytogeographers. Some of the important contributors on the flora of this region include Collett (1921), Chowdhery & Wadhwa (1984) and Kaur & Sharma (2004). However, there have been rapid changes in habitat conditions in this region due to heavy anthropogenic pressures. The author has been making observations on the flora of the lower Himachal especially the Sirmaur district for the past ten years. In this article, a few rare and little known species from the lower parts of Himachal Pradesh have been appended along with their colour photos (Plate 6). Most of these species have very small and fragmented populations and they need to be given high priority for *in situ* conservation and regular monitoring.

1. ***Hibiscus trionum*** **Linn. (Malvaceae) :** So far recorded only 3-5 individuals near cultivated fields at Mangrah, Sarahan (1300m).

2. ***Rauvolfia serpentina*** **Benth. *ex* Kurz. (Apocynaceae) :** It had been reported only from Simbalwara Wildlife Sanctuary in the past but despite repeated search it has not been located since the past 10 years. It is feared that this species has gone locally extinct from the above sanctuary.

3. ***Sphaeranthus indicus*** **DC. (Asteraceae) :** Once frequent in paddy fields around Poanta Sahib, Barma Papri (Nahan). Now species is rarely seen perhaps due to excessive use of chemical fertilizers and intensive farming.

4. ***Uraria picta*** **Desv. *ex* DC. (Papilionaceae) :** Rare, reported from Himachal Pradesh but it seems to have gone locally extinct from most of the localities due to changes in habitat conditions and over exploitation.

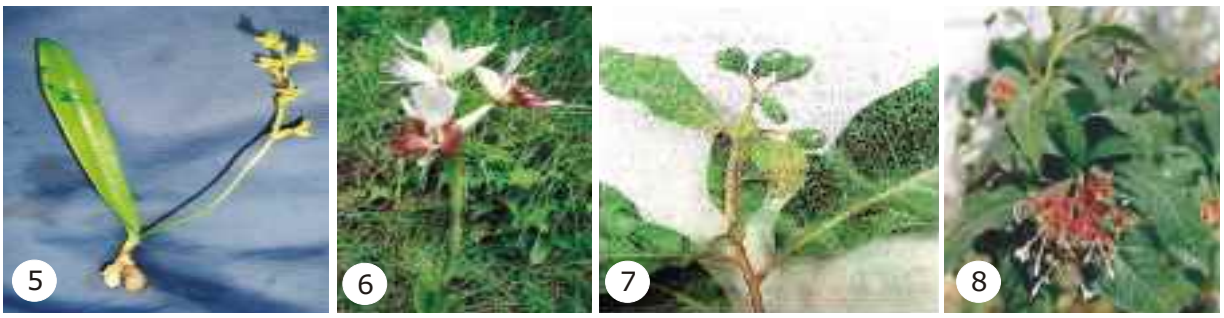
5. ***Onosma thomsonii*** **Clark (Boraginaceae) :** Extremely rare. Only 3-4 individuals seen at Devadhar near Sangrah (1500 m), on limestone rocks. There has been heavy quarrying of lime stone from the quoted locality and the species is on the verge of extinction. This species was reported for the first time recently (Lal & Rawat 2008). Previously known only from west of Kishenganga valley in Kashmir including Banihal Pass, Swat, Hazara and Kagan between 1000 – 2000 m asl.

6. ***Tricholepis roylei*** **Hook. (Asteraceae) :** An erect under-shrub up to 1.5 m high. Branches, petioles and leaves densely clothed with white tomentum. Leaves elliptic, 8 x 3 cm, toothed. Heads solitary, terminal, up to 5 cm in diameter, pink. Flowering and Fruiting: August – September. Sparse, 15 – 20 individuals were seen on way to Renuka between Shiv Temple to Raicha (1200-1400 m asl), especially dry rocky slopes (Lal & Rawat 2008).

7. ***Nervillia gammieana*** **Hook.f. (Orchidaceae) :** Rather sparse, on moist forest floors of Sal (*Shorea robusta*), seen at Shambhuwala, Nahan 700m.

8. ***Eulophia dabia*** **D.Don (Orchidaceae) :** Extremely rare. Recently located near Una (600 m) on the bank of seasonal stream in association with *Imperata cylindrica* and *Saachrum benghalense*.

Plate 6
Some Little Known Plants from Lower Himachal Pradesh



1. *Hibiscus trionum;* 2. *Peristylus constrictus;* 3. *Nervillia gammieana;*
4. *Abrus pulchellus;* 5. *Herminium monophyllum;*
6. *Pecteilis gigantea;* 7. *Semecarpum andcardium;* 8. *Rauvolfia serpentina;*
9. *Tylophora tennerima;* 10. *Cordia rothii;* 11. *Habenaria marginata;*
12. *Uraria picta;* 13. *Habenaria furcifera;*
14. *Pueraria montana var. chinensis;* 15. *Tricholepis roylei;* 16. *Eulophia dabia*

9. *Cordia rothii* Roem. & Schult. (Boraginaceae) Rare. Only three individual plants could be seen at Nahan at 900 m.

10. *Pecteilis gigantea* J.E. Smith (Orchidaceae) : Very sparse, seen on moist grassy slopes between Nahan and Kakog, Sangrah (900-1000 m).

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7.0 Some Plants of Taxonomic and High Conservation Significance in Uttarakhand Himalaya

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Introduction

Uttarakhand Himalaya has received attention of a large number of botanists yet it remains rather under explored. The state lies in the watersheds of Yamuna, Ganga, Ramganga and Kali (Sharda) rivers and its tributaries. It has four broad eco-climatic zones, *viz*., the Terai-Bhabar and Shiwaliks, the middle Himalaya, the Greater Himalayas and the Trans-Himalaya. The wide variation in altitude and climate makes it ideal for sustaining a rich diversity of plant and animal species. The major vegetation types includes Tropical Moist Deciduous Forests, Subtropical Pine Forests, Subtropical Broad Leaved Forests, Temperate Conifer and Broad Leaved Forests, Alpine meadows and Alpine scrub as one goes from the lower to higher altitudes in the state. Some of the botanical hotspots in the state are Corbett National Park, Patwadangar, Lower Gori valley, Kalamuni ridge, Mandal, Deoban, Binsar, Thalkedar, Yamunotri, Valley of Flowers, Nanda Devi and Ralam Valley. Even though the region has been extensively surveyed by the botanists in the past, several localities remain under-explored. Some of the groups need taxonomic revision and others need status surveys. It is interesting to note that some of the species reported as common are very rare. For example, *Cupressus torulosa*, the Himalayan Cypress is supposed to be a common coniferous tree in the Western Himalaya (Osmaston 1927), but the reality is different. There are only few isolated populations at Naina Peak in Nainital on the ascent to Kalamuni in Pithoragarh, Chakarata and small scattered trees elsewhere. All these populations are in the altitudinal range of 2000-2500 m above msl. The common species mistaken as *Cupressus torulosa* in Mussorie, Naintal and many other plantations are actually a mixture of different species of exotic *Cupressus*, *Juniperus* and other similar genera. One of the plantations near Nainital proved to be a mixture of 12 species of exotic *Cupressus*. This mixture is a result of collection of seeds from the exotic *Cupressus* collection in the FRI campus at Dehradun by the local seed suppliers in the past, resulting in mixed mother plantations from where further seed collection was done. The Forest Department has started measures to identify true populations as seed plots and supply certified seeds so that only the real *Cupressus torulosa* is introduced in future planations.

This article deals with ten interesting species of taxonomic value highly discussed among botanists regarding their rarity, systematic position and restricted distribution (Plates 7A & 7B).

Details of the species

1. *Butea pellita* Hook. f. (Fabaceae)

A perennial herbaceous legume of subtropical pine forests. It remains dormant (underground) during autumn and winter and sprouts up during the pre-monsoon showers in May. Leaves large, trifoliate, pubescent. Branches end in a terminal inflorescence. After seed fall above the ground portion of the plant dries off and becomes dormant till the next summer. This plant is found only at a few locations like Patwadangar and Banoliya in Nainital Forest Division, both at an altitude of 1500-1600m above msl. This plant is locally called 'Patwa' and the name of the place Patwadangar means 'The rocky hill full of Patwa'. The total population in this area is estimated to be around 100 plants.

2. *Symplocos ferruginea* Roxb. (Styraceae)

A medium sized evergreen tree, having restricted distribution, again around Patwadangar. It is easily identified by its large elliptic, serrate leaves. Petioles and veins underneath rusty. The inflorescence and peduncles are also rusty brown in colour, hence the specific name 'ferruginea'. There may be around 20 trees only in this area. The other associates in this area are *Symplocos crataegoides*, *Glochidion velutinum* and *Michelia kissopa.*

3. *Toricella tiliaefolia* DC. (Toricelliaceae)

A small tree with large cordate leaves and is the only representative of the family Toricelliaceae. The leaves resemble those of the family Aristolochiaceae. There are only two populations identified so far, Guini Band near Birhi, where a small population is visible from the roadside and Patal Bhubaneswar, where there are a few isolated trees. Both the places are in Pithoragarh Forest Division and the altitude ranges from 1500-1900m above msl.

4. *Trachycarpus takil* Becc. (Arecaceae)

A medium sized palm thought to be endemic to the Kumaon and Western Nepal Himalayas. The only known natural populations are Girgaon near Kalamuni and Thalkedar in Pithoragarh Forest Division. The palm grows on steep cliffs and is easily identified by the terminal rosette of orbicular, palmate, plicate and deeply incised leaves with glaucous shining undersides. The leaf sheaths shred out into fibrous material remaining persistent on the stem for a long time at least below the terminal rosette. This species is often confused with the ornamental palm *Trachycarpus fortunei* commonly grown in Mussoorie and Nainital, which is distinguished by the strap like long ligule unlike the short pointed ligule of *T. takil*. The specific name originates from the local name of the palm, 'Thakal'. One opinion is also that the specific name originates from the locality name Thalkedar. It is also possible that the name Thalkedar has come from 'Thakal Dhar', meaning 'the ridge of palms'. The species is under threat due to use of leaves for thatching, brooms and ornamental purposes and also due to fires in the steep grassy slopes.

5. *Cyathea spinulosa* Wall. (Cyatheaceae)

Only tree fern found in the Himalayan region and is in restricted distribution unlike its common occurrence in the Western Ghats and North Eastern States. This fern is easily identified by its tree like trunk and a rosette of terminal tripinnate fronds with spiny petioles. Only three populations are identified so far, *viz.*, below Sandev forests in Pithoragarh Forest Division, Birahi Ganga catchment in Badrinath Forest Division and above a landslide on Gopeswar-Tangsa road in Kedarnath Wildlife Division. All these populations are in the average altitude of 1100-1300m above msl. The population on a stream across Gopeswar-Tangsa Road was washed off in a landslide in 2007 leaving behind only a few individuals and some regeneration.

6. *Ceropegia wallichii* Wight. (Asclepiadaceae)

An erect and beautiful herb recently discovered during a survey in the Himalayan Botanic Gardens at Nainital where a degraded forest land was allowed to regenerate naturally by means of protection measures. This is a small perennial bushy plant unlike its counterparts which are climbers. The species is easily identified by the peculiar flower shape of all Ceropegias and by the very long slender follicles with numerous pappous hairy seeds inside. The plant has since been preserved, multiplied and planted in other places inside the garden.

Plate 7A
Some Interesting Plants of Uttarakhand -I

1. *Wallichia densiflora;* 2. *Phaius tankervilleae;*
3. *Toricellia tiliaefolia;* 4. *Dimeria ornithopoda;*
5. *Cyathea spinulosa;* 6. *Symplocos ferruginea*

Plate 7B
Some Interesting Plants of Uttarakhand - II

7. *Glyceria tonglensis;* 8. *Butea pellita;* 9. *Quercus lanuginosa;*
10. *Trachycarpus takil;* 11. *Ceropegia wallichii*

7. *Phaius tankervillae* (Banks) Blume (Orchidaceae)

A ground orchid found in the swampy evergreen microclimates in the Sal forests of the Shiwalik and foothills of the Himalaya. This orchid was presumed to be extinct in the wild due to its heavy exploitation in the past for ornamental purposes. This species was recently rediscovered in a small population in a swamp near Gajar sot in Corbett National Park. The plant is easily identified by its long plicate leaves and the large showy inflorescence with brown tepals with white undersides. The labellum forms a small cylindrical tubular structure in the middle of the flower.

8. *Wallichia densiflora* Mart. (Arecaceae)

A dwarf palm endemic to Himalaya found in dense moist shady regions and is very rare and restricted in distribution. The palm can be easily identified by its size and large lobed pinnate leaves with sinuate margins and shiny, glaucous undersides. The inflorescence is a dense axillary spadix. This palm is found in extremely small populations, the main localities being Gajar swamp in Corbett National Park, Mundiapani and Domunda in Kalagarh Forest Division, Kyari in Ramnagar Forest Division and Dogaon water falls in Nainital Forest Division. The palm is of high ornamental value and hence its exploitation has restricted its occurrence in rather inaccessible areas only.

9. *Glyceria tonglensis* C.B. Clarke (Poaceae)

A semi-aquatic grass found near the high altitude lakes and ponds and spends most of its life under submerged conditions and rest in the dried swampy portion of the lake side. The subsurface runners enable the species to extend all along the moist region around the lake. The plant can be easily identified by its branched panicle with stiff branches at an angle to the main rachis. The spikelets have several florets with overlapping glumes and blunt tips (Bor 1960).

10. *Dimeria ornithopoda* Trin. (Poaceae)

This is a very common ephemeral grass of mostly in peninsular India, but is found in the Himalayas in so far only one report from Chakori at 2000m altitude on a moist rocky ground, probably a granite outcrop, where it is found in a gregarious population. The other isolated record of this species is from Robber's cave in Dehradun. The disjunct distribution of this grass species, that too at a high altitude, is a mystery to be solved.

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8.0 Threatened Plants of Kedarnath Wildlife Sanctuary,Western Himalaya

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Introduction

The Western Himalaya is well known for its floral, faunal, cultural and aesthetic values. Though it forms only about seven percent of India's land surface, it plays a major role in shaping the Indian monsoon bestowing a tremendous life sustaining values to the Indian subcontinent. The establishment of several protected areas (PAs) in recent years in the Himalaya as well as other parts of the country (Rodgers & Panwar 1988) raises hopes for the long term conservation of representative ecosystems and biota. The existing PA network in the Himalaya covers diverse natural habitats for maximum species of flora and fauna but planning the proper size and shape of PAs suffers due to lack of information on the specific habitats of rare and endemic plants. Several workers have stressed the need for conservation of threatened flora in Himalaya *e.g.*, Deva (1968), Sahani (1979), Jain & Sastry (1980), Pangtey & Rawat (1984), Rao & Hajra (1986), Hajra & Rao (1990), and Rao *et al.* (2003). In this paper, we give a brief overview of the vegetation and threatened plants of Kedarnath Wildlife Sanctury. Patterns of their rarity and endemism are discussed along with their conservation status in and around the sanctuary.

The Sanctuary

The Kedarnath Wildlife Sanctuary (KWS) is one of the largest PAs (975 km^2) in the Western Himalaya, located in Chamoli district of Uttarakhand. It is bordered by high peaks *viz.*, Kedarnath (6940m), Mandani (6193m) and Chaukhamba (7068m) and extensive alpine meadows *i.e.*, Kham, Mandani, Pandavshera, Rudranath, Manpai in the north. The sanctuary covers a wide altitudinal range and has sizeable areas with limited human pressure. Hence, it harbours a great diversity of flora (>2000 species). However, some parts of the sanctuary which are heavily used by human beings for pilgrimage and livestock grazing, a few species have witnessed rapid decline during recent decades *e.g.* disappearance of Oaks, *Taxus*, *Cypripedium*, *Dactylorhiza*, *Aconites* and *Picrorhiza kurrooa*, *etc.*

Table 1. List of Threatened and Endangered plants of Kedarnath WS

Botanical name	Family	Habit	Indian RDB	Habitat
Acer caesium Wall. *ex* Brandis	Aceraceae	T	V	5, 6
Acer oblongum Wall. *ex* DC. var. *membranaceum* Benerji	Aceraceae	T	E	6
Aconitum ferox Wall. *ex* Seringe	Ranunculaceae	H	I	1
Allium stracheyi Baker	Alliaceae	H	V	1,3
Arnebia benthamii Benth.	Boraginaceae	H	E	1,5
Berberis pseudoumbellata R. Parker	Berberidaceae	S	I	5
Coelogyne cristata Lindley	Orchidaceae	H	I	6
Cyananthus integer Wall. *ex* Benth.	Campanulaceae	H	R	3
Dendrobium normale Falc.	Orchidaceae	H	I	6
Kobresia duthiei Cl.	Cyperaceae	H	I	1,3
Oreorchis indica (Lindl.) Hook.f.	Orchidaceae	H	I	5
Saussurea roylei (DC.) Sch. Bip.	Asteraceae	H	I	3
Saussurea bracteata Decne.	Asteraceae	H	R	1,3
Schizandra grandiflora (Wall.) Hk.f. & T.	Magnoliaceae	C	I	6
Silene kumaonensis Williams	Caryophyllaceae	H	R	1

Habit: H=Herb, S=Shrub, T=Tree, C=Climber, RDB Status: V=Vulnerable, E=Endangered, I=Indeterminate, R=Rare, Habitats: 1=Mixed herbaceous meadows, 2= Caves & Caverns, 3= Boulders and scree slopes, 4= Stream courses, 5= Alpine moist scrub, 6= Temperate oak forests.

Fifteen species of vascular plants found in KWS have been listed in the Red Data Book of Indian plants (Rao *et al.* 2003) under the different threat categories (Table 1). These include Endangered (2), Vulnerable (2), Rare (3) and Indeterminate (8). In addition, four species endemic to Indian Himalayan Region (IHR) have been recorded from the sanctuary which falls under restricted range species (Dhar and Samant 1993, Samant *et al.* 1998, Samant 1999). Among these, three species (*Aconitum heterophyllum*, *Allium stracheyi* and *Angelica glauca*) are endemic to Himalayan region and one species (*Falconeria himalaica*) is endemic to Uttarakhand.

Critical habitats for plants conservation in and around Kedarnath WS

Kedarnath WS has several extensive alpine meadows and quite a few dense broad leave forests in the fringes of the sanctuary which forms various habitats for the rare and threatened species. Following are the few critical habitats and corresponding species (Plate 8) within the sanctuary:

1. Mixed herbaceous meadows : Gentle and moist meadows above tree line have a large number of plant species *e.g.*, *Ranunculus hirtellus*, *Bistorta affinis*, *B. vivipara*, *Anemone rivularis*, *Geranium wallichianum*, *Potentilla atroisanguinea*, *P. argerophylla*, *Geum elatum.* These meadows support high value medicinal and aromatic plants such as *Aconitum heterophyllum*, *A. violaceum*, *A. ferox*, *Arnebia benthamii*, *Pichrorhiza kurrooa* and *Gentiana* spp.

2. Caves and Caverns : Rock crevices and caverns are shaded areas close to tree line. These habitats support some of the specific species *e.g.*, *Circaeaster agrestis*, *Woodsia alpina*, *Chamabania cuspidata*, *Parietaria debilis* and *Primula edgeworthii*.

3. Boulders and scree slopes : In the high altitude (above 3600m) regions of the sanctuary, especially the sites exposed to snow blizzard are characterized by dwarf cushionoid species clinging to the ground. Some of the species on moist aspects covered by boulders at such heights are *Saussurea obvallata*, *S. graminifolia*, *Falconeria himalaica*, *Bergenia strachyei*, *Nardostachys grandiflora*, *Allium stracheyi*, *Rheum moorcroftianum*, *Pleurospermum densiflorum.* These species are favoured for grazing by sheep, goats as well as blue sheep.

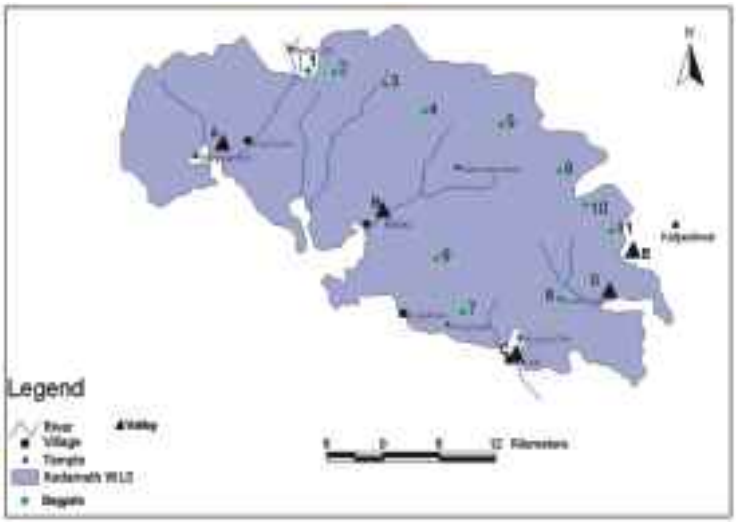
4. Stream courses : The stream courses in the sub-alpine and alpine regions of the sanctuary are mainly dominated by *Caltha palustris*, species of *Corydalis*, *Pedicularis* and *Primula*. Other species frequently seen in such habitats are *Meconopsis aculeata*, *Equisetum debile* and *Swertia speciosa*.

5. Alpine moist scrub : Shady moist slopes especially in adjacent to timber line between 3300-3700m asl often have extensive patches of dwarf *Salix lindleyana*, *Cassiope fastigiata* and *Rhododendron anthopogon*. The mat forming species support some of the threatened species *e.g.*, *Cypripedium himalaicum*, *C. cordigerum*, *C. elegans* and *Picrorhiza kurrooa.*

6. Temperate oak forests : Moist temperate forest of the region is mainly dominated by Banj oak (*Quercus leucotrichophora*), *Rhododendron arboreum* and *Lyonia ovalifolia*. These habitats are under tremendous pressure of human activities. Certain threatened plants *e.g.*, *Dendrobium normale*, *Paeonia emodi*, *Zeuxine flava* are associated with Banj Oak forests.

Above mentioned habitats need to be given high priority for conservation in Kedarnath Wildlife Sancturary. Some of the important localities suggested for restoration and monitoring of these habitats are Kedarnath, Kham, Tungnath and Bansinarayan. The impact of man and his domestic animals on the vegetation is seen everywhere. Excessive lopping in the temperate region and overgrazing of high altitude pastures by sheep, goats and buffaloes is an important factor responsible for change in the composition of vegetation in many regions in the sanctuary. Excess of tourism and pilgrimage has been an important reason for degradation of habitats and species. During peak summer, one can

Plate 8
Threatened Plants and their habitats in Kedarnath WLS



1= Kedarnath
2= Kham
3= Mandani
4= Thauli
5= Pandavshera
6= Bisuri
7= Tungnath
8= Rudranath
9= Brahm Kharak
10= Manpai
11= Bansinarayan
A= Kedarnath
B= Madhmaheshwar
C= Mandal
D= Rudranath
E= Urgam

Cypripedium cordigerum

C. elegans

C. himalaicum

Alpine Rocky Areas and Caves as
Special Habitats for *Primula edgeworthii*

Temperate Oak forests support various
orchids (inset : *Dendrobium normale*)

observe several shops selling holy flowers *i.e.*, davine lotus (Brahmakamal) being sold to pilgrims especially around the holy shrine of Kedarnath, Madhmaheshwar, Tungnath and Rudranath. Several herbs with beautiful flowers are plucked by tourists just for fun.

Conservation of these valuable species would not be possible without the active participation of the local people. It is high time that the management authorities of KWS initiate dialogues with the temple management committees / traots at each of the five Kedars to set aside a part of temple premise for protection of habitats and not to allow collection and sale of wild flowers such as Brahamkamal at these places. A new approach of habitat conservation rather than species conservation needs to be established. Conservation of forests at fringes of villages needs to be initiated to save various components of these forests to improve the habitat conditions.

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9.0 Distribution, Status and Conservation of *Picrorhiza kurrooa* in the Himalayan Region

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Introduction

Picrorhiza kurrooa Royle *ex* Benth. (Scrophulariaceae), popularly known as Kutki, Kadawi or Kuru, is not a new name for Ayurvedic practitioners, Vaids, Hakims and herbal industry. It is also not a new plant for botanists and plant ecologists. However, rapid decline of this species from wild during recent years is a new thing which has serious conservation implications. The increasing market demand of the plant has led to unscientific, unmanaged and overharvesting of the plant, raising concern amongst many ecologists, scientists and conservationists (Rai & Sharma 2000, Uniyal *et al.* 2002, Rawat 2005). As a result, the species has been included in the Negative List of Export by the Govt. of India and Appendix II of CITES. Based on the extensive collection for trade and dwindling population in the wild, the plant has also been categorized as Vulnerable in the Red Data Book (Nayar & Sastry 1987) and as 'Endangered' as per Conservation Assessment and Management Planning (CAMP) workshop (Ved *et al.* 2003).

This article deals with the status and distribution of *P. kurrooa* in the Himalayan region. Current levels of extraction and trade from different regions and conservation implications are discussed.

The Plant: Habit, Habitat and Distribution

P. kurrooa is a perennial herb with stout and creeping rhizome (Plate 9). Leaves are simple, spathulate with serrate margins. Flowers purplish blue in terminal racemes, seen during July-August. Its fruiting period is September-October. It is generally found in association with *Salix lindleyana*, *Nardostachys jatamansi*, *Gaultheria trichophylla*, *Selinum candollii* and *Meconopsis aculeata*. In India *P. kurrooa* is mainly distributed in the North-West (2A), West (2B) and Trans-Himalayan (1A) biogeographic zones. It has also been reported from some parts of central and North-east Himalaya (Rai & Sharma 2002, Haridasan *et al.* 2002). In Uttarakhand it has been reported from Valley of flowers National Park (VOF NP), Kedarnath Wildlife Sanctuary (KWLS), Nanda Devi Biosphere Reserve (NDBR), and alpine ranges of Ralam, Gori, Pindar, Bhagirathi, Yamuna, Dhauli and Kali valleys (Uniyal 1968, Rawat 1983, Kala *et al.* 1998, Uniyal *et al.* 2002, Rawat 2005, Semwal *et al.* 2007) In Himachal Pradesh its distribution ranges from as far as Trans-Himalayan regions of Lahaul-Spiti to alpine regions of Mandi, Kullu, Chamba, Kinnaur and Kangra districts. It has also been reported from Great Himalayan National Park (GHNP), Dhauladhar WLS (DWLS) and Kugti WLS (KWLS) (Shabnam 1964, Kala 2000, Singh & Rawat 2000, Samant *et al.* 2002, Uniyal *et al.* 2006). In Kashmir it has been reported from Gurez, Gulmarg, Lolab Karna and Padar ranges (Kaul & Handa 2002). *P. kurrooa*, like many other medicinal plants also has habitat specificity. It generally occurs 3600m above msl in the moist rocky habitats with well drained soil (Plate 9). As rhizome is the main source of the drug, the collectors uproot the entire plants thus affecting regeneration and population of *P. kurrooa* and degrading its habitat.

Population Status, Regeneration and Cultivation Efforts

Information on population and regeneration of medicinal plants is not only important to assess their availability in wild but is also a key requirement for threat categorization. Though emphasis on generating information on the population of medicinal plants has been laid, little work has actually been done in this aspect. One of the reasons is the difficult

terrain and unfavourable weather of high altitudes where these plants grow and the other is the lack of enthusiasm to work in the Himalaya. Recently, some workers have collected data on the distribution, abundance and uses of some important medicinal and aromatic plants of Himalaya including *P. kurrooa* (Singh 1999, Kala 2000, Rai *et al.* 2000, Uniyal *et al.* 2002, Kala 2004, Rawat 2005, Uniyal *et al.* 2006, Semwal *et al.* 2007). It has been proven through some habitat based studies that *P. kurrooa* has restricted and localized distribution. Its highest density has been reported from moist rocky slopes and under scrub habitats of >3600m altitudes (Uniyal *et al.* 2002, Semwal *et al.* 2007). In alpine ranges of Gori valley, its mean density was 3.89 individuals/ m^2. It was highest (12.92 individuals/m^2) in the moist rocky slopes and least in the grassy slopes (0.085 individuals / m^2). It was completely absent in the undulating and marsh meadows (Uniyal *et al.* 2002) whereas in the VOF NP, the population of *P. kurrooa* was 4.5 individuals/ m^2 (Kala *et al.* 1998). In another assessment of *P. kurrooa* from different valleys of Uttarakhand, the mean density of *P. kurrooa* has been reported to be 2.21 individuals / m^2. The highest population (1.61 individuals / m^2) being from alpine meadows of Gidara while lowest (0.11 individuals / m^2) was in the Kushkalyani (Rawat 2005). In Kedarnath WLS mean density of *P. kurrooa* was 2.2 individuals/ m^2. It was highest in the under scrub (5.6 individuals/ m^2) and steep slopes (5.2 individuals/ m^2) habitats while it was lowest (1.21 individuals / m^2 in the undulating alpine meadows (Semwal *et al.* 2007). However, highest density estimates for *P. kurrooa* have been reported from the Trans-Himalayan region. Distribution of *P. kurrooa* was very localized and found in patches and a density of 70.6 individual/ m^2 in Tarbak region of Spiti valley has been reported (Kala 2000). These studies indicate that the species not only has restricted and localized distribution but their population has also been influenced due to anthropogenic activities. None of the studies so far have actually collected information on its regeneration and taken time series information. Still, the baseline information that has been generated will certainly help in future monitoring of the plant population and its habitats. However, research on its cultivation and propagation methods has already provided very good results. A very high ranking has been given to *P. kurrooa* (ranked IInd) for *ex situ* cultivation in Himachal Pradesh. Its cultivation prospects have been ranked "A" (second highest rank) and marketing at national and international levels is also "A" (Badola 2002). *P. kurrooa* can be propagated through seeds as well as by vegetative means. Cultivation by vegetative means is more advantageous for eliminating difficulties associated with seed germination and seedling survival. It also reduces the length of cultivation cycle (Nautiyal 1995, Sundriyal & Sharma 1995). It has been reported that maximum seed production in *P. kurrooa* takes place when it grows under scrub dominated canopy (Nautiyal & Nautiyal 2004). Hence it's intercropping with saunf and *Digitalis purpurea* gave a better yield. Its production was 320kg/ha indicating a benefit of Rs. 87,600/ha when harvested during third year of growth at 1800 m elevation in the Himalaya. It has been found that post harvest drying at room temperature (15-20^{o}C) retains high picrotin and picrotoxin. Whereas drying in direct sun or in oven decreases the active compounds rapidly (Nautiyal & Nautiyal 2004). Besides these, plant tissue culture technique can also be employed for its clonal multiplication and it can provide an effective strategy for its conservation (Ahuja 2002). Though, it has been found through cost-benefit analysis that cultivation of *P. kurrooa* (Rs. 88284) can be far more profitable than cash crops such as potatoes (Rs. 12600) and rajma (Rs.5325), still no large scale cultivation of *P. kurrooa* is done in high altitude areas. Cultivation is restricted either to research sites developed by some institutions in collaboration with villagers (Haridasan *et al.* 2002, Kaul & Handa 2002, Rai & Sharma 2002, Ahuja 2002) or to few interior villages in Uttarakhand (Silori & Badola 2000, Uniyal *et al.* 2002). Most of the cultivation done in these villages is also through transplantation of species from wild to fields (Virdi 2002) and not through proper cultivation techniques. The main reason for which is the lack of proper information and guidance to villagers and problems associated with storage, transportation and marketing of medicinal plants. Hence, besides cultivation, research efforts on above mentioned aspects should also be undertaken for community based cultivation of *P. kurrooa*. Demonstration of propagation techniques and distribution of elite propagules to farmers interested in their commercial cultivation will not only generate self employment opportunities for the local people but will also pave the way for its *in situ* conservation.

Extraction and Trade

The roots and rhizomes of *P. kurrooa* contain 26-27% Picrorhizin in addition to other active constituents such as kutkoside. Picrorhizin is a major constituent of many important liver and stomach medicines. Besides, it is also used in drugs prescribed for treatment of respiratory diseases and allergic manifestations (Sarin 2008). Traditionally the plant

was collected during August – September, however, in order to maximize economic gains, now the collection starts in month of July itself. The entire plant is uprooted and material is cleared of adhering rootlets and dried in sun for a week. It is largely collected from Jammu and Kashmir, Himachal Pradesh, Uttarakhand and Sikkim. Annual transaction of 10,000 kg of *P. kurrooa* takes place in Delhi market. During 1998-99 it was sold at a price of Rs. 100-150/ kg which has increased to Rs. 230-280/kg in 2006 (Samant *et al.* 2002), while local people who actually traverse high altitudes to collect the plant still get a meager sum of Rs.10-60/kg (Awasthi and Uniyal 2003). Global supply (excluding China and Pakistan) of *P. kurrooa* is around 375 tons with India contributing around 70 tons next only to Nepal (250 tons). In order to meet the demand often *Lagotis cashmiriana* is adultered with *P. kurrooa*. In Nepal, *P. kurrooa* is traded in the name of *Neopicrorhiza scrophulariiflora* (Shrestha and Jha 2009).

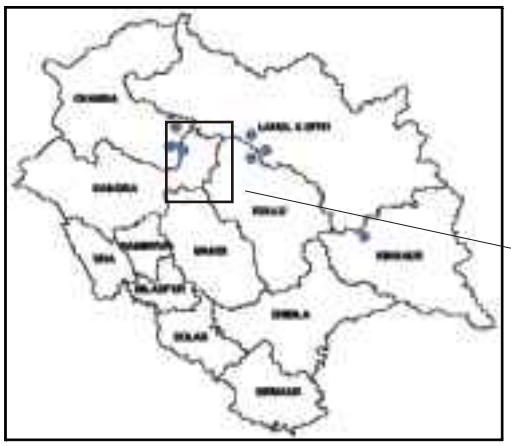
Because of its great therapeutic importance, demand for *P. kurrooa* is very high and steady in the market. It is one of the top 15 plant species traded in India (Malaisamy and Ravindran 2003). The demand for *P.kurrooa* is more than 5000 tons; however, its supply is less than 100 tons (Kumar 2006). With an annual growth of 20% in Ayurvedic medicine sector demand of medicinal plants has also increased by 11.1 % in recent years, resulting in an augmentation in the extraction of *P. kurrooa*. It has been reported that earlier (1988-89) only 1.468 tons of *P. kurrooa* was extracted from the entire state of Himachal Pradesh (Sharma 1995). Today, the extraction is 10 times higher (Singh 1999). Similar patterns have been reported from Uttarakhand, where more than 5 tons of *P. kurrooa* was extracted by 12 villages of Gori valley during 2000-01 (Virdi 2004). From Sikkim also, *P. kurrooa* to a tune of 6 tons is annually extracted (Rai *et al.* 2000). The amount of extraction figure available is just the tip of the iceberg as most of the trade in medicinal plants is illegal and secretive and data for which are still not available. Though cultivation practices for *P. kurrooa* have been developed (Nautiyal *et al.* 2001), still 90% of the plant material in trade comes from wild and is harvested following destructive methods. This has threatened the status of *P. kurrooa* in wild. As a result, *P. kurrooa* once plentiful, is now restricted to areas not easily accessible to man. A large majority of collectors have stated unambiguously that there is a decrease in the availability of medicinal plants. Now they have to spend more time and cover long distance for collecting same quantity of medicinal plant (Kumar 2006). Thus, it seems time is not far when these species will be locally extinct. A very good example of this is the Chhangu and Lachung valleys in Sikkim where rampant collection of *Podophyllum hexandrum* and *Panax pseudo- ginseng* have now made these areas devoid of both these herbs. Another important threat to its habitat highlighted recently is the complete receding of small glaciers (Shrestha & Jha 2009). On one hand there is dearth of information on the ecology, distribution and population of *P. kurrooa* and on other hand its population and habitat is shrinking.

Conservation and Management Implications

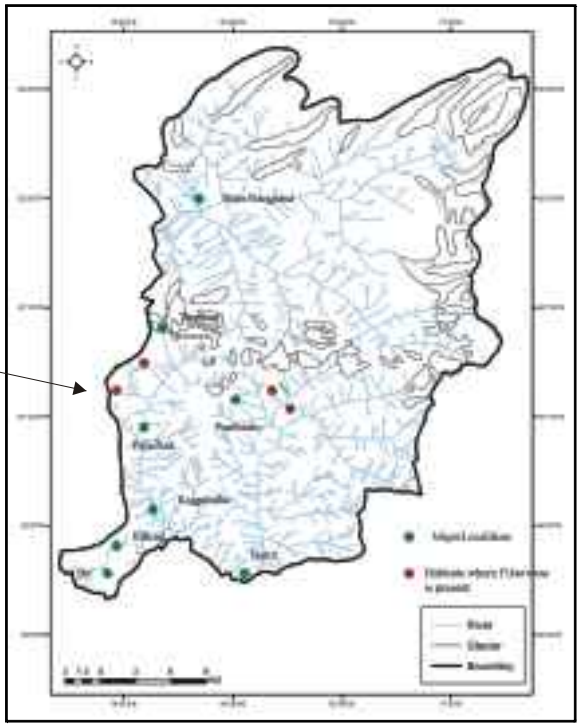
Keeping in view the status of *P. kurrooa* in wild, its sensitivity to anthropogenic impacts and its increasing demand in the market, it has been listed among top 20 species prioritized for conservation and development (Dhar *et al.* 2000). National medicinal plant board (NMPB) has also identified *P. kurrooa* for conservation and propagation through its various schemes. A total of 212 acres of land has been supported by NMPB for cultivation of *P. kurrooa* (which has increased from 7 acres in 2002-03 to 97 acres in 2005-06) (Kala & Sajwan 2007). It has already been provided protection under various conservation initiatives such as CITES, Red Data Book and IUCN list of threatened plants. Classification of species based on its area, distribution, abundance and use value at local and regional level is not only useful for its conservation but would also help in its proper management. Based on above mentioned classification *P.kurrooa* has been listed in RDHP (Restricted distribution and heavy pressure) category for alpine areas of Gori valley and KWLS (Uniyal *et al.* 2002, Semwal *et al.* 2007). For some other parts of Uttarakhand it has been listed as LCHP (locally common and heavy pressure) (Rawat 2005). Based on this criterion, some *P. kurrooa* specific conservation plots in wild should be marked in different valleys. Similarly, areas already reported to be rich in population of *P. kurrooa* should be marked as control sites for future monitoring and repeated sampling.

P. kurrooa being in steady demand has very high harvesting pressure. It is reported that a total of 286 plants as shoot part and 500 as root parts are harvested to make a kilogram weight of *P. kurrooa* (Rai *et al.* 2000). Hence collection from wild

Plate 9
Distribution of *Picrorhiza kurrooa* in Western Himalaya



Localities with good population of *P. kurrooa* in Himachal Pradesh



Distribution of *P. kurrooa* in a part of Dhauladhar WS, HP

Typical habitat of *P. kurrooa*

Collection of *P .kurrooa*

A blooming *P. kurrooa* in the in the alpine areas of Western Himalaya

should be done on a rotational basis which will help in the recuperation of the area and a sustainable harvest. It has also been reported that plants in the alpine areas complete their reproductive phase during the months of September and October. Hence harvesting should be done during the month of October when active constituents have the highest proportion (Nautiyal & Nautiyal 2004). This knowledge should also be spread amongst the collectors so that harvest is done after seed set.

Awareness generation amongst the local people and collectors will go a long way in medicinal plant conservation. Elite plant population with complete agro-technique package that includes good agricultural practices, good collection practices and post harvest management should be made available to the farmers for cultivation. Associated with cultivation is the marketing and trade. Trade related studies are very few and therefore need to be proposed and carried forward. We still do not have quantitative information on the distribution and population of medicinal plants from many interior areas of the Himalaya. This has been pointed out to be one of the major drawbacks in medicinal plant research. Therefore, concentrated surveys and exploration is the need of the hour. Studies on impact of changing climate on these rare and threatened plants of Himalaya should also be taken up.

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Sandeep Tambe

Section III:
Central/Eastern Himalaya and North-East India

10.0 Endemic and Threatened Orchids of Sikkim and Their Conservation

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Introduction

Sikkim (7096 km^2 ; 27º 5' to 28º 9¢ N latitudes and 87º 59' to 88º 56' E longitudes), is the smallest state of Indian Union, well known for its diverse eco-climatic zones and rich biological diversity. The major climatic zones in the state are Tropical, Sub-Tropical, Temperate, Dry-Alpine and Wet-Alpine. Through deep valleys, especially along Teesta, the hot and moist tropical climate penetrates right into the heart of the state, providing hotter southern and cooler northern slopes. Because of these geographical features, the state harbours a range of interesting plants including orchids. The state surpasses all other states of India in the diversity of orchids, trailing just behind Arunachal Pradesh. However, if the ratio of orchids with land mass is compared, the state ranks among the richest areas in the world. Arunachal Pradesh, whose geographical area is more than eleven times that of Sikkim has only 620 orchid species and Bhutan whose geographical region is six times the size of Sikkim has only 372 orchid species as compared to 523 species in Sikkim.

One more reason for high diversity and endemism among orchids of Sikkim could be its unique topography. The horse shoe shaped mountain ranges on the west act as a barrier for dispersal of many species and strongly influence regional climate. This has led to the formation of unique habitats in the state. Besides, the windward side on the southern part of the Dongkya range receives the maximum monsoon rain giving rise to wet alpine type of climate. The general trend of mountain ranges in Sikkim is from east to west-Mt Pandim (6691m), Mt Simvo (6811m), Mt Siniolchu (6887m), Mt Kabru (7338m) and Mt Narsing (5825m), but there are two main long south north directed ridges running parallel to each other 64 to 96 km apart. The Singalila range which is about 64 km long, almost starts from plains level, separates Sikkim from Nepal in the West and culminates near its northern extremity in world's third highest mountain, the Mt Khanchendzonga (8598m). The Chlola range in the East, in comparison is much higher in elevation and separates Sikkim from Bhutan East. Besides that there is the deep Chumbi valley separating Sikkim and Bhutan. There is another central longitudinal ridge which separates the great Teesta catchment in the East from the Rangit catchment in the west, culminating at Moinam Peak (3234m). In general, the valleys are narrow at the top and broader at the base. But in Sikkim valleys are broad at the top. Broad valleys like Donkong, Gyamchona, Cholamu and Muguthang are stretches of plain areas with unique faunal and floral diversity similar to that of Tibetan plateau.

Studies on Orchids of Sikkim

First collection of orchid in the state was done by Griffith, followed by Cathcart, then Sir J D Hooker (Mathew 1970). Kataki *et al.* (1984) documented the threatened and endemic orchids of Sikkim. King & Pantling were the first to carry out orchid surveys in Sikkim during 1898, that led to the publication of "The Orchids of Sikkim Himalaya". These authors recorded 448 species of orchids from the state. Despite several floristic surveys in the state no comprehensive account and update on the orchids of state was available until recently when the author initiated systematic studies in 1986. More recent works on the orchids of the state include Shukla *et al.* (1998), Sathish kumar (2001). A detailed investigation for two decades has resulted in several new discoveries and new records. Presently, the state has more than 523 species spread over 134 genera (Lucksom 2007). It is to be noted that still there are quite a few under-explored and virgin forests which may yield several interesting varieties and new records in the state.

Distribution of Orchids in the state

The sub-tropical belt (1000 – 1500 m asl) in the state is richest in terms of orchid diversity. The following table gives an idea about the distribution of orchids in various altitudinal zones (though there is some overlap):

Table 1 : Altitudinal distribution of orchids in Sikkim

Climatic Zonation	Altitudinal Zonation (m)	Number of orchid species
Tropical Forest	Upto 1000m	80
Sub-Tropical Forest	1000 – 1500m	240
Temperate Forest	1500 – 3500m	170
Alpine grasslands & Scrub	3500 - 4500m	33
Total		**523**

Some of the endemic and threatened orchids of Sikkim have been listed below (Table 2) along with their habitat and altitudinal range (Plate 10).

Table 2. Some Threatened and Endemic orchids of Sikkim and their altitudinal distribution.

Sl.No.	Species	Habitat	Altitudinal Range
1.	*Bulbophyllum trichocephalum* var. *capitatum* S.Z. Lucksom	Lithophytic	800 – 1000 m
2	*Calanthe anjanii* S.Z.Lucksom	Terrestrial	2000 – 2500 m
3	*Calanthe keshabii* S.Z.Lucksom	Terrestrial	2000 – 2600 m
4.	*Calanthe yuksomnensis* S.Z.Lucksom	Terrestrial	1000 – 2700 m
5.	*Coelogyne pantlingii* S.Z. Lucksom	Epiphyte	2100 – 2500 m
6.	*Epigeneium treutleri* (Hook.f.) Ormerod	Epiphyte	<900 m
7.	*Cremastra appendiculata* var. *sonamii* S.Z.Lucksom	Terrestrial	920 – 1000 m
8.	*Malaxis saprophyta* (K&P) Tang & F.T.Wang	Terrestrial	1200 m
9.	*Cymbidium whiteae* King & Pantling	Epiphyte	800 – 2000 m
10.	*Dendrobium eriiflorum* var. *sikkimensis* S.Z. Lucksom	Epiphyte	800 – 1000 m
11.	*Didiciea cunninghamii* King & Prain *ex* King & Pantling	Terrestrial	4000 m
12.	*Goodyera dongchenii* S.Z.Lucksom	Epiphyte	2000 – 2300 m
13.	*Gastrochilus sonamii* S.Z.Lucksom	Epiphyte	2300 – 2700 m
14.	*Neottia alternifolia* (King & Pantl.) Szlach	Terrestrial	3000 – 3500 m
15.	*Liparis chungthangensis* S.Z.Lucksom	Lithophyte	1800 – 2000 m
16.	*Liparis dongchenii* S.Z.Lucksom	Terrestrial	1500 – 2000 m
17.	*Liparis lydiaii* S.Z.Lucksom	Epiphyte	1000 – 1300 m
18.	*Liparis pygmaea* King & Pantling	Lithophyte	4350 m
19.	*Malaxis saprophyta* (King & Pantling) T. Tang & F.T.Wang	Terrestrial	1800 m
20.	*Oberonia kingii* S.Z. Lucksom	Epiphyte	1000 m
21.	*Stigmatodactylus paradoxus* (Prain) Schltr.	Terrestrial	2000 m
22.	*Peristylus pseudophrys* (King & Pantling) Kranzlin	Terrestrial	1800 m

It has been observed that the forested habitats and abundance of several orchids have changed drastically over 2-3 decades. For example, prior to 1985 the sub-tropical area (800 – 1000 m) around Pabong in south Sikkim had plenty of *Dendrobium aphyllum* hanging from each and every tree and *Dendrobium moschatum* on *Schima wallichii*. Now the populations of both the orchids have declined drastically and there is hardly any *D. moschatum* in this area. It is felt that

massive afforestation and plantation of several miscellaneous species such as *Populus gamblei* might have affected the vegetation structure and micro-habitat of many orchids leading to their decline. Close to Pabong, there is a small town named as Sintam. This town also had a good population of *Dendrobium aphyllum.* However, there has been a decline in tree cover due to mushrooming of buildings and other developmental activities. Even now a few scattered trees continue to support good population of these orchids.

In the deep wooded areas where the tree canopy is very high and where no sun rays can penetrate into the forest floor, we do not find any epiphytic orchids. In such areas especially between 2000 – 2700m altitude several saprophytic or holomycotrophic orchids such as *Aphyllochis montana*, *A. alpina*, *Galeola falconeri*, *G. lindleyana and G. cathcartii* can be seen. Some orchids *e.g.*, *Rhynchostylis retusa* and *Aerides multiflora* show close affinity with their host trees. These two orchid species are seen growing profusely on *Mangifera indica* and *Polyalthia longifolia* near Siliguri at Salugarh on both sides of the National Highway. But as soon as one leaves the area, both sides of the National Highway are lined with tall trees of *Shorea robusta*. Though these trees are full of other types of orchid species yet not a single tree is seen with the plants of *Rhynchostylis retusa* and *Aerides multiflora*. But these two species suddenly reappear in small population at Ranpo Baghey area. *Rhynchostylis retusa* has been seen up to 1600 m. Similarly, at Mangley (West Sikkim) populations of *Aerides multiflora* can be seen growing naturally at *ca* 1300 m. Occurrence of *Zeuxine seidenfadenii* Deva & Naithani was first reported in the state by Deva and Naithani in 1986. Present author confirmed its presence in the Sub-tropical mixed deciduous forest at an altitude of 900m.

***Bulbophyllum sterile* (Lam.) Suresh** grows frequently in Rangit valley Legshep at 600m altitude in West Sikkim and up to 2000m altitude at Rumtek in East Sikkim. It can be seen often on *Schima wallichii* below Forest Secretariat Building at Gangtok, Sikkim. N.R. Pearce & P.J. Cribb the authors of "Orchids of Bhutan" have not named the places of its occurrence in Bhutan; rather they have mentioned the species location in the state of Sikkim. Even the orchid species in the list of Eastern Arunachal Pradesh by A.N Rao and Ajay Rastogi have not named the place of its occurrence. But its presence in Nepal is mentioned in "The Orchids of Nepal Himalaya" by N.L.Banerjee and Prabha Pradhan. Hence it can be said that Sikkim and Eastern Nepal form the seat of origin of this species.

Hara (1971) reported the distribution of *Dactylorhiza hatagirea* (D. Don) Soo from Kashmir to Bhutan. However, Pearce and Cribb as well as A. Nageswara Rao and Ajay Rastogi have not listed the species from Bhutan and Arunachal Pradesh. In Sikkim the species is not yet reported; rather it is always confused with *Gymnadenia orchidis* whose under ground tubers resemble that of *Dactylorhiza hatagirea*. Tubers of *G. orchidis* are short, joined in halfway whereas the tubers of *Dactylorhiza hatagirea* are longer, tubular and joined at the base. Besides that the flowers in former are much smaller and compact but tubular head as compared to latter.

***Cypripedium cordigerum* D.Don** has been reported from Jammu & Kashmir to Nepal (Deva and Naithani 1986). So far this species has not been reported from Sikkim. But Pears and Cribb have reported it from various parts of Bhutan. This needs to be verified.

After sudden disappearance of *Cymbidium whiteae* King & Pantling, an endemic orchid from the Gangtok town, several individuals and institutions became concerned. Consequently two schools of thought emerged out on this issue of how and why the species disappeared from the place of its discovery. One school of thought is of the opinion that removal of trees is the main cause of the disappearance. But on the contrary, the other school of thought is of the opinion that the disappearance is due to over plantation. Based on a careful analysis the author came to the conclusion that, unlike other orchid species, *Cymbidium whiteae* may be very sensitive to air pollution. Because of this fact the species has totally vanished from Gangtok from where its first discovery was made by Mrs Claude White, the wife of political agent during 1989. Till late sixties its presence was reported from Gangtok. But now it is no more there, even when the habitat of Gangtok town is as it was before; even when the populations of preferred host trees of *Engelhardtia spicata* are in

Plate 10
Threatened Orchids of Sikkim

Pleione humilis

Pleione praecox

Gastrodia elata

Odontochilus grandiflorus

Phaius maculatus

Geodorum densiflorum

good numbers. It is also possible that certain pollinators have vanished from Gangtok town due to pollution. But the species can be seen in good number at Rumtek forest, the opposite hill of Gangtok town where pollution is almost nil as compared to Gangtok. This shows that the main cause of disappearance of the species is air pollution.

Till 1990 *Dendrobium amoenum* used to occur commonly at altitude between 900 – 1600 m in Sikkim. Till then there was no report of the species from Gangtok town. But during 1990 its presence was observed in Gangtok town at 1800 m. Now it is very common around Gangtok town especially on the bark of *Alnus nepalensis* trees. Some tall trees of *Alnus nepalensis* in B.S.I. campus are laden with the species. Similarly, *Cleisostoma linearilobulatum* (Seidenf. and Smitinand) Garay was never reported by King and Pantling within the greater Sikkim. But during recent survey, the author discovered this species occurring from 700m to 1200m altitude. But then its occurrence was only up to 1200m. More recently it has been found on the Pear trees at 2000m in Rumtek Botanical Garden.

Presence of some ground orchid species in the said areas indicates the Forest types of the area. For example the presence of ground orchids like *Cymbidium lancefolium* indicates that the forest area is dominated by *Castanopsis hyxtrix*.

***Calanthe brevicornu* Lindl :** *C. brevicornu* in East Sikkim occurs at an altitude of 2200 – 2500m (Plate 10) and the host trees in this zone are mainly *Castanopsis tribuloides*, *Machilus odoratissima* and *Ehretia wallichiana* along with some bamboo, ferns and grasses species. Similarly the occurrence of *Calanthe brevicornu* in Rabdentse Monastery area in West Sikkim at the same altitude have about 80% of similar types of trees and herb species combination as that of E. Sikkim.

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11.0 The Alpine Landscape in Western Sikkim: Special Habitats and Threatened Plants

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Introduction

The alpine landscape in the Himalaya is lined up as an archipelago on high mountains at the southern periphery of the high central Asia, separated from each other by deeply incised transverse valleys (Miehe 1997). Spread on either side of the Greater Himalaya or *Himadri*, this zone exhibits exceptional ecological, geohydrological, aesthetic and biological values. This zone is demarcated by a distinct treeline towards lower elevation that lies around 3300+200 m above msl in the western and 3800+200 m in the eastern Himalaya. The area immediately above natural treeline is usually occupied by a range of vegetation formations such as *Krummholz* (= stunted forest or crooked wood, German), matted strands of shrubs, herbaceous meadows, bogs, and fell-fields paved with mosses and lichens.

The alpine region in Sikkim and other parts of eastern Himalaya differs considerably from that of western Himalaya in terms of extent, terrain, climate, plant community composition, primary productivity, faunal assemblages and history of human use. This zone becomes rather limited in extent and fragmented from west to east. The eastern Himalaya has a prolonged monsoon season from June to September and little precipitation is received from western disturbances in winter. The western Himalaya, on the other hand, has a short monsoon from July to August and a fairly long wet season from November to April. The eastern Himalaya is more tropical in latitude and is geographically closer to the Bay of Bengal and heavily influenced by the monsoon winds. Consequently, it has an oceanic climate with higher humidity and exhibits higher seasonal primary productivity. The tree line is higher at 4000 m and the permanent snow line at 5500 m. The *krummholz* and alpine scrub zone is also more extensive. It has a relatively recent history of extensive grazing and pristine areas with an insignificant history of grazing still exist. The recent geological origin, limited extent and fragmentation, steeper terrain and higher rainfall make them more fragile as compared to the western Himalaya.

The Khangchendzonga NP is located on the western flank of Sikkim (India) between 27° 30' to 27° 55' N latitude and 88° 02' and 88° 37' E longitude and spreads over 1784 km^2 adjacent to Nepal. The park is named after Mt. Khangchendzonga (8586 m), the third highest peak in the world. The park covers nearly 25% of the geographical area of the state (Sikkim). The climate of KNP is characterized by a long monsoon followed by a long winter. The annual rainfall varies from more than 300 cm in the southern part to less than 150 cm in the north and altitude ranges from *ca*. 1220 m to 8586 m. As per the classification by Champion & Seth (1968), as many as 18 distinct types and sub-types are discernible within KNP. Floristic study by Maity and Maiti (2007) indicates that the KNP and surrounding buffer forests harbour about 1580 species of vascular plants which include 106 species of Pteridophytes, 11 Gymnosperms and 1463 Angiosperms. The alpine zone as used in this article includes the areas between 4000 and 5000 m elevation. Physiognomically it starts from where the *Krummholz* thickets end and the alpine scrub begins and extends up to the subnival vegetation. About 22% of the park with an extent of 390 km^2 falls within this zone.

Vegetation Structure and Composition

The alpine meadows of KNP are dominated by sedges namely *Kobresia nepalensis* (on smooth slopes), *Kobresia duthiei* (on broken slopes) and *Kobresia pygmaea* and *Kobresia schoenoides* (in dry meadows). Grassy meadows of *Danthonia cachemyriana* and tall forb communities in deep soil are more characteristic of the western Himalaya and were virtually absent in KNP (Rawat 2005). The major grass-dominated vegetation in the KNP is the *Deschampsia caespitosa* marsh meadow found only in the fringes of glacial lakes and streams. The subalpine thickets of *Rhododendron* and alpine scrub vegetation of *Rhododendron*, *Cassiope* and *Juniperus* is much more extensive in the Sikkim Himalaya. Based on numerical classification the vegetation of the alpine zone was segregated into 11 types namely, krummholz thicket, Juniper scrub, *Rhododendron* scrub, morainic scrub, *Salix sikkimensis* riverine thicket, *Myricaria rosea* riverine scrub, *Kobresia nepalensis* moist meadow, *Kobresia duthiei* moist meadow, *Kobresia pygmaea* moist meadow, *Deschampsia caespitosa* marsh meadow and *Anaphalis xylorhiza* dry meadow (Plates 11 A & 11B). Brief description of the special habitats is as follows:

(i) *Krummholz* thickets : Extensive *Krummholz* thickets are found between 3600 to 4200 m. This category extends upwards from the tree line and gradually becomes stunted with elevation before giving way to the alpine scrub communities. They favour shady and moist localities and are most luxuriant in the north and northwest aspects especially on rocky slopes. The vegetation formation is dense, thicket forming and impenetrable with the canopy height generally varying between one to four meters mostly dominated by various species of *Rhododendron*. The following associations are easily identifiable *viz.*, *Rhododendron campanulatum*, *R. lanatum*, *R. thomsonii* and *R. wightii – R. fulgens*. The floor is thickly carpeted with mosses and fallen leaves and the ground flora is generally sparse (Plate 11A).

(ii) Alpine scrub : Dwarf Rhododendron scrub is widespread in the higher reaches above the *Krummholz* zone. This category (less than 1 meter tall) represents alpine moist scrub and favours the north - northeastern aspects between 3900 to 4600 m. This vegetation is very dense and the *Ericaceous* cover is more than 50% with very few gaps or openings. The shrub layer is co-dominated by three species of *Rhododendron*, *viz.*, *R. anthopogon* (sun-pate), *R. setosum* and *R. lepidotum.* Juniper scrub is found generally between 3700 to 4400 m on warmer slopes i.e, south and southwest aspect. The characteristic species are *Juniperus recurva* and *J. indica*. The former is prostate in habit and found more commonly between 3700 - 4100 m, while the latter usually occurs in the form of erect shrub between 4000 to 4400 m. In the inner dry valleys this Juniper ascends up to 4800 m.

(iii) *Kobresia nepalensis* moist meadow is the most widespread and dominant vegetation in altitudes ranging from 4000 to 5100 m in the alpine zone. It occurs most luxuriantly on the smooth slopes and ridge tops in the upper reaches of moist, exposed, glaciated valleys. This dense soft mat like formation has an average height of 0.1 m. The cover of *Kobresia nepalensis* (sun buki) varies a lot with micro-topography and co-dominates with *Bistorta milletii*, *Potentilla peduncularis*, *Rhododendron lepidotum*, *Primula capitata* and species of *Arenaria*, *Juncus* and *Carex.* Openings in rich soils are colonized by *Potentilla peduncularis*, around cattle camps by *Ranunculus hirtellus* (khorsane) and compacted soils by *Bistorta* sp., *Picrorhiza scrophulariiflora* (kurki), *Lomatogonium* spp. (Vern. Sharmaguru and Mahaguru) are the valuable ethno-medicinal plans found in this vegetation. This is the most extensive and nutrient rich vegetation that sustains livestock and wild ungulate populations in the KNP.

(iv) *Kobresia duthiei* moist meadow found in pockets prefers moist valleys on slopes that are bouldery and steep in the 4000 to 4600 m elevation zone. The vegetation is tussock forming dominated by *Kobresia duthiei* (cover greater

than 40%) with an average height of 0.30 m. In openings *K. nepalensis*, *Kobresia capillifolia*, *Rheum acuminatum*, *Rhododendron anthopogon*, *Geranium donianum* and species of *Heracleum*, *Swertia* sp. and *Pleurospermum* and *Juncus* are usually found. Good population of valuable medicinal plants like *Aconitum ferox*, *Nardostachys grandiflora*, *Bergenia purpurascens* can be seen at such sites.

(v) *Kobresia pygmaea* moist meadow is found in the upper reaches of the glaciated and relatively dry Zemu and Lhonak valleys in the elevation range of 4400 to 5100 m. As the name suggests in the upper reaches this vegetation is stunted having average height of 0.05 m. In the lower reaches, especially along streams *Kobresia schoenoides* and *Bistorta vivipera* and in the upper reaches *Kobresia* spp., *Bistorta milletii*, *Potentilla fruiticosa* and *Aster falconeri* co-dominate.

(vi). *Anaphalis xylorhiza* dry meadows are found in the trans-Himalayan glaciated valley flats usually between 4500 to 5100 m. This Tibetan steppe like vegetation grows in dry, arid conditions and is characterized by dwarf herbaceous formations (average height is 0.1 m). The total vegetation cover is not more than 40%. *Anaphalis xylorhiza* is the dominant species (cover greater than 20%) with other associates such as *Bistorta vivipera*, *Kobresia schoenoides*, *Kobresia nepalensis*, *Lancea tibetica* and various species of *Arenaria* and *Pedicularis.* Other species include *Aster diplostephiodes*, *Delphinium caeruleum*, *Cyananthus incanuns*, *Cortiella* sp., *Scabiosa* sp., *Gentiana stipitata*, *Lonicera rupicola*, *Elymus nutans* and species of *Rhodiola* and *Oxytropis.*

Floristic Structure and Threatened Plants

Based on extensive floristic surveys conducted during 2004 - 2007, we have recorded a total of 585 species of angiosperms within the alpine zone of KNP. These belong to 67 families and 243 genera. The dominant families are Asteraceae (69 species), Ranunculaceae (35 species), Poaceae (32 species), Scrophulariaceae (30 species), Cyperaceae (28 species) and Rosaceae (28 species). The prominent genera are *Pedicularis* (21 species), *Carex* (18 species), *Saxifraga* (18 species) and *Rhododendron* (17 species). The gymnosperms in the subalpine and alpine zones include *Taxus baccata* subspecies *wallichiana*, *Tsuga dumosa*, *Abies densa*, *Juniperus indica*, *Juniperus recurva* and *Ephedra gerardiana*. The KNP along with the adjacent reserve forests is home to as many as 22 endemic and 22 rare and threatened plants. Species of high conservation value and botanical interest in sub-alpine and alpine areas include *Schizandra grandiflora* (a primitive climber with flowers like miniature *Magnolia*), *Helwingia himalaica* (bearing flowers at the center of the leaf and endemic to the Eastern Himalaya), *Circaeaster agrestis* (*Chloranthaceae* of uncertain affinity), *Pinguicula alpina* (an insectivorous plant), *Triosteum himalayanum* (endemic to Himalaya), *Brachycaulos simplicifolius* (an unusual herb of *Rosaceae*) among others. Few more alpine plants needing special mention for their high conservation significance are the wild poppies (*Meconopsis* sp.) which bear spectacular flowers and have several medicinal properties, species of *Corydalis*, *Rhodiola*, *Pleurospermum*, *Saussurea*, *Primula*, *Gentiana*, *Swertia*, *Pedicularis*, *Polygonatum* and several ground orchids. Among the rhubarb species *Rheum nobile* is particularly vulnerable owing to its striking inflorescence which is often plucked by the herders and local communities to make pickle.

Key floral species for conservation are *Rheum nobile* (Kenjo), *Gymnadenia orchidis* (panch amle), *Nardostachys grandiflora* (jatamansi), *Ephedra gerardiana*, *Picrorhiza scrophulariiflora* (kurki), *Aconitum ferox* (Bikh), *Saussurea obvallata*, wild Alliums, Giant Lily (*Cardiocrinum giganteum*), Pseudo-ginseng (*Panax pseudo-ginseng*), *Pleurospermum* sp. and Caterpillar-mushroom (*Cordyceps sinensis*). Status of a few species is given below :

***Saussurea obvallata* (DC.) Sch.-Bip. (Asteraceae)**
Local Name : *Brahma-Kamal*
Distribution : Relatively drier valleys of Lachen and Lachung in North Sikkim
Habitat : Along streams in sub-alpine fir and alpine scrub habitats between 3,500 to 4,000 meters elevation
Threat : Grazing and inflorescence valued as an offering to Hindu deities

***Gymnadenia orchidis* Lindl. (Orchidaceae)**
Local Name : *Panch-Amle*
***Distribution* :** Relatively moist valleys in West and North Sikkim
Habitat : Sub-alpine fir and alpine scrub habitats between 3,000 to 4,000 meters elevation
Threat : Digitate tuber collected for medicinal purposes

***Rheum nobile* Hook. f. & Thorns. (Polygonaceae)**
Local Name : *Kenjo*
Distribution : Endemic to Eastern Himalaya, it is distributed in the moist valleys of Sikkim
Habitat : Scree slopes in the high alpine areas between 4,700 to 5,500 meters elevation in skeletal soils
Threat : Grazing and collection by herders for making pickle

***Aconitum ferox* Seringe (Asteraceae)**
Local Name : *Bikh*
Distribution : Moist valleys of Sikkim
Habitat : Sub-alpine fir and alpine scrub habitats between 3,000 to 4,000 meters elevation
Threat : Tuber collected for medicinal purposes

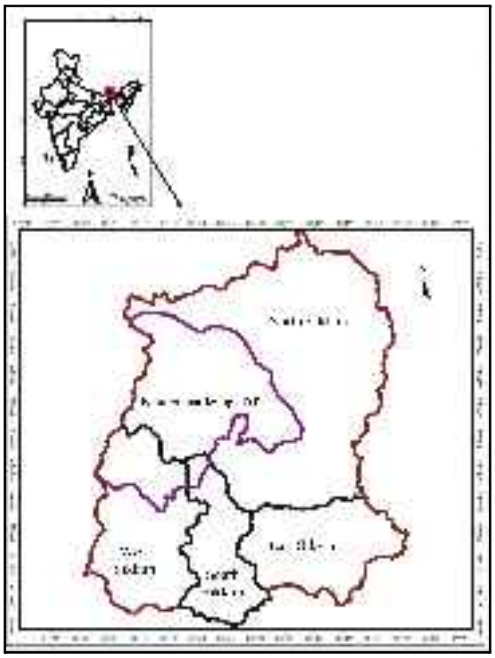
Impacts of Anthropogenic Activities

Pastoralism, collection of medicinal and aromatic plants and subsistence hunting were the main livelihoods prevalent in the KNP traditionally, while trekking tourism has expanded rapidly since early 1990s. Major impacts of anthropogenic activities on alpine vegetation are discussed below:

i. *Impacts of Pastoral Practices* : In the KNP the livestock biomass increased from 608 metric tonnes in 1950 to 763 metric tonnes in 2004 owing to a substantial rise in the populations of yak and cow-yak crossbreeds. The livestock impact units in the winter pastures increased more than 8 times from 2 to 17 Livestock Unit days ha^{-1} during this period. The main impacts of pastoralism on the natural environment are clearing and burning of forests, localized extraction of slow growing Juniper and Rhododendron firewood and a decline in the population of grazing sensitive plants. The herders carried out habitat manipulation by converting vegetation types like Juniper scrub in the alpine zone and the oak, hemlock and fir forests in the temperate and sub alpine zones into artificial pastures. Plants sensitive to yak grazing found in pastures not grazed by them are *Heracleum* sp. (ganer), *Allium pratti* (dandu), *Kobresia duthiei* (bhalu buki), *Pleurospermum* spp. (seto cheeru and shyamphul), *Saussurea obvallata* (brahma kamal) and *Saussurea uniflora* (thulo dudhe jhaar). These plants are annual or biannual, tall and regarded as nutrient rich by the herders.

ii. *Impacts of Medicinal and Aromatic Plant Collection* : Alpine medicinal plants mostly *Aconitum ferox* (bikh) and *Picrorhiza scrophulariiflora* (kurki) were in high demand and were collected from 1970s to 1990s in truckloads with dried tubers of *Bikh* fetching USD 0.33 kg^{-1} and dried stems of *Kurki* fetching USD 0.44 kg^{-1}. The state government banned the commercial collection of medicinal plants for ten years from 2001 onwards. Aromatic plants *Juniperus recurva* (sikpa) and *Juniperus indica* (bhairung) were in high demand for incense making and large scale commercial collection was done by the yak and dzo herders between 1970s and 1990s. Dried *Juniperus recurva* used to fetch USD

Plate 11A
Alpine Habitats of Khangchendzonga NP, Sikkim



Krummholtz thicket (3800 – 4400m)

Juniper scrub (4000 – 4400m)

Rhododendron scrub (4000 – 4500 m)

Kobresia meadow

Kobresia pygmaea moist meadow

Anaphalis xylorhiza dry meadow

Plate 11B
Some Threatened Plants of Alpine Zone of Sikkim

Saussurea obvallata
(BRAHMA-KAMAL)

Gymnadenia orchidis
(PANCH-AMLE)

Rheum nobile
(KENJO)

Aconitum ferox
(BIKH)

0.033 kg^{-1} while dried *Juniperus indica* USD 0.056 kg^{-1} in the local market and were collected in truckloads. At present no apparent impact of past collection was noticeable except very low populations of the high value species in south-western parts of KNP. The abundance of these plants is relatively better in Zemu valley, which has remained relatively untouched in terms of commercial exploitation of plants.

Conservation Action : In Sikkim a determined political leadership along with strong support from the local people is initiating conservation action to reduce the yak (and their hybrid) numbers in the greater Himalayan part of KNP while also providing alternative livelihood support to the herders from ecotourism enterprise. Consequently over the last few years the livestock population in the KNP has reduced significantly. Commercial harvest and transit of medicinal and aromatic plants has been banned from the forest areas of the State since 1990 owing to degradation of habitat and rapid depletion of this valuable resource.

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12.0 Arunachal Pradesh – The Cradle of Flowering Plants

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Introduction

The land of the rising sun, Arunachal Pradesh or the NEFA (North-East Frontier Agency) of yester years is situated in the extreme north-eastern corner of India. It covers an area of 83740 km^2 and lies between 26° 28' to 29° 30' North latitudes and 90° 30' to 97° 30' East longitudes. It is bounded by Mc-Mohan Line in the north that separates India from Tibet (China), by Myanmar (Burma) in the east, the states of Nagaland and Assam in the south and by Bhutan in the west. Administratively, the state is divided into 15 districts which represent more or less distinct water-sheds or ethnographic sub-regions, invariably named after a river. The state is well known for its diverse ethnic groups, inhabiting various regions, each with its distinct culture and dialect. Traditionally, the state is divided into 5 ethnographic regions (based on the predominance of native communities): i. Aka hills, ii. Daphla hills, iii. Miri hills, iv. Abor hills and v. Mishmi hills.

Biogeographically, Arunachal Pradesh forms major part of Eastern Himalaya (2C), the richest biogeographic province in India. The entire territory forms a complex system of hills with varying elevation ranging from 50m asl adjacent to Assam plains to about 7750m in the Great Himalayan range. The hill ranges are extremely rugged, dissected by deep river valleys and streams which run more or less in north-south direction. The rainfall spreads over 8-9 months except during winter season and it varies from 2,000 mm in the higher reaches to 8,000 mm in the foot hills. There are six major rivers flowing through the state, viz., Kameng, Subansiri, Siang, Lohit, Tirap and Dibang. These rivers and their tributaries form distinct catchments culminating at snow peaks towards higher reaches and finally drain into Brahmaputra. There are six principal rivers in the state namely: Kameng, Subansiri, Siang, Lohit, Tirap and Dibang. Physiographically the state can be divided into three zones from south to north as follows:

i. ***The Alluvial Plains*** *:* This is a narrow division running parallel to foot-hills along the southern border of Arunachal Pradesh and includes the longitudinal alluvial plains Kameng, Subansiri, Siang, Dibang and Lohit. The area has a more or less flat topography that gradually merges with the plains of Assam in the northern part of Brahmaputra valley.

ii. ***The Lesser Himalaya***: Rising abruptly from the foot hills, this region is interspersed by heavily dissected Shiwalik formations and sedimentary rocks of Lesser Himalaya. The highest altitude of this zone is about 1000m.

iii. ***The Greater Himalaya***: It is the dominant division of the state, marked by the peaks reaching as high as 6000m and more. Some of the known peaks of this division are: Gorichen (7300m), Kangto (7090m), Namche Barwa (7756m) and Kulangri (7544m).

General Vegetation

The diversity of topographical features and climatic conditions has favoured the growth of luxuriant forests, which cover about 61.55% of the total geographic area. The forest vegetation comprises some of the tallest trees, tree ferns, bamboos, a large number of orchids, rhododendrons, several botanical curios, rare, endemic, primitive flowering plants and a store house of a large number of economically important species. Such an unparallelled occurrence of life forms can be attributed to the peculiar location of the state which is at the junction of the Paleoarctic, Indo-Chinese, and Indo-Malayan biogeographic regions. The biotic elements from all these regions occur in this state making its biological diversity extremely rich.

The characteristic three storeyed sequence of vegetation particularly in the tropical and subtropical zones is one of the significant features in Arunachal Pradesh where the shrubs and small trees form the ground storey, the medium sized trees form the middle storey and the lofty trees with dense canopy form the top storey. The vegetation of Arunachal Pradesh can be divided into following categories:

(A) Tropical Forests: Based on the composition and structure this can be further divided into two subtypes *viz.,* Tropical Evergreen, and Tropical Semi-evergreen. The former typically extends from foothills up to 1000m in the areas receiving maximum rainfall. Species of *Altingia, Amoora, Artocarpus, Terminalia, Canarium, Castanopsis, Dysoxylum, Cinnamomum, Quercus, Magnolia, Mesua, Duabanga, Lagerstroemia, Ptereospermum, Dillenia, Bischofia* and *Gmelina* are some of the common trees of this type. The top canopy or the upper storey in these forests cover stifle plants of the lower storeys providing ideal conditions for the profuse growth of understorey vegetation as well as epiphytes including orchids, ferns and a variety of climbers.

(B) Subtropical Forests: These forests, basically evergreen in nature and having continuous dense canopy, occur mainly between 900-2000m. The trees attain large dimensions i.e., 25-40m in height. These forests are dominated by species of *Acer, Alnus, Beilschmiedia, Litsea, Kydia, Quercus* and *Magnolia* and harbour profuse growth of epiphytic orchids, ferns and climbers. The humus rich forest floors are occupied with dense and diverse ground flora consisting of a large number of herbaceous species and terrestrial orchids.

*(C) Pine Forests***:** These forests extend both in subtropical and temperate belt in between 1000 m to 1800m elevation. Generally occupying the smaller rain shadow areas, these forests are represented by three species of *Pinus, viz., P. roxburghii, P. wallichiana* and *P. merkusii* occasionally mixed with species of *Alnus, Betula*, *Rhododendron, Quercus, Lyonia, Tsuga* and *Prunus*. The ground flora is less diverse compared to other categories and do not support luxuriant growth of vascular and non-vascular epiphytes.

(D) Moist Temperate Forests **:** These forests occur in all districts as a continuous belt between 1800-3500 m altitude and can be divided into two subtypes, viz., Temperate broad leaved and Temperate Conifer forests. The former extend from 1800 to 2800m. *Quercus-Michelia-Acer, Castanopsis-Acer-Magnolia, Magnolia-Quercus- Exbucklandia* and *Rhododendron- Quercus- Magnolia* are some of the common associations found in these forests. The epiphytic flora is dominated by a number of species of orchids, Rhododendrons, ferns and fern allies. The ground flora abounds in terrestrial species of orchids and other herbaceous elements. The Temperate conifer forests are found between 2800 to 3500m elevation except in Tale valley. These areas experience heavy snowfall during winter. The domoinent species of this zone are *Abies, Taxus, Picea, Larix, Juniperus* mixed with species of *Pinus, Acer, Rhododendron, Viburnum, Gaultheria, Berberis* with gregarious undergrowth of temperate bamboo at places and terrestrial orchids.

(E) Subalpine and Alpine Forests : There is no sharp division between subalpine and alpine type and only a rough distinction can be made with concentration of certain elements. The zone between 3500-4000 m is termed as the subalpine zone characterized by tree species like *Abies spectabilis, Cupressus corneyana, Juniperus recurva, Larix griffithiana, Pinus wallichiana, Rhododendron* spp., *Taxus wallichiana* and *Tsuga dumosa*. The common shrubs are *Berberis asiatica, B. wallichiana, Eurya acuminata, Gaultheria fragrantissima, Photinia integrifolia* and species of *Vaccinium.* Towards higher altitude a few terrestrial orchids and other small alpine herbs like *Aconitum, Primula, Saussurea, Gentiana, Polygonum, Rhodiola, Sedum, Saxifraga* dominate the ground vegetation.

The alpine zone (4000 to 5500m asl), i.e. area above tree line remains covered with snow for the major part of the year. The vegetation is dominated by dwarf shrubs such as species of *Rhododendron* and herbaceous elements with attractive brilliantly coloured flowers. Various species of *Aconitum, Arenaria, Gentiana, Meconopsis, Polygonum, Primula, Rhodiola, Saussurea, Saxifraga* and *Sedum* abound in the alpine region.

(F) Secondary Forests: Degraded forests as a result of anthropogenic pressures in the form of shifting cultivation, developmental activities and urbanization and forest fires lead to secondary scrub and open woodlands. Such forests at the lower altitudes are characterized by the presence of species of *Bauhinia, Callicarpa, Glochidion, Mallotus* alongwith common shrubs like *Capparis, Clerodendrum, Croton, Eurya, Randia, Rubus, Viburnum* species weeds like *Ageratum, Eupatorium* and *Mikania.* In temperate belt, subsequent to 'Jhum' cultivation species of bamboo, e.g., *Bambusa, Chimonobambusa, Dandrocalamus, Schizostachyum* take over. Open forests and areas with poor soil are dominated by various grasses e.g., species of *Arundinella, Chrysopogon, Eragrostis, Imperata, Mnesithea, Paspalum, Saccharum, Setaria, Themeda* and *Thysanolaena.*

Floristic Diversity and Plants of High Conservation Significance

The state is home of myriad plant and animal species making it one of the important biodiversity hotspots in the world (Chowdhery *et al.,* 1996, 2008; Chowdhery 1997). It harbours over 5000 species of flowering plants distributed across a wide range of habitats. These include a large number of economically important, interesting and biologically curious plants which are confined to this state. The early history of botanical explorations in the state can be seen in Burkill (1924 – 25). Some of the angiosperm groups having high conservation significance (Plate 12) are briefly described below:

(a) Wild Edible Plants : A large number of wild plants are consumed as vegetable, fruits, etc. these are collected from the forests by the locals and many of them are sold in the local markets also. *Alternanthera philoxeroides* (leafy vegetable), *Baccaurea ramiflora* (fruits), *Begonia josephii* (leafy vegetable), *Calamus erectus* (fruits), *Castenopsis indica* (seeds), *Dioscorea bulbifera* (tubers), *Elaeagnus latifolia* (fruits), *Flemingia procumbens* (tuberous roots), *Houttuynia cordata* (leafy vegetable), *Impatiens longipe* (leafy vegetable), *Polygonum* spp. (leafy vegetable), *Rhus semialata* (fruits), *Viburnum* spp. (fruits), etc. are some of the commonly used plants for food.

(b) Wild Relatives of Cultivated Plants: Arunachal Pradesh falls under 'Hindustan Centre of Origin of Cultivated plants'. Several species from which the present day cultivated plants were selected still continue to exist alongwith their close relatives. The genes from wild relatives may help plant breeders to breed crops that can resist pests and diseases and thus are in utmost need more than ever before to feed the fast expanding world population. The state is rich in wild varieties of *Musa, Citrus, Allium*, *Brassica*, barley, maize, buckwheat, fingermillet, foxtail- millet, amaranth, french bean, soybean, cowpea, blackgram, pea, scarlet bean, pumkin, cucumber, ginger, chayote, tree tomato, pome and stone fruits. Apart from these, the state is equally rich in tall and drought-hardy types of Sesame, tree cotton, taros, yam and species of *Colocasia* and *Capsicum*.

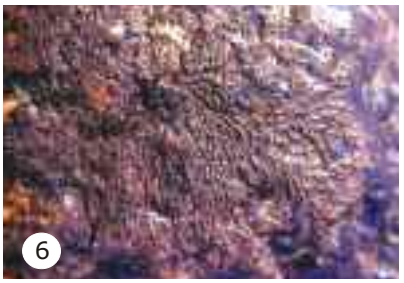
(c) Species of Medico-ethnobotanical Importance: The north-eastem region especially Arunachal Pradesh is the home of a large number of tribal population having immense information on the use of natural resources acquired over centuaries through their experience. A large number of plants and animals are used by them in their day to day life for food, medicine, fish-poisoning, dye making, local drinks, etc. A wide range of medicinal plants are used by the local people for health care and a majority of them are used in the preparation of various Ayurvedic, Homoeopathic and Unani medicines. In addition there are several species of other ethnobotanical value e.g., *Acacia rugata* (powdered stems are used in fish-poisoning); *Amischotolype mollissima* (plant juice is used as arrow-poison); *Gallium mollugo* (decoction is used in dying clothes); *Anisomeles ovata* (used to relief mascular pain); *Berberis wallichana* (bunch of spines are used in tattooing chin and forehead); *Bidens biternata* (leaves are as substitute for tea); *Callicarpa arborea* var. *ovalifolia* (stems are used as bstitute of tobacco); *Chenopodium album* (seeds are used for preparation of country liquor' Apong'); *Chimonobambusa callosa* (bark is used as rope);*Chlrophytum arundinaceum* (used as substitute of onion); *Crassocephalum crepidioides* (leaf juice is used to prevent bleeding); *Dendrobium hookerianum* (flowers are used to prepare yellow dye); *Dendrocalamus strictus* (planted near the house in spiritual belief of keeping the devil spirit away); *Elscholtzia blanda* (paste prepared from leaves is used to clear pus and maggot of cattle); *Gaultheria fragrantissima* (leaves and tmigs are used as incense); *Gentiana bryoides* (whole plant mixed with' sillu' leaves used as incense, leaves are used in malaria and dysentery); *Geranium nepalense* (the paste prepared from whole plant mixed with turmeric and mustard oil is used in cases of eczema, itch and other skin diseases); *Gerbera piloselloides* (used as hot fomentation to relief rheumatic pain); *Impatiens racemosa* (whole plant is used in malarial fever); *Lasianthus longicauda* (fruit extract is used as gum for catching birds); *Plectranthus hispidus* (whole plant is used in cough and cold); *Rubus paniculata* (leaves are used as substitute for peper betel); *Scrophularia elatior* (decoction of whole plant is used in urinary trouble); *Tacca integrifolia* (decoction of leaves is used in blood dysentery and diarrhoea).

(d) Botanical Curiosities: Several species of angiosperms represent unique evolutionary links and botanical curiosities. For example, *Sapria himalayana* -one of the largest root parasites first reported by Griffith from Mishmi hills in Lohit district, *Rhopalocnemis phalloides* in Namdapha in Changlang district, *Balanophora dioica, Aeginetia indica* and *Boschniakia himalaica*, a parasite on the roots of *Rhododendron* spp. is found in the alpine meadows of the state. Among the common saprophytes, *Monotropastrum humile* and orchids such as *Epipogium* spp. and *Galeola* spp. are found in dense humid forests on humus rich soil. Among other curious plants mention may be made of *Drosera peltata,* an insectivorous plant and *Zeylanidium olivaceum,* a lichen like thallose herb which grows under water in fast running streams.

(e) Endemic species: The state abounds in endemic plant species. Some of the important endemic taxa include *Acer oblongum* var. *microcarpum*, *A. sikkimense* var. *serrulatum*, *Aconogonum pangianum, Begonia aborensis, B. scintillum, Capparis pachyphylla, Coptis teeta, Hedychium longipedunculaturn, Illicium cambodianum, Lysimachia congestiflora* var. *santapaui, Maesa arunachalensis, Merrilliopanax listeri, Paphiopedilum wardii, Pholidota watii, Primula subansirica, Pternopetalum senii, Pueraria bella, Rhododendron santapaui, Rhynchoglossum lazulinum, Schefflera venulosa, Tricarpelema glanduliferum,* and *Wallichia triandra*, etc.

(f) Rare and Endangered Plants: Shifting cultivation, over exploitation of medicinal and other useful economic plants, rapid development of infra-structure such as new townships, roads, industries, clearing of forest land for permanent agriculture have led to decline of many plant populations and degradation of their habitats. Some of the rare, endangered and vulnerable categories of plants are: *Ardisia rhynchophylla, Aquilaria malaccensis, Cymbidium hookerianum, C.eburneum, Coptis teeta, Dioscorea laurifolia, D. orbiculata, Diplomeris hirsuta, Drosera peltata, Eria ferruginea, Galeola falconeri, Gastrochilus inconspicuus, Huodendron biaristatum, Ilex venulosa, Nomocharis synaptica, Rhododendron nuttalli, R. santapaui, Rhopalocnemis phalloides, Sapria himalayana, Saurauia griffithii, Sunipia fusco-purpurea,* and *Tylostyli discolor*.

Plate 12
Plants of High Conservation Significance in Arunachal Pradesh



1. *Coptis teeta* Wall.; 2. *Dimocarpus longan* Lour.;
3. *Magnolia griffithii* Hook.f. &Thoms.; 4. *Aspidocarya uvifera* Hook.f. & Thoms.;
5. *Exbucklandia populnea* (R. Br. ex Griffith) R. Br.;
6. *Zeylanidium olivaceum* (Gardn.) Engl.; 7. *Alsophila spinulosa* (Wall. ex Hook.) Tryan;
8. *Caryota urens* L.; 9. *Arundina graminifolia* Hochr.;
10. *Renanthera imshootiana* Rolfe; 11. *Epipogium indicum* H.J.Chowdhery *et al.*;
12. *Sapria himalayana* Griffith; 13. *Magnolia hodgsoni* (Hook.f. & Thoms.) King

(g) Primitive Angiosperms : Presence of a large number of primitive Angiosperms in the state such as *Altingia excelsa, Aspidocarya uvifera, Betula alnoides, Decaisnea insignis, Euptelea pleiosperma, Exbucklandia populnea, Haematocarpus validus, Holboellialatifolia* var*. angustifolia, Houttuynia cordata, Magnolia caveana, M. griffIthii, M. hodgsonii, M. pterocarpa, Pycnarrhena pleniflora, Tetracentron sinense* and species of *Camellia, Magnolia, Michelia, Rhododedron,* orchids and several wild and economic plants suggest that perhaps in this region evolutionary development of Angiosperms have taken place. Takhtajan (1969) has suggested North Eastern Region of India as the true "Cradle of flowering plants" due to the presence of large number of primitive Angiosperms.

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13.0 Special Habitats and Threatened Plants of Meghalaya

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Introduction

The North-eastern region of India assumes a special significance in the biogeography of the country due to its unique location and varying eco-climatic conditions. It is located at the confluence of Indian Peninsula, Indo-Malayan and Indo-Chinese biogeographical zones (Rao 1994). It is regarded as one of the 25 biodiversity hotspots in the world (Myers 1988). The undulating topography, high rainfall and varied altitudes are main factors that have contributed to its rich ecosystem and habitat diversity. The region represents about 50% of the floristic wealth of India and contains about 8000 species of flowering plants including several representatives of primitive or ancient angiosperms (Takhtajan 1969). It abounds in gene pool of cultivars and land races of crop plants. So far, about 64 species of *Citrus* have been recorded from this region, of which, *Citrus assamensis*, *Citrus indica* and *Citrus latipes* are confined within Nokrek National Park of Meghalaya suggesting a strong indication that North-eastern region has been the centre of origin for *Citrus* (Singh 1984). However, this biodiversity is dwindling at an alarming rate due to high population pressure and ruthless exploitation of the forest resources. Consequently, more than 700 taxa of plants have been pushed to various categories of threat in this region (Nayar & Sastry 1988 - 90).

The state of Meghalaya is characterized by a wide range of physiographic, edaphic and climatic conditions making it a congenial area for luxuriant growth of vegetation. The recorded forest cover of the state is 9,496 km^2 (42.34 % of the total geographic area). More than eight different forest types ranging from tropical to temperate categories, a large number of primitive species (Haridasan & Rao 1985-87) and high level of endemism (1236 species *i.e.* 37.11% of total plant species including ferns and bryophytes) make this state extremely important for plant conservation point of view (Khan *et al*. 1997). The three ethnographic zones of the state *viz.*, the Khasi, Jaintia and Garo Hills have long been focal points of botanical exploration. According to Champion & Seth (1968), Assam Sub-tropical Hill Savanna, Khasi Sub-tropical Hill Forests, Assam Sub-tropical Pine Forests and Assam Sub-tropical Pine Savannah are the major forest types in the state of Meghalaya. Haridasan & Rao (1985-87) recognized following major categories of vegetation in Meghalaya: Tropical Evergreen Forests in low-lying, high rainfall areas; Tropical Semi-Evergreen Forests (up to elevation of 1200m, where annual rainfall is 1500-2000mm); Tropical Moist Deciduous Forests in areas with less than 1500 mm rainfall; grasslands and savanna on the tops of Khasi, Jaintia and Garo Hills. Isolated patches of temperate forests are found at higher altitudes in Khasi and Jaintia hills. Sub-tropical Pine Forests are also found at higher altitudes in such areas where the original broad-leaved forests were felled or disturbed otherwise.

The major anthropogenic activities such as shifting cultivation, infra-structure development and mining have led to decrease in forest cover, habitat fragmentation and loss of biodiversity. This article deals with some of the important vegetation types (broad habitats, *sensu lato*) and corresponding plant species peculiar to such areas.

Major Habitat / Vegetation Types :

1. *Tropical Evergreen forests :* This forest type spreads over the lower reaches of Khasi and Garo hills, up to 1200m. The dominant tree species include *Castanopsis indica, Callophyllum polyanthum*, *Dysoxylum gobara*, *Elaeocarpus rugosus*, *Engelhardtia spicata, Gynocardia odorata* and *Helicia robusta,* which are densely interwoven by lianas and a few emergents. The shrub species are *Dendrocnide sinuata, Lasianthus hookerii, Rhynchotechum ellipticum*, *Boehmeria platyphylla, Leea crispa* and *Allophyllus distachys*. During monsoon season members of Acanthaceae are quite abundant. The ground vegetation is dominated by *Impatiens* spp., *Polygonum* spp., *Ophiorrhiza* sp., *Globba clarkei*, *Hedychium* spp., and *Costus specious* among others. The forest floors are laden with a variety of ferns. The tree trunks and branches are covered with profuse growth of mosses, ferns, orchids and other epiphytes. Lianas and climbers like *Rhaphidophora* spp. are also abundant.

2. *Semievergreen forests* : These forests constitute the major natural habitat type of the state (IIRS 2003) and occupy the north-eastern and northern slopes with lesser rain-fall. The deciduous elements such as *Albizzia* spp., *Callicarpa arborea, Careya arborea*, *Dillenia pentagyna, Parkia roxburghii, Rhus javanica* and *Shorea robusta* are common. Other dominant species are *Elaeocarpus floribundus*, *Micromelum integerrium*, *Garcinia* spp., *Sapindus rarak* and *Symplocos paniculatus.* The forest floor has luxuriant growith of several shade loving species such as *Boehmeria sidifolia* along with members of Acanthaceae, Rubiaceae and Zingiberaceae.

3. *Moist Deciduous forests* : These forests are found in areas of lower rainfall (<1500 mm annual) and thin soil. Largely dominated by species such as *Terminalia myriocarpa*, *Sterculia villosa*, *Lagerstroemia* spp., *Gmelina arborea*, *Artocarpus gomezianus*. *Schima wallichii*, *Albizzia* spp., *Tetrameles nudiflora*, *Erythrina stricta*, *Vitex peduncularis* and *Tectona grandis* (plantations) are also seen frequently. Some evergreen species found mingling with these are *Elaeocarpus floribunda*, *Toona ciliata* and *Engelhardtia spicata*. *Leea* spp., *Desmodium* spp. *Lantana camara* and *Eupatorium* spp. form the ground cover.

4. *Bamboo brakes* : The Bamboo brakes are scattered in small patches sporadically among the jhum fallows. These can be described as the arrested successional stages, which follow the slash and burn for jhum cultivation. The dominant species of bamboo are *Melocanna bambusoides*, *Bambusa tulda*, with a few other tree species. The ground vegetation is dense and diverse.

5. *Pine forests* : Pine forests are confined to the higher reaches of the Shillong plateau in Khasi and Jaintia hills. *Pinus kesiya* is the principal species which forms pure stands. Often these patches are interspersed by a few broad leaved tree species like *Schima wallichii*, *Lyonia ovalifolia*, *Acacia dealbata*, *Myrica esculenta*, *Erythrina arborescens*. The shrub layer is sparse and is composed of a few species e.g., *Gualtheria fragrantissima* and *Eupatorium adenophorum.* Usually *Asplenium* sp. are found epiphytic in these patches.

6. *Riverine forests* : These forests are found in the vicinity of and along the course of the rivers. They form the seral type of tropical forests and are described as edaphic formations of the riverbanks due to the constant supply of telluric moisture (Champion & Seth 1968). The vegetation is dominated by trees like *Caryota urens*, *Drymicarpus racemosa, Aesculus assamica, Sapium baccatum* and *Ficus*. The species such as, *Leea indica*, *Leea edgeworthii*, *Dracaena elliptica*, *D. angustifolia*, *Rhinchotechum* spp., *Piper* sp. form the shrub layer. The presence of variety of epiphytes, ferns and lianas makes these forests physiognomically similar to evergreen forests mentioned above. The ground vegetation is dominated by *Ammomum* spp., *Elatostemma* spp., and several species of ferns.

7. *Hill Top / Plateau Grasslands* : Although most of the grassy blanks in the forested habitats are secondary in nature **(**Haridasan & Rao 1985), certain hill tops and high plateaus e.g, Balphakram and Shillong Plateau support peculiar grassland vegetation dominated by a few species of *Arundinella, Chrysopogon, Agrostis*, *Setaria glauca*, *Axonopus*

compressus along with the members of Cyperaceae, (e.g., *Fymbristylis dichotoma*, *Cyperus* spp.) and Eriocaulaceae. Moist hill slopes have dense growth of *Gualtheria fragrantissima*, *Eurya* spp., *Polygonum* spp., *Osbeckia stellata*, *Drosera peltata, Utricularia stiatula* and *U. bifida.*

8. *Sacred groves* : The age old traditions of all three tribes of Meghalaya, namely the Khasis, Jaintias and the Garos, have saved the patches of forests in prestine conditions till date. These secred groves chiefly fall in the subtropical zone represent the tropical broad-leaved hill forests (as described by Champion & Seth 1968) of the region. These groves harbour a plant wealth uncomparable with any other forest types of the region. Many of the endangered species are presently confined to the sacred groves. Members of Fagaceae family, *Rhododendron arboreum* and *Elaeocarpus* spp. dominate the vegetation. The trees show typically stunted growth. Epiphytes are found completely covering the tree trunks which support a number of epiphytic orchids and ferns (Plate 13A).

Threatened and Endemic Species

1. *Aeschynanthus superba* Wall. *ex* DC. (Gesneriaceae)

An epi- or lithophytic species with long, branched stem. Leaves 15 x 5 cm., entire, petiole 1.2 cm. Peduncles 1 – 1.5 cm, terminal and on short axillary spur, stout. Bracts upto 2.5 cm., ovate, deciduous, rose-red. Inflorescence sub-umbelled. Sepals thin, caducous. Corolla tubular, curved, mouth slightly oblique. Filaments exerted, minutely glandular hairy. Capsule 20 – 35cm.

Distribution : North-east India (Meghalaya upto 2000 m).
Status : Endangered

2. *Balanophora dioica* R.Br. *ex* Royle (Balanophoraceae)

Very variable root parasite. Rootstalks tuberculous. Shoots 3.5 – 7 cm, stout, covered with glabrous, imbricate scales. Flowers in a fleshy clubshaped usually unisexual receptacle. Perianth surrounded by fleshy, linear, truncate reddish bracts. Heads ovoid. Perianth segments white, generally 4, ovate, reflexed when open, Anther one, sessile, domeshaped. Female flowers closely packed, stigma protruded, white.
Distribution : Tropical and Sub-tropical belt of North-east India, Meghalaya (1000 – 2000m), Myanmar.
Habitat : Usually in evergreen forests of tropical and subtropical zone.
Status : Near Endemic and Rare

3. *Citrus latipes* (Swingle) Tanaka (Rutaceae)
Local names : Khasi – Soh- kymphor

A tree more than 15m in height, mostly furrowed at the base. Spines small and ascending. Leaflets 2.5 – 8 x 2.5 – 6 cm,, ovate- elliptic to lanceolate, petiole winged, wings of the same size or even larger than the leaflet. Entire or minutely crenulate, glabrous, coreaceous, punctate with oil glands. Flowers axillary, solitary or in few flowered cymes, white or light purplish, upto 2.5 cm in diameter, pedicels 6 cm long. Calyx small, 4-5 sepals. Petals 4. Stamens 20-25. Fruit 7 – 10 cm in diameter, punctate with large oil glands, pulp colourles, juice very acidic.

Distribution : Mikir Hills, gregarious in Khasi Hills.
Status : Endemic.

4. *Citrus indica* Tanaka (Rutaceae)
Local names : Khasi – Soh-manong ; Garo – Narang

A shrub with straight, ascending spines. Leaflets light green, 8- 15 x 5 – 8 cm, elliptic- ovate to oblong-lanceolate, crenulate-serrate, with translucent dots at the sinuses, petiole without wings. Flowers white, usually tinged with red, sweet scented, solitary or up to 10 in a receme, often unisexual. Petals linear- oblanceolate, gland- dotted. Stamens 20-40, filaments reddish. Fruit 8 – 12 x 5 – 7 cm, obovoid-oblong, often mamilate at the apex,yellow when ripe, aromatic, with thick spongy rind and colourless vescicles.
Distribution : Assam, along the edge of marshes and streams, up to about 1400m.
Status : Endemic

5. *Dendrobium williamsonii* Day & Reichb. f. (Orchidaceae)

Epiphytic herb. Leaves and sheaths puberulous, leaves oblong or lanceolate. Flowers 1-2 on a short bracteate peduncle. Sepals lanceolate, acuminate, dorsal ovate acute. Petals oblanceolate, mentum funnel shaped, side lobes of lip rounded, midlobe orbicular, ciliate. Disc obscurely 3-ridged. Flowers yellowish, lip dashed with red within.
Distribution : **Assam, Khasi Hills.**
Habitat : **Epiphyte**
Status: Endemic to north- east India, Endangered

6. *Monotropa uniflora* L. (Ericaceae)

A glabrous saprophytic herb. Stem single flowered, covered with scales upto 2 cm, ovate – lanceolate. Flowers nodding. Calyx lobes 4, resembling scales. Corolla lobes 5-6, ultimately deciduous, hardly saccate at the base, Stamens 10-12, anthers peltate, horizontal. Ovary 5-celled, ovules many on axile placenta. Capsule globose, 5-celled, 5-valved.
Distribution : Temperate Himalayas, Khasi Hills, upto 6000 ft.
Habitat : Mostly present in the Pine forests.
Status : Rare and endemic.

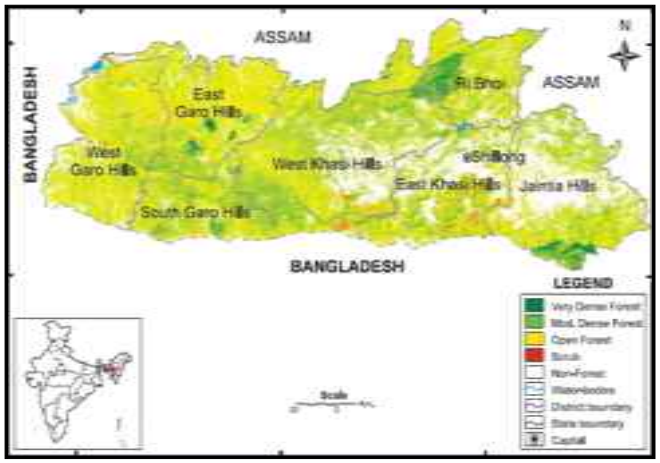
7. *Nepenthus khasiana* Hook.f. (Nepenthaceae)
Local names : Khasi – Tiew-rakot; Garo – Memang kokshi

A scandent shrub. Dioecious, climbing by leaves. Leaves alternate, an expanded lamina with tendril terminated by a pendant, coloured cylindrical pitcher with a recurved fluted rim and operculum. Inflorescence raceme or panicle. Flowers actinomorphic. Tepals 3 – 4, in 2 whorls, nectariferous. Male flowers: stamens 2 – 24, filaments connate, anthers bilocular. Female flowers : carpels 3 – 4, ovary superior, ovules many, style 1, stigma discoid. Fruits elongated, leathery capsule. Seeds numerous, filiform.
Destribution : Endemic to Meghalaya.
Habitat : Forest margins surrounded by grasslands.
Status : Critically endangered and endemic, confined to a few pockets of its natural habitat in Meghalaya.

8. *Osbeckia capitata* Benth. (Melastomataceae)

A lax branched perrenial shrub. Leaves ovate acute from a broad cordate base, subsessile, flowers capitate, mauve in colour, calyx segments lanceolate rounded, ciliate on the back, not persistant. Anthers with a beak more than half their own length. Ovary with bristles on its apex. Fruit ovoid.
Distribution : Bhutan, North-east, Meghalaya (upto 1800m).
Habitat : Forest edges
Status : Near endemic (North-east).

Plate 13A
Special Habitats and Threats in Meghalaya



G.S. Rawat

Balphakram National Park

Grassland at Cherrapunji

Mawphalang Sacred Grove,
East Khasi Hills

Ravee Bhat

Riverine Habitat at Mawlynnong

Hemant Tripathi

Limestone Mining near Cherrapunji

Plate 13B
Threatened Plants of Meghalaya

G.S. Rawat

John Lakadong

Ravee Bhat

John Lakadong

John Lakadong

Ravee Bhat

Ravee Bhat

John Lakadong

1. *Citrus indica*; 2. *Citrus latipes*; 3. *Aeschynanthus superba*;
4. *Dendrobium williamsonii*; 5. *Osbeckia capitata*; 6. *Panax pseudoginseng*;
7. *Nepenthes khasiana* (showing pitcher); 8. *Nepenthes khasiana* (in flowers);
9. *Balanophora dioica*; 10. *Monotropa uniflora*

9. *Panax pseudoginseng* Wall. (Araliaceae)

Herb with a horizontal root stalk. Stem 12 – 35 cm, erect, glabrous, terminated by a whorl of leaves. Leaflets 3 to 5, 5 12 x 2 – 4 cm, acuminate, caudate, tapering at base, serrate or bi-serrate, with scattered bristles. Petiole 5 - 12 cm, Inflorescence simole or with 2-5 umbellate heads. Bracteoles upto 0.6 cm, lanceolate. Flowers monoecious. Fruits red or black and red.
Destribution : North-east, Meghalaya
Habitat : Evergreen forests.
Status : Vulnerable.

10. *Taxus wallichiana* Zucc. (Taxaceae)

A small tree, dioecious, 6 m high. Stem fluted; bark thin, reddish brown; branchlets spreading. Leaves linear, 2-3.8 x 0.3 cm, coriaceous, flattened, arranged in two vertical opposite rows, dark grey glossy green above, paler beneath. Cones axillary, sessile, male and female cone on separate trees. Male cone solitary, axillary, sub-globose, bracts empty; stamens 10. Female cone solitary, few imbricate scales around an erect ovule; ovule surrounded at base by membranous cup shaped disc. Disc in fruit bright red, succulent, enlarged; 7-8 mm. Seeds olive green.
Distribution : Myanmar, South West China, Vietnam. Himalayas, Meghalaya, Naga hills, Manipur.
Habitat : In temperate moist and riverine forests.
Status : Globally the species has been cateorized under 'Least Concern', but it is very sparse in Meghalaya. It is basically a Himalayan element and its occurrence at lower altitude (up to 15 m asl) in the state calls for further genetic studies and it is vulnerable on account of its high value drug 'Taxol'.

Conservation

Although there are two National Parks, three Wildlife Sanctuaries and more than twenty-five reserved forests established to safeguard the floral and faunal diversity of the state, most of the threatened species occur outside the existing network of protected areas. In addition, there are a number of forest patches which are conserved by the local communities on the religious and cultural ground. The reserved and community forests altogether, constitute only about 5% of the state, while the protected areas cover <2% area (Khan *et al.* 1997).

The major threats to the plant populations are over-exploitation, habitat destruction and forest fragmentation. The forest cover has been depleted during last one decade (Roy & Tomar 2000). Various human activities such as agriculture, deforestation, coal mining and road construction have caused tremendous habitat destruction. Frequent land slides and forest fires have also led to depletion of forested habitats. Also, another cause for concern is lack of proper inventory of ecologically sensitive sites of endemic species. This calls for better conservation planning and site specific action plans so as to restore the special habitats and threatened plant populations. Unless preventive as well as remedial measures are taken, the rich floral diversity of the state will not be able to withstand the burgeoning anthropogenic pressures.

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An Interesting Species of *Pteris* from Mizoram

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During a recent floristic survey in Tawi Wildlife Sanctuary, Mizoram (18th January 2007), we collected an interesting fern from dense forests. On critical examination this species turned out to be *Pteris tricolor*. After a detailed scrutiny of literature it was revealed that this species has never been collected from the state so far. The specimen (collection no: 40630) was later confirmed by Chris Fraser – Jenkins, Kathmandu. This is the first collection from Mizoram. The species grows as an understorey in the undisturbed semi-evergreen forests among dense leaf litter. We could locate only a single clump on the forest floor. The forest was dominated by *Callophyllum polyanthum, Ostodes paniculata, Engelhardtia spicata, Diospyros toposia, Phoebe attenuata, Quercus polystachya, Cinnamomum bejolghota.*

Pteris tricolor

G. S. Bhardwaj

Section IV:
Upper Gangetic Plains, Arid & Semi-Arid Zones

14.0 Threatened Plants and Their Habitats in Indian Thar Desert

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Introduction

The arid region of India lies between 24° to 29° N latitudes and 70° to 76° E longitudes. It occupies nearly 9% of India's geographical area and covers 208,751 km² in Rajasthan alone and about 62180 km² in Gujarat (Rahmani 1997). Biogeographically, it is divisible into two provinces *viz*., Thar Desert of Rajasthan (3B) and Katchh Desert of Gujarat (3A) (Rodgers & Panwar 1988). The Thar Desert comprises southern Dune systems, northern Dune systems, eastern transition or Bagar located in Jalore, Jodhpur, Nagaur and Churu districts. The Katchh is further divisible into Little Rann, Great Rann, Islands and southern hills or *Bets*.

The Thar Desert is the eastern extension of the vast Persio-Arabian desert, which joins the great Sahara desert. It is about 640 km long and 160 km wide. It is covered by a depth of several meters of sands which are constantly shifted by winds blowing from the southwest (Krishnan 1982). The sand covers an irregular rocky floor, but occasionally local prominences and ridges rise above the level of the sand. Covering an area of around 62% in 12 districts of Rajasthan, this desert extends in the eastern part of Pakistan. Sand dunes are present in nearly 58% of the area (Shankarnarayan 1988).

A major portion of western Rajasthan falls under Sand dunes and sandy plains. Occurrence of saline-sodic soil with pH up to 9.0 is a common feature. The soils of the desert plains are sandy loam with a significant proportion of lime within 150 cm of soil profile (Dhir & Jain 1982).The average annual rainfall in the region is 275 mm and it is less than 100 mm in the extreme west. Luni River forms the main drainage system during rainy season. The climate of the desert region also shows extremes with temperatures ranging from sub-zero in winter to as high as 52°C in summer. Dust storms in the desert tracts may reach a velocity of 130 km/h and may deposit 50-75 mm of dust on the ground per storm. The relative humidity varies from 25% (April) to 85% (July). Frosts are generally severe during winter, particularly in the sandy areas. Tree saplings up to 2 m in height, sometimes, succumb to such frosts. The vegetation is extremely sparse in most of the land forms and generally described as Tropical thorn scrub and desertic formations.

The flora of the Indian desert is an admixture of the western (65.8%) as well as the eastern (34.2%) taxa migrated from both the regions, while only 9.4% species are endemic (Anonymous 1988). Blatter & Hallberg (1988) reported 507 species of flowering plants which was later updated by Bhandari (1990). The flowering plants in Indian desert including both indigenous and naturalized plants comprises of 682 species belonging to 356 genera of 87 families. *Poaceae*, *Fabaceae*, *Asteraceae* and *Cyperaceae* are the dominating families having about 111, 65, 41 and 36 species respectively (Bhandari 1990). The flora of the Thar desert are adapted to exploit the special microhabitats influenced by peculiar topography, geology, edaphic and climatic conditions. The Thar Desert harbours about 16 endemic plant species (Pandey *et al.* 1983, Singh & Pandey 1999).

Special habitats

Extremely harsh climatic conditions and varied micro-topographic features give rise to various plant associations which exhibit stark seasonality. The vegetation is mainly dry open and interspersed grasslands consisting mainly of stunted, thorny or prickly shrubs and perennial herbs which are mostly drought resistant. The ephemerals come up

during the rainy season, complete their life cycle before the advent of summer and the bulk of area is once more transformed into open sandy plains, desolate and barren. Desert vegetation is mainly categorized on the basis of its habitat (Shetty & Singh 1987). This article gives basic information on some of the special habitats, corresponding vegetation and unique plants associations in the arid zone (Plates 14A & 14B).

a. The Sandy plain and Sand dunes : The major portion of the desert is covered by sandy plains and sand dunes with varying degree of stability. The area is characteristic for its various vegetation associations in different regions. Generally the stabilized sandy plains and sand dunes are covered with vegetation of trees and shrubs *viz.*, *Leptadenia pyrotechnica*, *Crotalaria burhia*, *Sericostoma pauciflorum*, *Calligonum polygonoides*, *Capparis decidua*, *Lycium barbatum*, *Zizyphus nummularia*, *Aerva tomentosa*, *Calotropis procera*, *Acacia jacquemontii*, *Acacia senegal*, *Prosopis cineraria*, *Salvadora oleoides*, *S. persica*, *Tecomella undulata* and *Maytenus emarginatus.* Common herbs include *Argemone mexicana*, *Tephrosia purpurea*, *T. falciformis*, *Farsetia hamiltonii*, *Convolvulus microphyllous*, *Boerhavia diffusa*, *Heliotropium* sp., *Indigofera linifolia*, *I. cordifolia*, *Tribulus terrestris*, *T. rajasthanensis* and *Echinops echinatus. Citrullus colosynthis*, *C. lanatus*, *Cucumis* sp., *Cocculus pendulus*, *Mukia maderaspatana*, *Momordica dioica*, *Coccinia grandis* and *Pergularia daemia* are the typical climbers of sandy plains and sand dunes. Some grasses *viz.*, *Aristida funiculata*, *A. adscensionis*, *Cenchrus ciliaris*, *C. biflorus*, *C. prieurii*, *C. setigerus*, *Eragrostis* sp., *Cyperus* sp., *Dactyloctenium sindicum*, *D. aegyptium* and *Lasiurus scindicus.* Whereas inter dune areas also support similar vegetation but abundance of species may vary depending upon the availability of moisture and stability of sand dunes. Sandy and unstable areas lack any vegetation but at times some ephemerals can be seen during the rainy seasons *e.g.*, *Cleome viscosa*, *Polycarpaea corymbosa*, *Corchorus tridens*, *Triumfetta pentandra*, *Tribulus terrestris*, *Gisekia pharnaceoides*, *Mollugo cerviana*, *Mollugo nudicaulis*, *Pedalium murex*, *Sesamum indicum*, *Martynia annua*, *Amaranthus spinosus* and *Euphorbia* sp. *Cistanche tubulosa* a root parasite usually seen in this habitat and commonly associated with *Calligonum polygonoides*, *Capparis decidua* and *Calotropis procera.*

Pandey *et al.* (1983) and Bhandari (1990) reported a few threatened plants from the sandy habitats, *e.g.*, *Gisekia pharnacioides*, var. *pseudopaniculata*, *Ceropegia bulbosa*, *Caralluma edulis*, *Tecomella undulata*, *Cleome gynandra* var*. nana*, *Convolvulus auricomus* var*. ferruginosus*, *Convolvulus auricomus* var. *volubilis*, *Convolvulus blatteri* var. *Convolvulus scindicus*, *Euphorbia jodhpurensis*, *Alysicarpus monilifer* var. *venosus*, *Psoralea odorata*, *Rhynchosia schimperi*, *Tephrosia falciformis*, *Abutilon pakistanicum*, *Zizyphus truncata*, *Withania coagulans*, *Tribulus rajasthanensis*, *Cenchrus prieurii*, *Cenchrus rajasthanensis* and *Ephedra ciliata.*

b. Gravelly or rocky plain : Gravelly pediments or rocky plains, known as Magra, are important areas of desert, generally seen around Pokaran - Jaisalmer, Barmer, Jodhpur and Bikaner. Common species of this habitat are *Cleome vahliana*, *C. viscosa*, *C. gracilis*, *Fagonia indica*, *Rostellularia procumbens* and *Sericostoma pauciflora.* Besides this, some common prostrate plants growing in the gravelly ground are *Tribulus terrestris*, *Indigofera linnaei*, *I. linifolia*, *I. cordifolia*, *Heliotropium rariflorum*, *Euphorbia prostrata*, *E. granulata*, *E. clarkeana*, *Mollugo cerviana* and *Mollugo nudicaulis.* Common shrubs of gravelly habitat include *Euphorbia caudicifolia*, *Leptadenia pyrotechnica*, *Capparis decidua*, *Calotropis procera*, *Zizyphus nummularia*, *Acacia senegal*, *Prosopis cineraria*, *Salvadora oleoides* and *Maytenus emarginatus. Dactyloctenium sindicum*, *Blepharis sindica*, *Melanocenchris jaquemontii*, *M. abyssinica*, *Oropetium thomaeum* and *Tragus roxburghii* are some of the common grasses in such habitat. The rocky areas represent different geological formations ranging from shallow depressions to elevated areas and foot hills. The rocky slopes have typical species such as *Anogeissus pendula*, *Asparagus racemosus*, *Balanites aegyptiaca* and *Euphorbia caudicifolia.*

According to Pandey *et al.* (1983) and Bhandari (1990), the plants of gravel habitat which are threatened in Thar desert include *Odontanthera varians*, *Commiphora wightii*, *Farsetia macrantha*, *Heliotropium rariflorum*, *Alysicarpus tetragonolobus*, *Monsonia heliotropioides*, *Abutilon bidentatum* var. *major*, *Pavonia arabica* var. *massuriensis*, *Tribulus*

rajasthanensis Aristida royleana, *Cenchrus prieurii* var. *scabra*, *Cenchrus prieurii* var. *prieurii* and *Cenchrus prieurii* var. *scabra.*

c. Small hillocks and rocky projections : There are many small hillocks and rocky projections isolated form Aravalli range *e.g.*, Massuria hill, Mador, Kailana hill, Viratra hill, Neemdi and Mata ki phadi which support a rich assemblage of plants such as *Capparis decidua*, *Grewia tenax*, *Euphorbia caudicifolia* (often associated with root parasite *Striga* sp.), *Rhus mysorensis*, *Commiphora wightii*, *Zizyphus nummularia*, *Acacia senegal*, *Anogeissus pendula*, *Boswellia serrata*, *Maytenus emarginatus* along with herbs *viz.*, *Tephrosia* sp., *Convolvulus* sp., *Boerhavia diffusa*, *Heliotropium* sp., *Tridax procumbens*, *Tribulus terrestris*, *Anticharis senegalensis*, *Barleria* sp., *Rhynchosia minima*, *Asparagus racemosus* and *Fagonia indica.*
Some of the threatened taxa found in such habitat are: *Convolvulus stocksii*, *Abutilon fruticosum* var. *chrysocarpa*, *Pavonia arabica* var. *massuriensis*, *Sida tiagii*, *Anticharis glandulosa* var. *caerulea*, *Tribulus rajasthanensis*, *Aristida royleana* and *Cenchrus prieurii* var. *scabra.*

d. Saline tracts : Saline-sodic soil is a common feature in this area with pH up to 9.0. Such habitats are characterized by the presence of salt tolerant taxa such as *Prosopis juliflora*, *Tamarix indica*, *Trianthema portulacastrum*, *T. triquetra*, *Zaleya govidea*, *Chenopodium album*, *C. murale*, *Salsola baryosoma*, *Suaeda fruticosa*, *Haloxylon recurvum*, *Sesuvium sesuvioides*, and *Portulaca oleracea. Pulicaria rajputanae* is endemic plant for saline habitat of Rajasthan and has very low abundance.

e. Aquatic and marshy habitats : Some natural and artificial water bodies and marshes harbour characteristic aquatic species such as *Lemna paucicostata*, *Naja graminea*, *N. welwitschii*, *Potamogeton crispus*, *P. pectinatus*, *Spirodela poyrhiza*, *Vallisneria spiralis*, *Nelumbo nucifera*, water hyacinth *Eichhornia crassipes* and *Wolffia* species. According to Panday *et al.* 1983, *Ammannia desertorum* is a threatened plant for aquatic habitat.

Threatened Plants

Drastic changes in the land use in recent decades and changes in habitat conditions due to invasion of alien invasive species are the major causes of concern in Thar Desert. For example, Indira Gandhi Canal has changed the moisture regime and soil pH in many parts that has led to changed species composition and decline in typical desert species. Water hyacinth (*Eicchornia crassipes*), which never occurred in the region has invaded several water bodies. A few species of water logged habitat such as *Arundo donax*, *Typha angustifloia*, *Phragmitis karka* have proliferated in waterlogged areas (Prakash 2001). Invasion of a thorny shrub *Prosopis juliflora* is a major threat to native flora and fauna. Some of the threatened plants of Thar Desert which need immediate conservation measures are mentioned below:

(i) *Ephedra foliata* Boiss. & Kotschy. (Family Ephedraceae)
Local Name : *Lana* (*Macadam*), *Suo-Phogaro*, *Unth Phog* or *Andho-Khimp*

Only Gymnosperm in the Thar Desert, rare in sandy habitat and occasionally climbing on shrub or a tree. It is a perennial, climbing fascicled branches, smooth, slender, striated, knotted stems. Male flowers in spikes, 1 to 3 together, on 1-2 cm long peduncles. Bracts 1.5-2 X 1.2-15 mm, rotund, obtuse, connate, ciliate. Perianth-lobes *ca* 2.5m m long, obovate, ciliate. Staminal column slightly exserted. Female spikes 2 to 3 flowered, subsessile, in pedunculate cymes. Bracts connate: outer *ca* 1mm long: inner ones 4-5mm long. Fruits 6-7 X 5.5- 6.5mm, ovoid-globose, fleshy, white. Seeds 2, 5-6 X 2-2.5mm, plano-convex, acute at apex, glabrous, brown. *Fl. & Fr.*: Sep.-Dec.

Ephedra foliata is a typical Gymnosperm of hot deserts reported from Afghanistan, Syria, Pakistan and India. In India it is distributed in Ajmer, Bikaner, Churu, Barmer, Jodhpur and Jhunjhunu districts of Rajasthan. However, its status in various districts has not been assessed so far.

(ii) *Caralluma edulis* (Edgew.) Benth. & Hook.f (Family: Asclepiadaceae)
Local Name : *Pimpa*

An annual erect succulent herb, 15-60 cm high, branches, 4-angled. Leaves 0.6-1.3cm long, linear or ovate-lanceolate and acute. Flowers 1-3, in the axils of leaves, all along distal nodes. Corolla campanulate, *c.*7mm long, purplish inside; lobes ovate-lanceolate, acute, glabrous within. Corona in two rows; outer, 5-lobed, each lobe produced into 2 distinct, subulate teeth; inner one linear, subacute. Follicles 8-17cm long, lanceolate, terete, smooth. Seeds brown, winged on the margins; coma *c.*2.5cm long. *Fl. & Fr.*: Feb.-Sep.

According to Bhandari (1990), *C. edulis* is endemic to deserts of Pakistan and Western Rajasthan. The young shoots are eaten as vegetable and often sold in market at Jaisalmer (Mohangarh).

(iii) *Farsetia macrantha* Blatter & Hallberg (Family: Brassicaceae)
Local Name : Motio-Hiran Chobbo

A twiggy, rigid undershurb. Leaves 4-7 x 1.5-2.5 cm, broadly linear-lanceolate, attenuated at the base, sub-coriaceous. Flowers in 5 to 15 terminal racemes, creamy white to pinkish white. Fruits 30-35 x 5-6 mm, oblong, compressed, densely strigose, narrowed at both ends. Seeds 6 x 3mm, compressed, brown. *Fl. & Fr.*: Aug.-Jan.

Threatened and endemic to deserts, a few individuals can be seen on rocks of Mataji's temple in Barmer.

(iv) *Tephrosia falciformis* Ramasw. (Family: Fabaceae)
Local Name : *Rati Biyani*

A shrub with white silky branches. Leaflets 5-17, 2.5-4.5 x 0.3-1.0cm, oblanceolate or oblong, mucronate or emarginated, appressed hairy. Flowers in racemes, longer than leaves, purple-red. Calyx-teeth as long as tube. Standard silvery-white outside. Style incurved. Pods flat, sparsely hairy and 3-5-seeded. *Fl. & Fr.*: Aug.-Oct.

It is a threatened species, endemic to Thar Desert. Occasionally seen in sand-dunes and distributed in Churu, Jaisalmer, Jodhpur and Pali districts of Rajasthan.

(v) *Withania coagulans* (Stocks.) Dunal. (Family: Solanaceae)
Local Name : *Paneer-bandh*

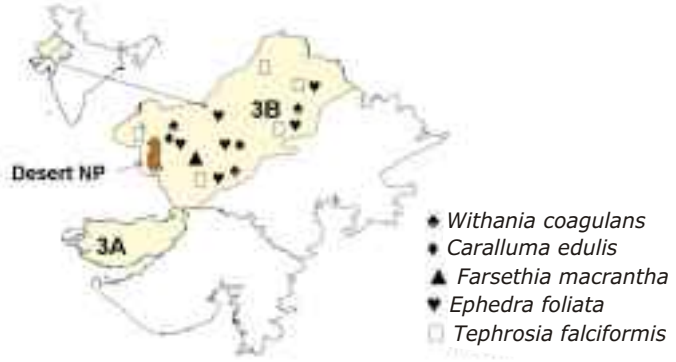
A stiff, ashy-grey undershurb, up to 1m high. Stem woody, terete, densely clothed with mealy, stellate tomentum, sulcate when dry. Leaves 2-7 x 1.0-2.5cm, elliptic-lanceolate or oblanceolate, coriaceous, obtuse at apex, attenuated at base into an obscure, flat petiole, grey tomentose on both surfaces. Male flower stamens reaching up to top of corolla tube, filaments glabrous. Female flower ovary ovoid, style glabrous, stigma 2 lamellate. Berries globose, surrounded by scurby-pubescent, membranous calyx. Seed ear-shaped, glabrous. *Fl & Fr.*: Nov-March.

W. coagulans is distributed in drier tracts of Afghanistan, Pakistan and India. In Rajasthan, it has been reported from parts of Barmer, Jaisalmer and Jodhpur and locally called Paneer-Bandh because the fruit are used for coagulating milk and making Paneer. It's earlier name *Punneria coagulans* was perhaps related to this property. This species is has become extremely rare now.

(vi) *Zizyphus truncata* Blatt. & Hallb. (Family: Rhamnaceae)
Local Name : *Boti*

A rare endemic shrub with divaricate branches, younger parts downy. Leaves up to 3.5 x 3.0cm, orbiculate, subcordate, serrulate, coriaceous, and 3-nerved from the base. Stipular prickles 2, tomentose at the base, one shorter and straight,

Plate 14A
Special Habitats and Landforms in Arid Zone



Arid zone of India with distribution of Threatened plants

NASA satellite image of
Thar Desert

Unstable sand dunes

Sandy plain

Gravelly plains with *Salvadora oleoides*

Inter-dune vegetation

Grassland of *Lasiurus scindicus*

Saline habitats

Plate 14B
Threatened Plants of Indian Arid Zone

Ziziphus truncata

Withania coagulans

Farsetia macrantha

Tephrosia falciformis

Ephedra foliata climbing on *Salvadora oleoides*

Caralluma edulis

the other longer and recurved. Flowers in short axillary cymes, greenish yellow. Drupes *c*. 0.75cm across, globose, glabrous, yellow when ripe. *Fl. & Fr.*: Oct.-Jan.

Ziziphus truncata is endemic to N. W. Rajasthan, distributed in Jaisalmer and Jodhpur districts.

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15.0 Status Survey of Threatened Plants in Kachchh Desert, Gujarat

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Introduction

Kachchh, the second largest district in India forms major portion of a biogeographic province within Indian Desert (Rodgers *et al.* 2000). This dry land is endowed with varied micro-habitats and an array of xerophytic vegetation adding uniqueness to the biodiversity of the Gujarat state and India. This district (45,652 km^2; 22^o 41' 11" to 24^{o}41' 47" N and 68^o 9' 46" to 71^o 54' 47" E), located in the westernmost part of Gujarat state, covers about 73% of the total arid region in the state. It experiences extreme climatic conditions from very hot in summer (mean maximum temperature 39 – 45^{0}C) and cold (mean minimum 2^{0}C) in winter. Droughts are frequent with normal rains once in two to three years, which averages to 326mm in 13 rainy days. These climatic conditions have resulted in unique habitats which vary from tropical thorn forest to extensive grasslands, mangroves, mud flats along the coast, seasonal wetlands and the most unique *Rann* (saline desert) interspersed with elevated land masses, called 'Beyts'. These habitats support several species of plants many of them are highly threatened.

As per the classification by Champion & Seth (1968), as many as 14 different sub-types or categories of vegetation can be seen in the area. Approximately 768 plant species have been recorded from this region so far, which constitutes about 18% flora of the state (Shah 1978). However, being a typical desert, the region is marked by sparse vegetation cover and low biomass productivity. According to Nayar & Sastry (1988, 1990) as many as 48 species of vascular plants, typical of Indian Deserts are found in the Kachchh region, which fall in one or other category of Red Data Book (RDB). Major causes of their depletion are ever increasing anthropogenic pressures, changes in land use practices and resultant alteration of natural habitats. Therefore, it becomes imperative to identify and locate populations of rare and threatened taxa in different biogeographic zones and evolve strategies for their conservation. In this paper we present the findings of a short status survey of selected RDB plants in the Kachchh deserts of Gujarat and discuss the conservation strategies.

Present Survey

Nineteen plant species categorized as 'Threatened' by the World Conservation Monitoring Centre (1994) and also listed under various threat categories in the RDB of Indian Plants (Nayar & Sastry 1988, 1990) were surveyed in the Kachchh region of Gujarat during 1998 to 2001. The localities from where these plants had been reported in the literature were revisited and known habitats were sampled for their populations. The survey was done using belt transects and circular plots (Mueller-Dombois & Ellenberg 1967, Kershaw 1973). The belt transects (1- 5 km x 6 m wide) were walked across the sampling patches along a fixed direction starting from a random point within the patch. The number of line transects depend upon the size of the patch. Along these transects the targeted species were searched. Whenever a threatened species was encountered, plant specific circular plots of varying radii (1m for herbs and 3m for shrubs and climbers) were laid to enumerate the number of individuals. In addition, site specific intensive search was made using belt transects (herb 10 x 2m and shrubs 25 x 4m) in six different directions leaving the line of movement to document the abundance of the target species.

Information on the type of habitat and perceived threats were recorded based on subjective rating (low, medium and high). The major threats identified were: Habitat degradation (grazing and soil erosion), Habitat loss (industrial and urban development, mining, agriculture expansion, encroachment), Natural factors (pest attack, low propagation) and Exploitation (extraction and cutting). Threat status were assigned (based on status within survey area) to all these species within the study area by grouping them into highly threatened (HT), moderately threatened (MT) and less threatened (LT) categories. This was done based on the number of individuals, number of habitats and locations they were found. The species with <500 individuals, present in <3 habitats and <10 locations were categorized as HT; species with 500-1500 individuals, recorded from 3-6 habitats and 10-20 locations were categorized as MT species; species with >1500 individuals, found in >6 habitats and >20 locations were classed as LT species. The total length of transects sampled in various habitats were: Wetland - 11kms, Open scrub - 40kms, Forest - 34kms, Grassland - 19kms, Borders of agricultural fields - 18kms and coastal areas - 23kms. This exercise was attempted to prioritize the species which need immediate conservation action. Sighting locations were plotted on a base map to identify the threatened botanical hotspots for *in-situ* conservation.

Results and Discussion

Abundance and distribution: The 19 species surveyed include eight herbs, six shrubs and five herbaceous climbers. Among these, *Carollocarpus conocarpus* and *Ammania desertorum* had very low numbers *i.e.* seven (3 locations) and 16 individuals (two locations) respectively and had highly restricted distribution. *Commiphora wightii* and *Helichrysum cutchicum* showed wider distribution (75 and 40 locations respectively) and had 9774 and 6586 individuals respectively (Table 1).

Table 1 : Abundance, Distribution and Local Threat Status (LTS) of Threatened Plants in Kachchh Desert

Habit: H = Herb, S = Shrub, C = Climber, HC = Herbaceous Climber
LTS: HT-Highly Threatened, MT–Moderately Threatened, LT–Less Threatened

S. N	Species	Habit	Total Abundance	# Talukas (Locations)	No. of Habitats	LTS
1	*Ammania desertorum* Blat. & Hallb.	H	16	2 (2)	1	HT
2	*Campylanthus ramosissimus* Wight	S	3240	4 (11)	4	MT
3	*Citrullus colocynthis* (L.) Schrad.	HC	1980	6 (21)	7	LT
4	*Commiphora wightii* (Arn.) Bhandari	S	9774	8 (75)	13	LT
5	*Convolvulus stocksii* Boiss.	HC	2184	5 (19)	7	LT
6	*Corallocarpus conocarpus* (Dalz. & Gibs.) Hook. f. *ex* Clarke	C	7	2 (3)	2	HT
7	*Dactyliandra welwistschii* Hk.f.	C	38	1 (4)	1	HT
8	*Dipcadi erythraeum* Webb. & Berth.	H	1555	3 (13)	7	MT
9	*Ephedra foliata* Boiss.	S	1109	4 (21)	10	MT
10	*Helichrysum cutchicum* (Clarke) Rao	H	6586	7 (40)	9	LT
11	*Heliotropium bacciferum* var. *suberosum* (Clarke) Bhandari	S	2740	5 (14)	8	MT
12	*Heliotropium rariflorum* Stocks.	*S*	*2261*	*6 (34)*	*9*	*LT*
13	*Indigofera coerulea* var. *monosperma* (Sant) Sant.	S	1887	3 (12)	8	MT
14	*Ipomoea kotschyana* Hochst. *ex* Choisy	HC	1777	4 (16)	6	MT
15	*Limonium stocksii* (Boiss.) O. Kuntze	H	405	2 (2)	1	HT
16	*Pavonia ceratocarpa* Dalz.*ex* Mast.	H	124	5 (10)	5	HT
17	*Sida tiagii* Bhandari	H	3218	5 (23)	8	LT
18	*Schweinfurthia papilionacea* (Burm. f.) Boiss.	S	136	1 (1)	1	HT
19	*Tribulus rajasthanensis* Bhandari & Sharma	H	1071	4 (16)	8	MT

Habitat Specific Distribution: These species occupied six major habitat types, of which open scrub harboured highest number (eight) of species. These species had higher abundance in this habitat (35-100% of the total population). The second highest number of species (four) was recorded from grasslands (51-82%) and three in forested (41-65%)

habitats (Figure 1). *Ammania desertorum*, *Dactyliandra welwitschii*, *Limonium stocksii* and *Schweinfurthia papilionacea* were restricted to single habitat *viz*. wetlands, agricultural and fallow lands, coastal dunes and open scrub respectively. *Heliotropium bacciferum* var. *suberosum* (90%) also showed more affinity to the coastal habitats. Low abundance of some species could be inherent and for others it may be failure of regeneration. Water availability during and after germination in desert region is uncertain, which leads to high stress and mortality of annual plants (Le Houwrou 1984, and Van Rooyen *et al.* 1991). Singh (1998) noticed low propagation of even perennials due to frequent drought and high grazing pressure in the semi-arid area of Saurashtra. It is true for arid Kachchh which experienced 14 spells of drought within 23 years *i.e.* 1972 – 1994 (Anonymous 1996).

Commiphora wightii was recorded at 75 locations, eight areas (Talukas) and mostly occupied open scrub (57%) and forest (40%) on undulating terrain (Figure 1). This being a hardy species is reported to occur on undulating terrain, loamy and gravelly soil, with shallow depth, pebbly substratum low grazing area with open canopy favoring high density (Dixit & Rao 2000).

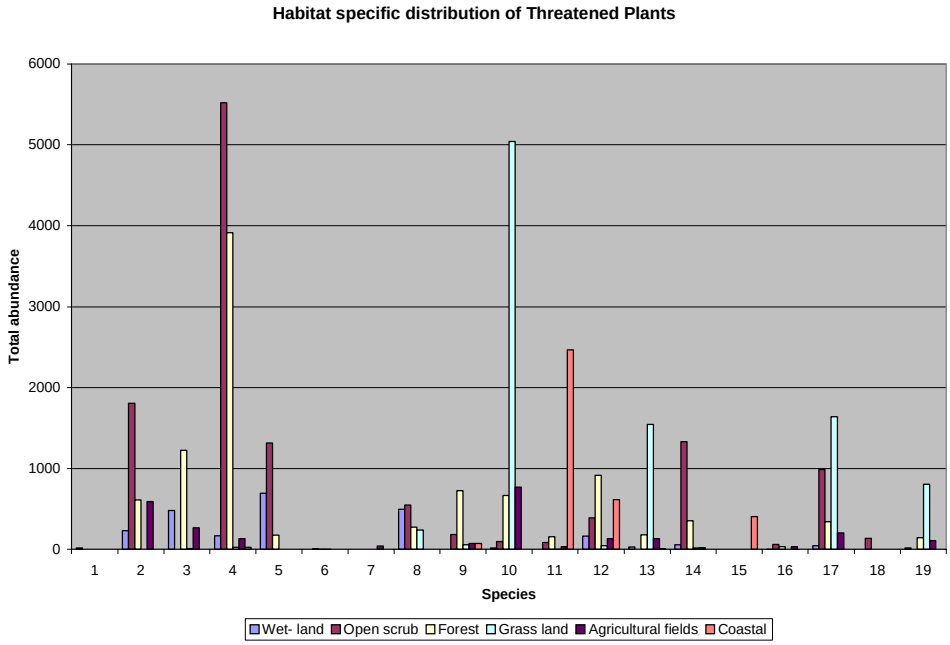

Figure 1. Habitat specific distribution of Threatened Plants. Species numbers are in the same sequence as given in Table 1.

Local Conservation Status: Based on abundance and distribution, six species *viz*. *A. desertorum*, *C. conocarpus*, *D. welwitschii*, *L. stocksii*, *Pavonia ceratocarpa* and *S. papilionacea* were found to be HT as these had low number (<500 individuals), present in <three sites and < three habitats. Seven species *viz*., *Campylanthus ramosissimus*, *Dipcadi erythraeum*, *Ephedra foliata*, *Heliotropium bacciferum* var. *suberosum*, *Indigofera caerulea* var. *monosperma*, *Ipomoea kotschyana* and *Tribulis rajasthanensis* were moderately threatened. Six species *viz*., *Citrullus colocynthis*, *Commiphora wightii*, *Convolvulus stocksii*, *Helichrysum cutchicum*, *Heliotropium rariflorum* and *Sida tiagii* were found to be less threatened (Table 1 & Figure 1).

Threats

Quantification of threats of annual plants is difficult when compared to perennials because of their smaller size and short life span. It is further complicated if it has restricted distribution and low abundance. The subjective rating of threats based on the field observation showed that except *C. wightii*, all other species faced major threat in the form of

habitat degradation due to excessive livestock grazing (Table 2). A recent study on grasslands of Kachchh estimated that out of nine Talukas, four were with very high and three with high intensity of grazing pressure (Anonymous 2004), which also induced erosion of top soil. It has been estimated that soil erosion in Kachchh ranges between 25-50% in different Talukas (Anonymous 1994).

Habitat loss is the second major threat to affect several species. This includes mining and industrial development. Nine species were under the threat of natural factors, of which *C. colocynthis* and *I. caerulea* faced lack of regeneration. However, survey of these species after rainy season would give a true picture. Rest of the seven species were affected by termite attack (Table 2). Among the assessed 19 species, 13 species are reported to be medicinally important in Kachchh (Silori *et al.* 2005). Of these, *C. colocynthis*, *D. welwistschii*, *E. foliata* and *S. papilionacea* are used at low level, while *C. wightii* is heavily exploited for local medicine. It has been reported that a mature *C. wightii* (Guggal), can produce 250-500 gm of gum (Atal *et al.* 1975) and an estimated 300-400 tones of Guggal has been sold in Bhuj every year. However, this plant was found to be widely distributed in Kachchh. Crude methods of gum extraction from younger plants (Joshi *et al.* 2004) is likely to affect its abundance in future.

Table 2 : Evaluation of Threats faced by Threatened Plants

S. N	Species	Habit	Total Abundance	# Talukas (Locations)	No. of Habitats	LTS
1	*Ammania desertorum* Blat. & Hallb.	H	16	2 (2)	1	HT
2	*Campylanthus ramosissimus* Wight	S	3240	4 (11)	4	MT
3	*Citrullus colocynthis* (L.) Schrad.	HC	1980	6 (21)	7	LT
4	*Commiphora wightii* (Arn.) Bhandari	S	9774	8 (75)	13	LT
5	*Convolvulus stocksii* Boiss.	HC	2184	5 (19)	7	LT
6	*Corallocarpus conocarpus* (Dalz. & Gibs.) Hook. f. *ex* Clarke	C	7	2 (3)	2	HT
7	*Dactyliandra welwistschii* Hk.f.	C	38	1 (4)	1	HT
8	*Dipcadi erythraeum* Webb. & Berth.	H	1555	3 (13)	7	MT
9	*Ephedra foliate* Boiss.	S	1109	4 (21)	10	MT
10	*Helichrysum cutchicum* (Clarke) Rao	H	6586	7 (40)	9	LT
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13	*Indigofera coerulea* var. *monosperma* (Sant) Sant.	S	1887	3 (12)	8	MT
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18	*Schweinfurthia papilionacea* (Burm. f.) Boiss.	S	136	1 (1)	1	HT
19	*Tribulus rajasthanensis* Bhandari & Sharma	H	1071	4 (16)	8	MT

Threatened Botanical Hotspots: Nineteen threatened species were recorded from 337 locations covering all the nine Talukas of Kachchh district. Threatened Botanical Hotspots were identified by plotting all the 125 locations of only highly and moderately threatened species. Both HT and MT species were present in all the Talukas, except in Anjar. Among the talukas, Bhuj showed presence of 11 species at a maximum of 41 locations, which formed 32.80% of the total locations, followed by Abdasa (six species at 26 locations, forming 21%). Grouping of locations based on their distribution resulted in two threatened botanical hotspots. Of these, one hotspot is located in Abdasa taluka at the south western part. This hotspot identified as Naliya Biodiversity Reserve (NBR), is predominantly a grassland habitat, locally known as Naliya grassland. The second hotspot is located at southern part covering the area at the tri-junction of Bhuj, Mandvi and Mundra talukas, which includes the forested areas of Megpar and Dhunai villages in Mandvi, Kera and Dahisara villages of Bhuj, and Dahisara Reserved Forests (Figure 2 & Plate 15). This has been identified as Kachchh Threatened Plant Reserve (KTPR), which included 30 (46.88%) of the total 64 locations of the three talukas. Further, this area is predominantly with hilly terrain dominated by *Acacia senegal* and *A. nilotica* thorn forest interspersed with *Euphorbia cadusifolia* and *Grewia tenex* open scrub.

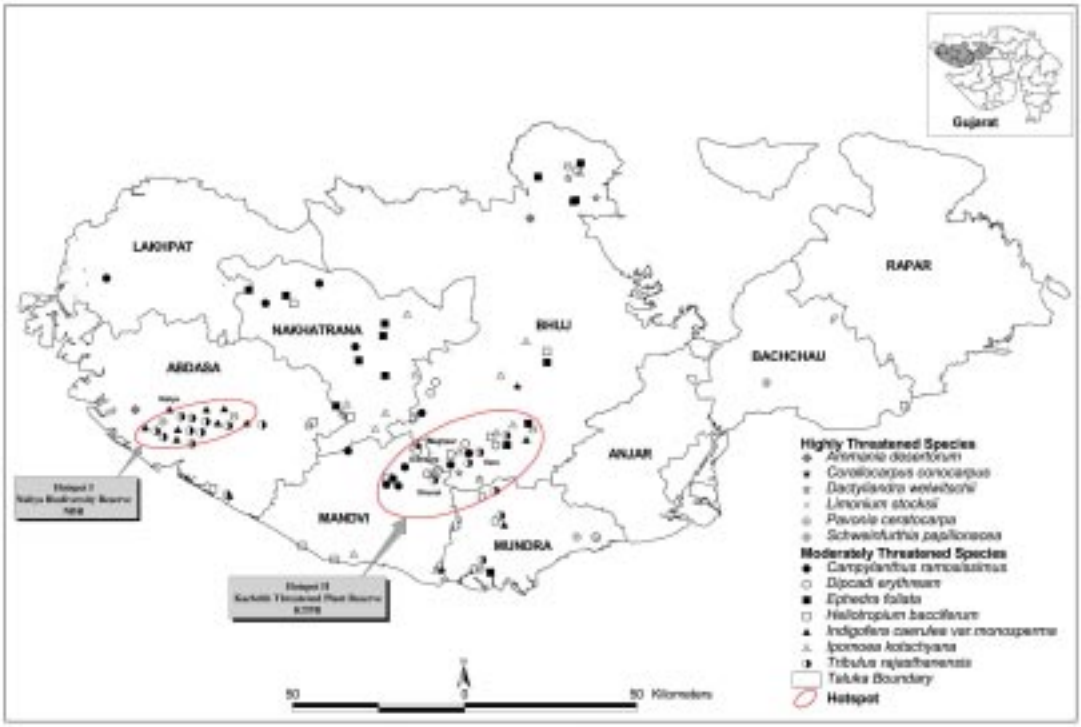

Figure 2. Distribution of Threatened Plants in Arid Kachchh, Gujarat

Conservation Strategies :

(i) Since majority of the threatened species are annuals and more susceptible to uncertain arid climate and prolonged drought, it would be necessary to carry out an intensive survey of these species following good monsoon which will give true picture of the distribution, abundance and regeneration status of these species.

(ii) The intensive survey of HT and MT species would be needed so as to identify more sites and initiate *in- situ* conservation measures.

(iii) The Naliya Biodiversity Reserve (NBR) encompasses the Naliya grassland covering roughly 100km^2 of almost continuous grassland with few shrubs (Savannah). This area needs to be brought under Protected Area Network, considering that this ecosystem itself is endangered and it is home of ten threatened animal species in addition to eight threatened plant species.

includes the environs of Megpar and Dhunai villages in Mandvi and Dahisara village of Bhuj, which includes Dahisara Reserved Forests that needs to be immediately brought under strict protection from wood cutting, livestock grazing, quarry lease (small scale mining), the major threats of the area. This can possibly be notified as a Kachchh Threatened Plant Reserve as it harbours overall nine threatened plants.

(v) Considering the rarity of these species, steps should be taken immediately to grow or propagate both the HT and MT species in botanical gardens so as to conserve them as part of *ex situ* conservation plan. In addition, propagation techniques for the species which are under heavy exploitation for enthno-medicine should be developed and the possibilities of cultivating them must also be encouraged so as to reduce the pressure on the wild population.

Plate 15
Threatened Plants of Kachchh, Gujarat

1. *Heliotropium bacciferum*
2. *Sida tiagii*
3. *Helichrysum cutchicum*
4. *Ephedra foliata*
5. *Commiphora wightii*

(vi) Awareness on the rarity and the conservation significance of the different species should be created among the locals especially the native healers involved in using these plants in Traditional Health Care System for healing various types of diseases.

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16.0 Semiarid Region of India: Vegetation Characteristics and Threatened Plants

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Introduction

The arid and semiarid region of India covers *ca.* 3,17,090 km^2 area and is mainly spread over seven states *viz*., Rajasthan, Gujarat, Haryana, Maharashtra, Karnataka, Andhra Pradesh and portions of Jammu & Kashmir. Climatically, the semi-arid region (annual rainfall 400 – 1000 mm) is further divisible into two zones (Rodgers & Panwar 1988). The first zone lies in Rajasthan, Gujarat, Western Madhya Pradesh, Punjab and Haryana, immediately west of which lies the Indian Desert. The second zone extends to the rain-shadow area of Western Ghats in Maharastra, Andhra Pradesh, Karnataka and Tamil Nadu. The former zone has been recognized as Zone 4 (semiarid) while the latter forms a part of Zone-6 (the Deccan Plateau). Zone 4 is further divisible into 4A (The Punjab Plains) and 4B (Gujarat-Rajputana) (Plate 16A). The semiarid region in the country is generally demarcated based on 400mm isohyets.

The semiarid zone in India represents 'Savannah' vegetation and extensive xerophilous grasslands rich in legumes and shrubs. Some of the wildlife protected areas in this region attain very high ungulate biomass *e.g.*, Ranthambore, Sariska, Gir, Velavadar, Nalsarovar, Jessore, National Chambal Sanctuary, Karera Sanctuary, Kuno - Palpur Sanctuary, Mount-Abu Sanctuary, Sitamata and Kumbalgarh Sanctuary. *Dicliptera abuensis*, *Strobilanthes hallbergii*, *Berberis asiatica*, *Ceropegia odorata*, *C. hirsuta*, *Ceropegia vincaefolia* are some of the interesting plants of this zone. In this article we discuss salient features of semiarid vegetation in Rajasthan, Gujarat and Madhya Pradesh along with description of special habitats and some examples of threatened plants.

Vegetation Characteristics

In Rajasthan, Aravalli Hill range separates semiarid tract from the arid zone. The average annual rainfall to the east of Aravalli ranges between 525-675 mm and reaches 1000 mm at some location. Eastern Rajasthan has rich alluvial soil that supports good forests and agricultural crops. The vegetation comprises Tropical Dry Deciduous Forests, Savannah woodland and Tropical Thorn Forest. *Anogeissus pendula* is the dominant species. Other associates are *Buchanania lanzan*, *Diospyros melanoxylon*, *Mitragyna parvifolia*, *Cassia fistula*, *Schrebera swietenioides*, *Pterocarpus marsupium*, *Holoptelea integrifolia*, *Butea monosperma* and *Mallotus philippensis*. *Boswellia serrata* occupies hill crests of Aravallis, *Terminalia arjuna* forms riparian forests. *Sterculia urens* is distributed throughout Aravalli range and *Anogeissus latifolia* is mainly found in open forest of Aravallis range in southern Rajasthan. Other locally common species in the region are *Kydia calycina*, *Mangifera indica*, *Woodfordia fruticosa*, *Lannea coromandelica*, *Cochlospermum religiosum*, *Flacourtia indica*, *Tectona grandis* and species of *Bauhinia*, *Albizia*, *Acacia*, *Ziziphus*, *Capparis*, and *Ficus* (Sharma & Tiagi 1979, Shetty & Singh 1987).

The Gujarat state is divided into six geomorphologically distinct regions *viz.*, South Gujarat, Central Gujarat, Aravalli and adjoining tract, Kathiavad Peninsula, the Kutchh Peninsula with the Rann (true saline desert) and the Costal tract. The semiarid region in the state is formed by Central Gujarat, Aravalli and adjoining tracts, Kathiavad Peninsula, with an average rainfall of 250mm to 1250mm. According to Champion & Seth (1968) four different forest types are found in this region *viz.*, Tropical Moist Deciduous Forest, Littoral and swamp Forest, Tropical Dry Deciduous Forest and

Northern Tropical Thorn Forest. *Tectona grandis*, *Anogeissus pendula*, *Boswellia serrata*, *Acacia nilotica*, *Euphorbia caducifolia*, *Flacourtia indica*, *Helicteres isora*, *Holarrhena antidysentrica*, *Bridelia squamosa*, *Emblica officinallis*, *Butea monosperma*, *Diospyros melanoxylon*, *Anogeissus latifoia*, *Lannea coromandelica*, *Sterculia urens*, *Mitragyna parviflora* and species of *Wrightia*, *Carissa*, *Zizyphus*, and *Capparis* are common woody elements. *Heteropogon contortus*, *Aristida* spp., *Eragrostis* spp., *Chloris* spp., and *Aeluropus* spp., are the common grasses (Shah 1978, Patel 1971).

The semiarid tract in Madhya Pradesh is represented by Chambal catchment extending up to Narmda and Betla Rivers. The forest types of the region are Tropical Dry Deciduous and Tropical Thorn Forests where more than 1000 flowering plants have bean reported. The common tree species include *Anogeissus latifoia*, *A. pendula*, *Tectona grandis*, *Lannea coromandelica*, *Diospyros melanoxylon*, *Sterculia urens*, *Mitragyna parviflora*, *Butea monosperma*, *Emblica officinalls*, *Boswellia serrata*, *Bridelia squamosa* and *Hardwickia binata.* Species composition at shrub and ground layer is similar to that of semiarid regions of Gujarat. A few climbers of this area include species of *Rhynchosia*, *Atylosia*, *Cocculus*, *Cissampelos*, *Ipomoea*, *Pergularia daemia*, *Pueraria tuberosa* and *Tinospora cordifolia* (Verma *et al*. 1993).

Special Habitats

Sambhar Lake

Sambhar, the largest salt lake of the India, has been recognized as a wetland of international importance *i.e.*, Ramsar site (Plate 16A). The length is 32 km from northeast to southwest, while the width varies between 3-2 km. The wetland area is a key wintering area for tens of thousands of flamingos and other migratory birds from northern Asia. The different group of algae (Cyanophyceae and Rhodophyceae) and bacteria growing in the lake provide striking water colour and support the lake ecology that, in turn, sustains the migrating wetland birds. Distinguished among the species are halophytes, which can be seen in this area. *Salsola baryosoma*, *Suaeda fruticosa*, *Haloxylon recurvum*, *Sesuvium sesuvioides*, *Chenopodium album* and *C. murale.* The other species of interest around Sambhar lake include *Portulaca oleracea*, *Trianthema portulacastrum*, *T. triquetra*, *Zaleya govidea*, *Aeluropus logopoides*, *Tamarix troupii*, *Acacia nilotica*, *Calotropis procera*, *Capparis deciduas*, *Salvadora oleoides* and *Prosopis juliflora*.

Rocky outcrops of Aravalli Ranges

The metamorphic rocks of Aravalli generally support poor soil and sparse vegetation. The dominant species being *Anogeissus pendula*, commonly associated with *Diospyros melanoxylon*, *Acacia leucophloea*, *Bauhinia racemosa* and *Wrightia tinctoria*. In parts of Jaipur and Ajmer districts, *Acacia senegal* is common on the upper slopes with different plant associates *e.g. Sterculia urens*, *Boswellia serrata* and *Lannea coromandelica* and along the foothills with *Butea monosperma.* The other species found are *Dichrostachys cineraria, Balanites aegyptiaca*, *Maytenus emarginata*, *Rhus mysurensis*, *Securinga leucopyrus*, *Grewia flavescens* and *G. tenax. Acacia catechu* forests are common in the south-eastern regions of Rajasthan *e.g.* Baran, Jhalawar, Kota, Swaimadhopur, Chittorgarh and Alwar. The area under this type covers roughly 3% of the total forest area (Sharma & Tiagi 1979).

Mount Abu

Mount Abu, situated on the south western border of Rajasthan, is the highest peak between western Himalayas and Nilgiri hills with a maximum height of 1727m. The vegetation is peculiar due to relatively high altitude together with climatic and edaphic factor for semiarid habitat and again highlights this area as a hotspot due to the presence of some endemic and threatened plants *viz. Dicliptera abuensis*, *Strobilanthes hallbergii*, *Bonnaya bracteoides*, *Oldenlandia clausa*, *Veronica anagallis* var. *bracteoa*, *Ceropegia odorata*, *C. hirsuta*, *C. vincaefolia*, *Ischaemum kingii*, *Rosa involucrate*,

Sterculia villosa, *Eulophia ochreata*, *Aerides crispum*, *A. multiflora*, *A. maculosum* and *Vanda testacea* and associated with common plants *Carvia callosa*, *Erythrina* sp., *Kydia calycina*, *Mangifera indica*, *Mallotus pilippensis*, *Lannea coromandelica*, *Jasminum humile*, *Flacourtia indica*, *Crateva nurvala* and *Ficus* spp. (Mehta 1979, Sharma & Kotia 2008).

Ravines of Chambal

Around 4.5 lakh hectares area in Madhya Pradesh and Rajasthan falls under ravines. These areas face a continuous threat of human encroachment for reclamation and habitation. Thorny bushes or small trees commonly found in this area include *Capparis deciduas*, *Capparis sepiaria*, *Balanites aegyptiaca*, *Acacia senegal*, *A. nilotica*, *A. leucophloea*, *Prosopis juliflora*, *Butea monosperma*, *Maytenus emarginata*, *Tamarix* sp., *Salvadora persica*, *S. oleoides*, *Crotalaria medicaginea*, *C. burhia*, *Clerodendrum phlomidis*, *Calotropis procera*, *Xanthium indicum* and *Leptadenia pyrotechnica* associated with climbers such as *Maerua oblongifolia*, *Pergularia daemia*, *Ceropegia bulbosa,* herbs *e.g.*, *Argemone mexicana*, *Farsetia hamiltonii*, *Tephrosia purpurea*, *Cleome viscosa*, *Tribulus terrestris*, *Glinus lotoides*, *Sericostoma pauciflorum*, *Rivea* sp., *Ipomoea* sp., *Pedalium murex*, *Sesamum mulayanum*, *Lepidagathis* sp, *Boerhavia diffusa*, *Chrozophora* sp., and grasses like *Cyprus* sp., *Fimbristylis* sp., *Brachiaria* sp., *Cenchrus* sp., *Dichanthium* sp., *etc.*

Malwa plateau

The south-eastern part of Rajasthan, eastern part of Gujarat and western MP come under Malwa plateau. *Anogeissus pendula*, *Acacia catechu*, *Boswellia serrata*, *Tectona grandis*, *Aegle marmelos*, *Madhuca indica*, *Mitragyna parvifolia*, *Butea monosperma*, *Cassia fistula*, *Terminalia tomentosa*, *T. bellirica*, *Diospyros melanoxylon* are the common species associated with various shrubs and grasses. Moist areas have good abundance of *Syzygium* sp., *Terminalia arjuna*, *Mitragyna parvifolia*, *Hiptage bengalensis*, *Ixora arborea*, *Mangifera indica*, *Carissa congesta*, *Cissus* sp. and *Pueraria tuberosa* among others.

Threatened Plants

According to Puri (1952), Pandey *et al.* (1983), Sabnis & Rao (1983), Shah (1983), Shetty & Singh (1991) and Pandey & Teotia (2000) following plants have been recognized as typical and threatened species of semiarid zone: *Dicliptera abuensis*, *Strobilanthes hallbergii*, *Bonnaya bracteoides*, *Oldenlandia clausa*, *Veronica anagallis* var. *bracteoa*, *Ceropegia odorata*, *C. hirsuta*, *C. vincaefolia*, *Ischaemum kingii*, *Rosa involucrata*, *Sterculia villosa*, *Eulophia ochreata*, *Aerides crispum*, *A. multiflora*, *A. maculosum*, *Nervilia oragonna*, *Vanda testacea*, *Anogeissus sericea* var. *nummularia*, *Blumea bovei*, *Chlorophytum bharuchae*, *Commiphora wightii*, *Convolvulus auricomus*, *C. stockii*, *Gloriosa superba*, *Heliotropium rariflorum*, *Tribulus rajasthanensis*, *T. jamnagarensis*, *Butea monosperma* var. *lutea*, and *Cochlospermum religiosum.* Main threats for these plants include degradation of forests due to excessive biotic pressure including livestock grazing. Besides, invasive species like *Prosopis juliflora* and *Lantana camara* are big competitors and inhibitors for native flora as they occupy continuously major portion of habitat. Some of the threatened plants of the semiarid region which need immediate conservation attention (Plate 16B) are as follows:

***Berberis asiatica* Roxb. *ex* DC. (Berberidaceae)**
Local name : *Kantela*, *Kamadi*

Erect, spiny bush with pale bark. Leaves unifoliolate, leaflets in fascicles, 2.5-7.5 cm long, obovate or orbicular, sub-entire or with large distant spinescet teeth, whitish beneath, rigidly coriaceous. Flowering in short corymbose racemes. Berries 8 mm ovioid or subglobose, red or black, glaucous. *Fl.*: Feb.-April & *Fr.*: May-June.

Commonly found in the Himalayan region but a small isolated population can be seen in Mount Abu. This species has declined rapidly in Mount Abu due to habitat loss and over exploitation for its medicinal values.

***Ceropegia odorata* Nimmo. *ex* Hook.f. (Asclepiadaceae)**
Local Name : *Khilodia*, *Khadulia*

Slender, tuberous twiner. Stem mostly glabrous. Leaves hairy above. Cymes few to many-flowered, peduncles hirsute, pedicels usually glabrous. Corolla 3-4 cm long, bright yellow, fragrant, tube 1.8-20cm corona of 5 entire lobes, glabrous, inner linear or elongate- triangular, erect, divergent at apex. *Fl. & Fr.*: Aug.-Sept.

An endemic plant of India, distributed in Mount Abu (Rajasthan), Gujarat, Konkan and Maharashtra (Ansari 1984). Over exploitation of tubers, over grazing and rapid invasion by *Lantana camara* are the major causes fo its decline.

***Ceropegia vincaefolia* Hook. f. (Asclepiadaceae)**
Local Name : *Khilodia*, *Khadulia*

Tuberous twiner. Branches glabrous. Leaves 5-10cm, narrowly lanceolate or ovate-cordate, obtusely acuminate to acute. Flowers in few-umbellate cymes, peduncles hirsute, pedicels glabrous. Corolla 3-8 cm long, greenish. Blotched with purple, tube inflated at base, funnel-shaped at mouth, lobes pubescent inside. Follicles linear-lanceolate, finely pointed glabrous. *Fl. & Fr.*: July-Oct.

A threatened plant for Maharashtra (Jain & Sikarvar 2004). It is distributed in Maharashtra and Rajasthan (Ansari 1984). It grows in the similar areas as *Ceropegia odorata* and has similar threats.

***Cordia crenata* Delile. subsp. *crenata* (Boraginaceae)**
Local Name : *Gundi*

According to Pandey & Teotia (2000) this taxon is almost extinct in wild. Small tree, wholly glabrous except minutely hairy inflorescence. Leaves alternate or subopposite, 2.5 - 7.5 cm long, elliptic or elliptic-lanceolate, rounded, sub-acute or shortly acuminate at the apex, obliquely rounded or crenate at the base, margins crenate- dentate or deeply dentate at least towards the apex. Flowers in small, compact, pendunculate cymes from the axils of the uppermost leaves. Drupes *ca.* 8 mm long, ovoid, acute. *Fl. & Fr.*: Jan.-April.

***Dicliptera abuensis* Blatter (*Acanthaceae*)**

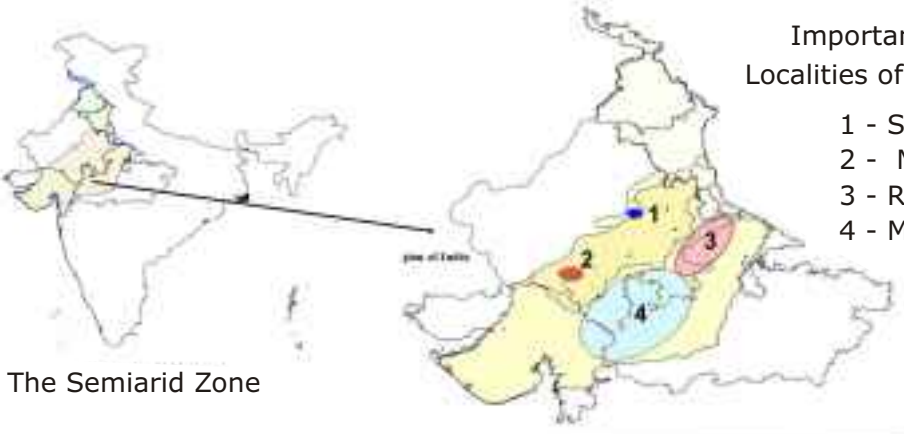
Much Branched, stragling shurbs. Leaves up to 5 x 2.75 cm, ovate, acute, subentire, sparingly hairy. Flowers in dense axillary cymes, white with deep pink tinge. Bracts 2, ovate-laneolate, unequal, with densely ciliate and scarious margins. Calyx-lobes 5, subulate. Corolla glabrous. Stamens 2. Capsules *ca.* 4.0 x 1.5 mm, yellowish. Seeds 4, *ca.*1 mm across, suborbicular, compressed, brown, covered with many capitate hairs. *Fl. & Fr.*: Nov. - March.

First Type collection of this species was made from Mount Abu by Hallberg in 1916. After this, there is no collection recorded and population status in the wild has not been assessed. It is possible that its taxonomic status may be ambiguous.

***Strobilanthes hallbergii* Blatter (Acanthaceae)**

Shrubs, up to 3 m high. Leaves 2.5 cm long, ovate-elliptic, acuminate, with dentate-ciliate margins. Flowers in spike, purple. Bracts 2, opposite, ovate, obtuse, entire. Calyx 5 partite, hairy. Corolla bearded at the throat with yellow hairs. Stamens 4, longer filaments bearded. Capsules *ca.* 0.75 x 0.5 cm, compressed, 2-seeds, flattened, rectangular, glabrous. *Fl. & Fr.*: Oct.-March.

Plate 16A
Important Habitats of Botanical Interest in Semiarid Zone



The Semiarid Zone

Important Habitats and
Localities of Botanical Interest

1 - Sambhar Lake
2 - Mount Abu
3 - Ravines of Chambal
4 - Malwa Plateau

Malwa Plateau

Sambhar Lake

A Deep Valley

Ravines near the Chambal River

The Aravalli Range

Plate 16B
Threatened Plants of Semiarid Zone

Tecomella undulata

Ceropegia vincaefolia

Cordia crenata subsp. *crenata*

Ceropegia odorata

Tribulus rajasthanensis

Berberis asiatica

According to Shetty & Singh (1991) and Pandey *et al.* (1983) it is an endemic and threatened plant of Mount Abu. Over exploitation for fuel wood, overgrazing and intention of *Lantana camara* are the main causes of its decline.

***Tecomella undulata* Seem. (Bignoniaceae)**
Local Name : *Rohida*, *Marwar Teak*

A small tree. Leaves simple, with undulating margin. Corymbs few flowered. Corolla tubular, orange - yellow. Stamens scarcely exerted. Seeds winged. *Fl. & Fr.*: Dec.-May.

Its distribution is restricted to the drier parts of the Arabia, southern Pakistan and northwest India. In India, it occurs naturally in Maharashtra, Gujarat, Rajasthan, Punjab and Haryana. The species is mainly found in western Rajasthan. As *Tecomella undulata* wood is strong and durable, it forms a source of timber. It is also used widely in various Ayurvedic medicines. Hence, overexploitation is the reason for its decline.

***Tribulus rajasthanensis* Bhandari & Sharma (Zygophyllaceae)**
Local Name : *Marwadi Gokharu*

Prostrate to procumbent, annual herb, branches hirsute. Leaves 1.5-4.5 cm, leaflets 4-7 pair, elliptic-oblong to ovate-oblong, pubescent above, villous beneath. Flowers yellow, Stamens 10, 5mm long, Fruits c. 15mm across, mericarp densely hispid. *Fl. & Fr.*: Aug.-Nov.

It is distributed in southern Rajasthan to North Gujarat and west Rajasthan to Pakistan. According to Jain & Sikarvar (2004) habitat loss is the major cause of threat.

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17.0 Gangetic Khadar: One of the Most Threatened Biomes in India

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Introduction

Human beings have been modifying their environment since time immemorial in a number of ways without giving much thought to the long term ecological consequences. Though human activities at low magnitude usually do not lead to palpable changes in the ecosystems but those of chronic and high magnitude have visually discernible impacts. Most obvious changes include local extinction of species, changes in community structure and composition, and modification of biophysical features in a landscape. One of the most prominent examples where human impacts can be discerned is the Gangetic *Khadar*. Based on the physical structure, soil type, soil moisture and structure of floral and faunal communities the Gangetic plains can be divided in to two sub-regions, *viz.*, the *Khadar* and *Bhangar*. Gangetic *Khadar* represents a unique biome in the sense that low lying areas remain inundated with water during most part of the year. Such low lying areas adjacent to the river course have tall wet grasslands. It is followed by slightly raised ground, largely dry sandy beds, where short grasses grow along with some herbs and shrubs and termed as dry grasslands. These sand beds merge into gently sloping and undulating terrain locally known as *khola*(*s*) which ultimately give way to the leveled plains (*Bhangar*). *Kholas* are characterized by sandy to loamy soil and used to support luxuriant growth of trees, shrubs, herbs and grasses. Today, there are a few places along the flood plains of Ganges where discrimination between *Khola* and *Bahngar* is possible. Most of the *Kholas* have now been leveled off and converted into crop fields. Once extensive tracts of luxuriant tall wet grasslands in this biome have now reduced to a few intermittent and relic patches in a modified landscape. Dry grasslands have also been extensively converted into croplands.

This article presents salient findings of a case study on recent changes in land use / land cover and eco-floristic account of major habitats in Hastinapur Wildlife Sanctuary (HWS), Uttar Pradesh. Based on past floristic surveys conducted by various workers (Murty & Singh 1959, 1960, 1961) and recent update on the flora by the authors (Khan 1987, 2000, 2002, 2003, 2005; Khan & Khan 2000; Khan *et al.* 1984, 1985, 1986, 2006), the habitat specificity and declining trends in some species and preponderance of a few alien invasive plants are presented along with a plea for conservation of this highly threatened ecosystem as this is perhaps the only area along the the Ganges which still holds few natural patches of the Gangetic *Khadar.*

The Hastinapur Wildlife Sanctuary

The HWS (28^{o} 462 to 29^{o} 352 N and 77^{o} 302 to 78^{o} 302 E), covering an area of 2073 km^2, along the banks of the Ganges was established in 1986 with stated objective of conserving and preserving an example of Gangetic *Khadar* biome and its attendant fauna especially the swamp deer (*Cervus duvauceli duvauceli*). The sanctuary is heavily interspersed by human habitation and agriculture with several hundred villages inside and a few large cities at the periphery. Broadly, it has three distinct habitats types, *viz.*, (i) the tall wet grasslands (swamps), (ii) short dry grasslands, and (iii) forests on *Khola*. A sizable portion of the sanctuary *i.e.*, about 32% is under cultivation while only about 10% is covered by tall wet grasslands. About 13% is scrub, 5% dry grasslands and an equal proportion is under the category of forest (Plate 17A & 17B).

Recent Changes in Land Use and Land Cover

An analysis of recent changes in land use / land cover in and around HWS was carried out using remote sensing data and it was revealed that between 1992 and 2000 tall wet grasslands have shrunk by 21.2% (223.58 km^2 in 1992 and 176 km^2 in 2000) and the forest area has reduced by 59.0% (201.44 km^2 in 1992 and 81.37 km^2 in 2000). At the same time this area has witnessed 28% increase in agiculture and about 68% increase in other infrastructure especially buildings. Such large scale changes in the landuse/ landcover must have had significant impacts on the biological community in this ecosystem. However, in the absence of any baseline data and indepth scientific study it would be rather difficult to ascertain the magnitute of impact and exact changes in the ecosystem characteristics and species composition. There are only a few past records on selected taxa which provide some clue to the changing scenario on the region. For instance, Schaller (1972) observed large herds of swamp deer comprising several hundred individuals in and around the present limits of HWS during early 1960's. Today, swamp deer population is reduced to less than 500 and confined to a few scattered small groups within the limit of HWS only. A small and relict population (*ca*. 120) has recently been located some 100 kms north of this sanctuary along the course of Ganges in Haridwar district of Uttarakhand. The two populations might have been contiguous in the historical past. The changes in floristic composition over the last few decades is hard to assess due to the paucity of detailed analysis of flora. Considering these gaps we conducted surveys to document floristic composition within the sanctuary

Floristic Structure and Threatened Plants

Extensive floristic surveys were conducted during 2003 to 2006 covering major habitat types of Gangetic *Khadar* in and around HWS through a project funded by the Ministry of Environment and Forests (Khan *et al.* 2006). During these surveys a total of 740 species of angiosperms, belonging to 452 genera and 123 families, were collected, identified and recorded from this area. As expected, largest family of flowering plants in the sanctuary is grass Family (Poaceae) with 60 genera and 108 species, followed by Leguminosae (43 genera and 94 species; of which Fabaceae was the richest having 31 genera and 62 species). Asteraceae (42 gen., 59 spp.) and Cyperaceae (10 gen., 43 spp.) are other dominant families. Brassicaceae, Apiaceae and Rubiaceae had relatively high generic diversity and lower species diversity. Following is the general statistics of the flora of HWS:

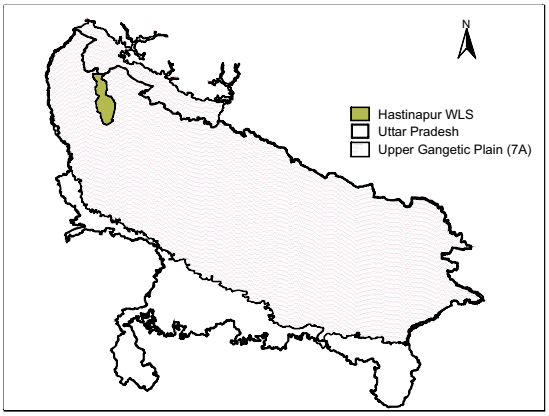
Table 1: Number of Dicot and Monocot (Angiosperm) Families, Genera and Species recorded from Hastinapur WS, Uttar Pradesh.

Group	Number of Families	Number of Genera	Number of Species
Dicots	98	345	540
Monocots	25	107	200
Total	**123**	**452**	**740**

A comparison of present floristic inventory and earlier record (Murty & Singh 1961) reveals that while 425 angiosperm species were recorded in both the studies, as many as 117 species reported earlier could not be found during the present study. Some examples of such plants include *Ranunculus aquatilis*, *Maerua arenaria*, *Hybanthus enneaphylla*, *Abutilon hirtum*, *Abutilon ramosum*, *Kydia calycina*, *Corchorus tridens*, *Fagonia arabica*, *Atylosia platycarpa*, *Crotalaria alata*, *C. mysorensis*, *Dalbergia latifolia*, *Indigofera cordifolia*, *Lathyrus sativus*, *Rhynchosia sericea*, *Uraria picta*, *Cassia obtusifolia*, *Acacia gageana*, *A. sinuata*, *Melothria purpusilla*, *Morinda tinctoria*, *Artemisia parviflora*, *Carthamus oxyacantha*, *Cotula anthemoides*, *Launaea asplenifolia*, *Seigesbeckia orientalis*, *Leptadenia pyrotechnica*, *Enicostemma axillaris*, *Hydrolea zeylanica*, *Heliotropium eichwaldii*, *Acalypha ciliata*, *Breynia vitis-idaea*, *Sapium sebiferum*, *Commelina attenuata*, *Cyanotis cristata*, *Aponogeton natans*, *Fimbristylis aestivalis*, *F. cynosa*, *Juncellus inundatus*, *Kyllinga nemoralis*, *Mariscus compactus*, *M. squarrosus*, *Acrachne racemosa*, *Aristida funiculata* and *A. hystrix*.

The study, however, resulted in the collection of 196 species which had not been recorded by the earlier authors. Many of these species are recently naturalized exotics or alien invasive species. Invasion by such species had initially been recorded by Singh (1973). The species which have seemingly declined during recent decades and now highly

Plate 17A
The Gangetic Khadar: A Threatened Habitat



Hastinapur WS: A Remnant Ecosystem in Gangetic *Khadar*

G. S. Bharadwaj

Swamp Deer Featured Species of Terai Grasslands

View of different Habitats

Threats

Amit Kotia

Hygroryza aristata –
A typical grass of marshy areas

Plate 17B
Characteristic Flora of Gangetic *Khadar*

Operculina turpethum

Pavonia repanda

Pankaj Kumar

Zeuxine strateumatica

Ammania baccifera

Arnebia hispidissima

Bacopa monnieri

Veronica agrestis

Withania somnifera

Cephalanthus occidentalis

threatened include *Bacopa monnieri*, *Hygrorhiza aquatica*, *Coix lachryma-jobi*, *Sisymbrium irio*, *Capparis zeylanica*, *Hypericum japonicum*, *Crotalaria orixensis*, *Alternanthera philoxeroides*, *Polygonum plebejum* var. *sindica*, *Rumex crispus* and *Mallotus philippensis*.

Some of the species recorded in the study area are specific to certain peculiar habitat types, for instance, *Celastrus paniculata*, *Combretum nanum*, *Galium aparine*, *Gloriosa superba*, *Jasminum arborescens* and *Mallotus philippensis* were restricted to *Kholas* only, while *Cephalanthus tetrandra* and *Epilobium hirsutum* were found only in swamps or tall wet grasslands. The wetlands are most vulnerable to local extension due to over growth of alien invasive species such as *Eichornia crassipes*, *Cyathocline purpurea* and *Potamogeton nodosus*.

Conclusions

The Hastinapur WS represents a small sample of highly threatened hygrophilous grassland ecosystem (Gangetic Khadar). The entire Terai ecosystem in Upper Gangetic Plain including this sanctuary has been facing onslaught of anthropogenic pressures leading to degradation and transformation of natural habitat and representative biota including threatened swamp deer and several species of plants. Some of the plant species recorded as frequent during early 1960s have gone locally extinct and other species are surviving in extremely low abundance. Considering the present rate of habitat loss (about 10% per annum) and rapid invasion by exotic species it is plausible that several remnant habitat islands and extant fragmented populations of native flora and fauna species would be vanished from this biogeographic region. This calls for an urgent conservation initiative on part of the government as well as non-government agencies in order to save this fast vanishing biome.

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Section V:
Western Ghats

18.0 Threatened *Ceropegias* of the Western Ghats and Strategies for Their Conservation

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Introduction

Ceropegia L. (Asclepiadaceae), a pantropical Old World genus of about 200 species exhibits a tremendous diversity with reference to habit, habitat, flower architecture and ecological adaptations. It is distributed over most of Africa, Madagascar, the Arabian Peninsula, the Indian subcontinent, the Far East and Northern parts of Australia. Ansari (1984) revised the Indian *Ceropegia* and reported 44 species, of which 28 are said to be endemic to India. After this revision, some 5 novelties have been added to the list. Presently the genus is represented by about 50 species of which about 38 occur in Western Ghats. Several species of *Ceropegia* are narrow endemics and fall under one or another IUCN Red-List category (Nayar and Sastry, 1987-89). In recent years, the genus has attracted an attention of several workers due to rarity of its species and recognized importance of conservation of rare plants of the globe. Species of *Ceropegia* possess curious flytrap flowers (Percival, 1969) with great diversity in flower design; corolla size, shape and coloring patterns; corona structures and mechanisms for illumination of essential organs (Yadav, 1996). Pollination biology of Indian species has been studied to some extent by Chaturvedi, 1993a, 1993b and Yadav, 1996. Morph-taxonomical (Patil, 1990) and physiological studies (Gaikwad *et al.*, 1989; Supate *et al.*, 1990) on some of the Indian species of *Ceropegia* have helped in better understanding of morpho-physiological adaptations in the genus.

Most of the endemic species of *Ceropegia*, by virtue of being restricted only to a special habitat and narrow ecological niche, are highly vulnerable and merit special consideration in their conservation. Reasons for their decline are many, *e.g.*, destruction of forests, modifications of habitats, industrialization, pollution and introduction of exotic weeds, *etc.* In order to evolve long term conservation strategies for this group, it is essential to collate information on their distribution, present status, immediate threats, *etc.* In this article, we give a brief overview of the threatened Ceropegias of Western Ghats (Plates 18A & 18B), information on their habitats, threats and ways to conserve them.

The Threatened Ceropegias of Western Ghats

The IUCN criteria for assigning threat categories to species of *Ceropegia* are at times difficult to meet. For example, some of the endemic species are known only from type locality and the individuals are to meet very sparsely distributed. It would be virtually impossible to come up with information on total population especially in case of sparsely distributed species which can be identified only in flowers. In any case, all the endemic *Ceropegias* deserve special status and demand immediate conservation measures. So far 38 species of *Ceropegia* have been reported from the Western Ghats. Based on an extensive and intensive search of this genus made by the authors, especially in the Northern Western Ghats, it can be said that of the 38 species 15 are narrow endemic and all of them are highly threatened. Based on detailed field investigations, present distribution and status, phenology, ecology and threats for these species have been summarized below.

1. *Ceropegia anantii* Yadav, Sardesai & Gaikwad in J. Bombay Nat. Hist. Soc., 101 (1): 141-143, Jan.-Apr. 2004.
Fls. & Frts : Aug.-Oct.

Distrib. : Maharashtra (Salva hills in Sindhudurg district).
Present Status : Endemic to Maharashtra & Endangered. Recently described species.
Field note : It is a tuberous, erect, narrow leaved species with one-flowered cyme. It grows on top of hill at an altitude of about 500 m in rocky places among grasses. About 100 individuals were observed in type locality during September 1998. Later it is found growing in shrubby vegetation in rocky places around Salva hills. It is restricted to about 20 sq. km. only.
Remarks : It is closely related to *Ceropegia attenuata* but differs in shape of corolla, type of light window and has characteristic dark purple two spots on either side of corolla lobe in lower region.
It is one of the endangered species and needs conservation measures.

2. *C. anjanerica* Malpure, Kamble & Yadav in Current Science, 91 (9): 1140-1142. 2006.
Fls. & Frts : Aug.-Nov.
Distrib. : Maharashtra (Anjaneri hills near Nasik)
Present Status : Endemic to Maharashtra & Critically Endangered. Recently described species,
Field note : It is a tuberous, erect, narrow leaved species with one-flowered cyme. It grows at an altitude of about 1296 m in well drained soil. The hill tops enjoy misty, humid climate throughout the rainy season during which the species shows vegetative growth and start flowering in August. The species is restricted to about 1 sq. km.
Remarks : It is closely related to *C. attenuata* but differs in having shorter flowers, flat corolla lobes forming an obovate head. It is restricted to exposed plateau of Anjaneri hills in Nasik district of Maharashtra. About 100 individuals were located in September 2005. It needs immediate action for conservation.

3. *C. attenuata* Hook. Ic. Pl. 9: t. 867. 1852.
Local Name : *Tilori*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra, Goa, Karnataka, Rajasthan.
Chr. No. : 2n= 22.
Present Status : Endemic and Vulnerable.
Field note : It is a tuberous, erect, narrow leaved species with one-flowered cyme found throughout shrubby open forest of Konkan, Goa and North Kanara. It grows in crevices of lateritic rocks in hilly tract ranging in altitude between 300-700 m.
Remarks : Tubers are edible. Flowers are long and are of ornamental value. It is easy to grow in gardens. It shows good fruit and seed setting both under cultivation as well as in wild. It shows great variations with reference to corolla size and colour. Due to forest clearing, the populations of the species are decreasing day by day.

4. *C. bulbosa* Roxb. var.*bulbosa* Roxb., Pl. Corom. 1: 11, t. 7. 1795 & Fl. Ind. 2: 38. 1832.
Local Name : *Kharpudi*
Fls. & Frts : July-Oct.
Distrib. : India, Bangladesh, Pakistan, Saudi Arabia, Oman, N Yemen, Ethiopia, Somalia, Kenya, Tanzania
Chr. No. : 2n= 22.
Present Status : Widely distributed species.
Field note : It is a tuberous, twining, broad leaved variety with many flowered cyme. Found in drier hilly regions amongst spiny and thorny bushes, which provide protection from grazing animals.
Remarks : Leaves and tubers are edible. It is easy to grow in gardens. It is a CAM plant (Gaikwad *et al.*, 1989) which explains its wide distribution range in drier parts.

5. *C. bulbosa* Roxb. var. *lushii* (Grah.) Hook.f. in Fl. Brit. India 4: 68. 1883. *C. lushii* Grah. in Bot. Mag. t. 3300. 1834.
Local Name : *Kharpudi*
Fls. & Frts : July-Oct.
Distrib. : India
Chr. No. : 2n= 22.
Present Status : Endemic & Common.
Field note : It is a tuberous, twining, narrow leaved variety with many flowered cyme. It is comparatively rare in occurrence but usually found in vicinity of *C. bulbosa* Roxb. var.*bulbosa*.
Remarks: Leaves and tubers are edible. It is easy to grow in gardens and shows good fruit setting in wild as well as under cultivation.

6. *C. evansii* McCann in J. Bombay Nat. Hist. Soc. 45: 209. 1945.
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Satara, Pune, Ratnagiri, Kolhapur).
Present Status : Endemic to Maharashtra & Endangered.
Field note : It is a tuberous, twining, broad leaved species with many flowered cyme. It is sparsely distributed throughout Sahyadri range from Khandala in North to Amboli in South. Usually it grows in *Carvia callosa* canopy on steep slopes at an altitude of 300-1000 m.
Remarks : It is difficult to locate in thick canopy of *Carvia callosa*. It does not thrive under garden conditions. During last 20 years author could locate only 10-15 mature individuals in the field.

7. *C. fantastica* Sedgwick in J. Indian Bot. Soc. 2: 124. 1921.
Fls. & Frts : July-Oct.
Distrib. : Maharashtra (Amboli), Karnataka (Sulgeri, North Kanara) and Goa (South Goa, Netravali)
Present Status : Endemic to Western Ghats & Critically Endangered.
Field note : It is a tuberous, twining, broad leaved species with many flowered cyme. It grows in partly cleared up semi-evergreen open forest at an altitude of about 300-700 m.
Remarks : The species can be easily distinguished from all other species by the curiously much elongated sepals longer than corolla. It is extremely rare species and on the verge of extinction. It is very sparsely distributed in its area of occurrence and needs immediate steps for its conservation. Department of Botany, Shivaji University, Kolhapur has under taken a program funded by DBT, New Delhi on its restoration. It performs well in home gardens.

8. *C. hirsuta* Wight & Arn. in Wight, Contrib. 30. 1834.
Local Name : *Haamana*
Fls. & Frts : Aug.-Nov.
Distrib. : Throughout India except Himalayan region and Thailand.
Chr. No. : 2n= 22.
Present Status : Common.
Field note : It is a tuberous, twining, broad leaved species with many flowered cyme. It grows in and around bushes in hilly tracts and shows wide ecological amplitude.
Remarks : The tubers are edible. The flowers show great variations in corolla size, colour and blotching pattern. The flowers are elegant. It is easy to grow in gardens and shows fairly good fruit formation and seed setting.

9. *C. huberi* Ansari in Bull. Bot. Surv. India 10 (2): 219. 1968 (1969).
Local Name : *Kharpudi*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Kolhapur, Ratnagiri, Satara).
Chr. No. : 2n= 22.
Present Status : Endemic to Maharashtra and Critically Endangered.

Field note: It is a tuberous, twining, narrow leaved species with many flowered cyme. It is restricted to higher peaks of Sahyadri ranges. It grows among the grasses (*Tripogon lisboe*) on steep western slopes of Sahyadri from 700 to 1200 m altitude. It enjoys misty climate prevailing in the region from June- Sept.
Remarks: It has glistening snow-white flowers and flat topped curiously formed corolla. It grows well in garden. Larvae of some butterflies feed on the leaves. Tubers are edible. It is of phytogeographical significance as the species possesses form of corolla similar to some of the species found in Africa.

10. *C. jainii* Ansari & Kulkarni in Bull. Bot. Surv. India 22 (1-4): 221. 1980 (1982).
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Satara, Kolhapur, Sindhudurg)
Chr. No. : 2n= 22.
Present Status : Endemic to Maharashtra and Endangered.
Field note : It is a tuberous, erect, narrow leaved species with one-flowered cyme. It grows in crevices of lateritic plateaus of higher altitudes (1200-1400 m). It grows in open rocky grounds on tops of Sahyadri ranges.
Remarks : The tubers are edible and mostly eaten by cowboys. It has curiously formed and beautifully coloured flowers. It faces problems in sexual reproduction probably due to disappearance of the pollinators. As the species is very specific in its edaphic and climatic requirements, it is difficult to maintain in gardens and needs *in-situ* conservation.

11. *C. juncea* Roxb. Pl. Corom. 1: 12, t. 10. 1795.
Local Name : *Kanvel*
Fls. & Frts : Aug.-Oct.
Distrib. : Peninsular India and Sri Lanka.
Chr. No. : 2n=66.
Present Status : Rare.
Field note : It is a non-tuberous, twining, scaly leaved, succulent species with many flowered cyme. It grows in rocky places along hill slopes throughout drier parts of Peninsular India. The stem is thick, fleshy and photosynthetic.
Remarks : It is the only Indian species which has thick fleshy twinning stem with Crassulean Acid Metabolism (CAM) [Supate *et al.*, 1990]. It is under cultivation in number of gardens for its curiously formed flowers and as a succulent. It performs very well under cultivation.

12. *C. lawii* Hook. f. in Fl. Brit. India 4: 67. 1883.
Local Name : *Tilori*, *Kharpudi*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Ahmednagar, Pune, Satara, Ratnagiri)
Present Status : Endemic to Maharashtra and Endangered.
Field note : It is a tuberous, erect, broad leaved species with many flowered cyme. It grows on steep slopes at inaccessible places of higher altitudes of about 1000-1400 m. It is closely related to *C. sahyadrica*.
Remarks : The tubers are edible. Very few individuals are found in its places of occurrence. The major threat to the species is destruction of habitats. It is of botanical interest. It needs immediate focus for its survival and conservation.

13. *C. maccannii* Ansari in Bull. Bot. Surv. India 22 (1-4) : 227. (1980) 1982. *Ceropegia lawii* auct. plur. nom Hook. f. Fl. Brit. India 4: 67. 1883.
Local Name : *Kharpudi*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Ahmednagar, Pune)
Chr. No. : 2n= 22.
Present Status : Endemic to Maharashtra and Endangered.

Field note: It is a tuberous, erect, broad leaved species with many flowered cyme. Flowers are small and bottle shaped. It grows on slopes of hills at an altitude from 600 to 1200 m.
Remarks: It has very narrow range of distribution and it could be eliminated in few decades if appropriate steps are not taken towards its conservation. It is allied to *C. panchganiensis.*

14. *C. mahabalei* Hemadri & Ansari in Indian Forester 97(2): 105. 1971.
Local Name : *Gauti Kharpudi*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Pune, Thane)
Present Status : Endemic to Maharashtra and Critically Endangered.
Field note : It is a tuberous, erect, narrow leaved species with one-flowered cyme. It is found growing on steep slopes of Ralegaon and Kasara hills. It grows at an altitude of about 750-1000 m.
Remarks : It has probably longest flower among Indian species of *Ceropegia* and is very closely related to the rather little known African *C. campanulata -C. insignis- C. turricula* group (Bruyns, 1997). It is of ornamental, botanical and phytogeographical significance. It needs immediate steps for its conservation.

15. *C. media* (Huber) Ansari in Bull. Bot. Surv. India 11: 199-201. 1969. *Ceropegia evansii* McCann var. *media* Huber in Mem Soc. Broter. 12: 67. 1957.
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Pune, Satara, Ratnagiri)
Chr. No. : 2n= 22.
Present Status : Endemic to Maharashtra and Endangered.
Field note : It is a tuberous, twining, narrow to broad leaved species with many flowered cyme. It grows around the bushes, shrubs and in grasses on steep slopes along forest borders of higher elevations of main Sahyadri ranges. It shows fairly good fruit and seed setting.
Remarks : The tubers are edible. The flowers are delicate and of ornamental value. It is difficult to maintain in Gardens and *in-situ* conservation is essential.

16. *C. mohanramii* Yadav, Gavade & Sardesai in Rheedea 16 (1): 33-36. 2006.
Fls. & Frts : Aug.-Nov.
Distrib. : Maharashtra (Sindhudurg)
Present Status : Endemic to Maharashtra and Critically Endangered. Recently described species.
Field note : It is a tuberous, erect, narrow leaved species with one-flowered cyme. The species grows on lateritic plateau at an altitude of 50-60 m in accumulated soil in rocky places.
Remarks: The species is extremely rare and so far known only from type locality-Kochara. Even in type-locality the population is restricted to 1-2 sq. km. It is critically endangered species and needs immediate steps for its conservation.

17. *C. noorjahaniae* Ansari in J. Bombay Nat. Hist. Soc. 69: 250, t. 1, f. 1-5. 1972.
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Satara, Amravati)
Present Status : Endemic to Maharashtra and Critically Endangered.
Field note : It is a tuberous, erect, sometimes twining, narrow leaved species with three-flowered cyme. It grows in grasslands on slopes of hills.
Remarks : The species has elegant, delicate flowers of great ornamental value. As it is sparsely distributed and restricted to few localities, it needs immediate steps for its conservation. It is easy to grow in gardens.

18. *C. oculata* Hook. in Bot. Mag. t. 4093. 1844.
Local Name: *Kharpudi*, *Khapar-khutti*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Ahmednagar, Amaravati, Mumbai, Kolhapur, Pune, Raigad, Ratnagiri, Satara, Sindhudurg), Kerala, Tamil Nadu.

Chr. No. : 2n= 22.
Present Status : Endemic to Western Ghats and Vulnerable.
Field note : It is a tuberous, twining, broad leaved species with many flowered cyme. It grows in bushes at an altitude ranging between 300 to 1200 m.
Remarks : The tubers are edible and the flowers are very curious and of great ornamental value. It shows great variations in the form of corolla, its colour and variegation pattern. It performs well in garden and deserves place in any home garden for its fascinating flowers.

19. *C. odorata* Nimmo in Grah. Cat. Bomb. Pl. 118. 1839, (*nom. nud.*) *ex* Hook. f. Fl. Brit India 4: 75. 1883.
Local Name : *Sulati Khutti*
Fls. & Frts : Aug.-Oct.
Distrib. : Rajasthan(Mt. Abu), Gujarat (Pavagadh in Panchamahal), Maharashtra (Amravati, Bombay, Nandurbar, Dhule and Thane).
Present Status : Endemic and Critically Endangered.
Field note : It is a tuberous, twining, narrow leaved species with many flowered cyme. It flowers profusely under cultivation and the flowers are odorous.
Remarks : It is very sparsely distributed species. It needs immediate conservation measures.

20. *C. panchganiensis* Blatter & McCann in J. Bombay Nat. Hist. Soc. 36: 534. 1933.
Local Name : *Kharpudi*, *Khartundi*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Satara, Ahmednagar)
Present Status : Endemic to Maharashtra and Critically Endangered.
Field note : It is a tuberous, erect, broad leaved species with many flowered cyme. It is known from Mahableshwar range in Satara district and Harishchandragad in Ahmednagar district. It grows on steep slopes of highest peaks of an altitude of about 1200 m.
Remarks : It is restricted to very small area and there are few individuals only. In nature, it has been observed that some butterflies larvae feed on leaves of the species. There is an urgent need for its conservation.

21. *C. rollae* Hemadri in Bull. Bot. Surv. India 10(2): 123-125, t. 1, f. 1-6. 1969.
Local Name : *Kharpudi*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Pune).
Present Status : Endemic to Maharashtra and Critically Endangered.
Field note : It is a tuberous, erect, broad leaved species with many flowered cyme. During September, 1998 about 50 individuals were observed at Durga fort and Dhaka fort in Pune district which is it's type locality. It grows on the open top of both the forts at an altitude of about 1200-1300 m.
Remarks : Fruit setting is rare. It is difficult to maintain in gardens. As it is restricted to a very small area of about 2 acres with countable number of individuals (about 50-75), which may be wiped out at any time. It needs immediate measures for its conservation.

22. *C. sahyadrica* Ansari & Kulkarni in Indian Forester 97: 688, t. 1, f. 1-4 & t. 2, f. A(1 & 2) & B (1). 1971.
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Pune, Kolhapur, Sindhudurg).
Chr. No. : 2n= 22.
Present Status : Endemic to Maharashtra and Critically Endangered.
Field note : It is a tuberous, erect, broad leaved species with many flowered cyme. It grows on steep, slopes and plateaus of altitude at about 700-1000 m in Sahyadri range. It grows on Western most main crest of the Sahyadri. Although it shows profuse flowering, fruit setting is very rare.

Remarks: Land slides and destruction of tubers by cowboys are the two major threats to the species. Similarly failure of seed setting (probably failure of pollination in absence of pollinators) seems to be major reason for its rarity. It is easy to grow in gardens. Butterflies larvae feed on the leaves. It needs steps towards conservation.

23. *C. santapaui* Wadhwa & Ansari in Bull. Bot. Surv. India 10: 95, t. 1, f. 1-9. 1968.
Local Name : *Khartundi*
Fls. & Frts : Aug.-Oct.
Distrib. : Maharashtra (Ratnagiri, Satara)
Chr. No. : 2n= 22.
Present Status : Endemic to Maharashtra and Critically Endangered.
Field note : It is a tuberous, twining, narrow leaved species with many flowered cyme. It grows among grasses on the unstable rocks along roadsides in Mahabaleshwar- Mahad ghat at an altitude of about 1150 m. Flowers are small and white.
Remarks : As the species is restricted to a very narrow area, it faces high risk of extinction due to landslides and road repairs and roadside clearing. It needs careful steps towards *in situ* and *ex-situ* conservation.

24. *C. spiralis* Wight, Ic. Pl. Ind. Or. 4: t. 1267. 1848.
Fls. & Frts : Aug.-Oct.
Distrib. : Andra Pradesh, Karnataka, Kerala, Tamil Nadu.
Present Status : Endemic to Peninsular India and Endangered.
Field note : It is a tuberous, erect, some times twining, narrow leaved species with one-flowered cyme. It has wide distribution in Peninsular India.
Remarks : It has flowers with spirally twisted corolla lobes and the architecture of the flower is of great ornamental value. It needs *ex situ* as well as *in situ* conservation.

25. *C. vincaefolia* Hook. in Bot. Mag. t. 3740. 1839.
Fls. & Frts : Aug.-Nov.
Distrib. : Maharashtra (Culaba, Pune, Ratnagiri, Raigad, Satara, Sangli, Kolhapur, Sindhudurg).
Chr. No. : 2n= 22.
Present Status : Endemic to Maharashtra and Vulnerable.
Field note : It is a tuberous, twining, broad leaved species with many flowered cyme. It grows at higher altitudes ranging between 800 to 1200 m along forest borders. It is sparsely distributed throughout Northern Western Ghats. It shows great variations with reference to size, colouring pattern and shape of flower.
Remarks : It is one of the highly variable species. It grows well in gardens and it is easy to maintain. The tubers are edible. It is one of the *Ceropegia*s with beautiful and curiously formed flowers. The flower has distinct kind of light window of translucent ring and small circular pore like areas in inflated bottom.

Numerical Analysis of *Ceropegia* species :

On the basis numerical analysis of morphological characters, 24 species studied fall under five following groups indicating their relationship:
Group I: *C. anantii*, *C. anjanerica*, *C. attenuata*, *C. jainii*, *C. mahabalei*, *C. mohanramii*, *C. noorjahaniae* and *C. spiralis.*
Group II: *C. lawii*, *C. sahyadrica*, *C. rollae*, *C. panchganiensis*, *C. maccannii.*
Group III: *C. odorata*, *C. media*, *C. santapaui*, *C. huberi*
Group IV: *C. evansii*, *C. fantastica*, *C. hirsuta*, *C. oculata*, *C. vincaefolia.*
Group V: *C. bulbosa*, *C. juncea*

Conservation Significance of Ceropegias :

In India, *Ceropegia bulbosa* and *C. hirsuta* are the only two widespread species. Out of the 38 species in Western Ghats, 32 are endemic to the region. About 15 species of Northern Western Ghats are narrow endemics and some of

them are known only from their type localities. *Ceropegia anjanerica*, *C. evansii*, *C. fantastica*, *C. huberi*, *C. lawii*, *C. maccannii*, *C. mahabalei*, *C. mohanramii*, *C. noorjahaniae*, *C. odorata*, *C. panchganiensis*, *C. rollae*, *C. sahyadrica*, and *C. santapaui* are critically endangered and if not cared for may vanish during the next few decades.

Indian species could be grouped into three groups on the basis ecophysiological and leaf characters. *Ceropegia bulbosa* possess succulent stem as well as leaves while *C. juncea* has small reduced scaly leaves and fleshy green stem. Both the species show Crassulean Acid Metabolism (CAM) (Supate *et al.* 1990; Gaikwad *et al.* 1989) and grow in comparatively drier parts of the country. Majority of the species have membranous broad or narrow leaves, C_3 pathway of photosynthesis and grow in semi-evergreen, evergreen forests, shrubby vegetation and on plateaus. Erect species usually grow in open grassy grounds, while climbing species grow in open shrubby forest. While erect habit is the inevitable result of open situations, climbing habit is in response to the support.

Tubers are starchy and edible. Some of the wild animals feed on *Ceropegia* tubers. Some of the butterflies rear on *Ceropegia* species and complete their life cycles. Some of the butterflies are host specific and disappearance of *Ceropegia* species may also lead to their disappearance from the region. Therefore, Ceropegias have well-established biological role. The tubers are used as a nutritive tonic in the bowel complaints of children that cure dysentery and diarrhoea. The alkaloid ceropegin from the tubers of *C. bulbosa* is used in Bihar in cold, eye-diseases and to cure sneezing (Kirtikar & Basu 1975.). The tuber of *C. bulbosa* is bitter, cures diarrhoea and dysentery, inflammation of gums and delirious fevers of parturition [Ayurveda] (Kirtikar & Basu 1975).

The Stapelieae to which Ceropegias belong are principally adapted to fly-pollination and have reached a great diversity in flower architectures (Leach 1978, Dyer 1983, Bruyns & Forster 1991, Endress 1994). The most complicated flowers of dicots are found in the genus *Ceropegia*, which, in itself, is a wealth of wonderful radiation (Huber 1957, Vogel 1961, Endress 1994). Indian *Ceropegia* species possess strange flowers of beauty and curiosity (Yadav 1996). The flytrap flowers and pollination mechanisms in the species of *Ceropegia* are interesting in understanding diversification and evolution of the genus.

Both Africa and Peninsular India belong to the same Gondvanaland and possess closely allied *Ceropegia* species of phytogeographical significance, which like many other examples, support theory of continental drift. *Ceropegia bulbosa* shows close relationship with *C. linophyllum* from West Africa; *C. mahabalei* has clear affinities to African species *C. campanulata-C. insignis - C. turricula* group; some of the non-succulent species without tubers from the Western ghats seem to be both vegetatively and florally quite similar to species from West Africa and even to *C. cumingiana* from Australia while *C. juncea* is not closely allied to any other species (Bruyns 1997).

Most of the Indian species of *Ceropegia* are very specific in their habitat preferences. The starchy tubers are prone to fungal infections and thus decay of tubers is major problem in their cultivation and maintenance. They dislike organic manure and excess watering. There is an urgent need for both *ex-situ* as well as *in-situ* conservation of Ceropegias. Species of *Ceropegia* are very difficult to propagate, cultivate and maintain in gardens. Conservation of *Ceropegia* species is a challenge to biologists. Concentrated and co-ordinated efforts by universities, forest departments, and local communities are needed to save Ceropegias of Western Ghats.

Short Term and Long Term Conservation Strategies

Prodigious task of saving vanishing Ceropegias of Western Ghats:

1. They are restricted in distribution and each has species-specific edaphic/climatic requirements.
2. The individuals of endemic species are very sparsely distributed and extremely rare in occurrence being restricted to small areas in remote places.
3. The tubers of Ceropegias are exploited by cowboys, cattlemen and also eaten by wild animals.

Plate 18A
Threatened *Ceropegias* of Western Ghats - I

Ceropegia anantii *C. anjanerica* *C. attenuata* *C. bulbosa*

C. evansii *C. fantastica* *C. hirsuta* *C. huberi*

C. jainii *C. juncea* *C. lawii* *C. maccannii*

Plate 18B
Threatened *Ceropegias* of Western Ghats - II

C. mahabalei *C. mohanramii* *C. media* *C. noorjahaniae*

C. oculata *C. odorata* *C. panchganiensis* *C. rollae*

C. sahyadrica *C. santapaui* *C. spiralis* *C. vincaefolia*

4. There is a great pressure on Western Ghats due to modification and destruction of the habitats leading to further decline and fragmentation of populations.
5. Most complicated flowers with highly specialized pollination mechanisms and species-specific pollinators resulting into low fruit and seed setting.
6. Many of seeds are worn out as they do not reach to proper place for seed germination and seedling establishment.
7. There is no easy way for their propagation.
8. The tubers are highly susceptible to microbial/fungal decay.
9. It is extremely difficult to maintain and store the tubers during dry spell of the year.
10. It is difficult to simulate growth requirements in *ex situ* conditions.
11. Destruction of aerial plant parts by caterpillars.
12. There are no apparent direct economic gains from *Ceropegia* species and unawareness of policy makers, people and researchers.

Ways to save Ceropegias of Western Ghats :

Micro-propagation is the only viable means to get planting materials. Hardening of plant materials is another critical step in reintroduction of planting material, which needs to be standardized. Following are probable and appropriate steps in saving the fascinating group of Ceropegias of Western Ghats.

1. Protecting habitats of Ceropegias.
2. Micropropagation and reintroduction.
3. Study pollination biology and fruit setting in *Ceropegia* species and to know constraints in sexual reproduction and production of seeds.
4. Establish methods for maintenance, storage and protection of tubers from microbes/fungi,
5. Understand suitable edaphic and climatic factors in maintenance of *Ceropegia* species.
6. Training forest officials in identification, protection and maintenance of *Ceropegia* species.
7. Cryo-preservation of germplasm of Ceropegias.
8. Develop package of practices to grow, maintain and protect *Ceropegia* species.
9. Coordinated efforts of researchers, forest officials and people to grow, maintain and protect *Ceropegia* species.
10. Popularization of Ceropegias through workshops, greeting cards, calendars, and photographs and distribution of planting materials to nurseries, botanical, private and home gardens.
11. Provision of finance for micro-propagation and hardening of *Ceropegia* species.
12. Establish field gene bank of all the *Ceropegia* species of Western Ghats.
13. Undertake restoration programs on Ceropegias

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19.0 Rare Flora of the Upper Palnis

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Introduction

The Palni Hills are an eastward spur of the Western Ghats in Tamil Nadu connected to the larger Annamalai hills of Kerala. They have a maximum (east to west) length of 65 km, a maximum width of 40 km (mean width 24km) and an area of 2068 sq km. The hills fall into two geographically distinct zones, the upper and the lower Palnis, divided by a pass running from Palni in the north towards Periakulam in the south. The base rock of the Palnis is almost entirely Charnockite; a bluish black granite formed some two and a half billion years ago. Soils, generally a sandy loam belonging to a class of "red" (black) soils common in S. India. Being in the rain shadow of the main body of the Western Ghats, the upper hills remain relatively dry during the south west monsoon but receive heavy cyclonic rains during the retreating north east monsoon in October to December. Total annual rainfall is c.1665mm while the general climate is often described as quasi temperate with the maximum temperature being about 25ºC. and the minimum 4ºC. Frost often occurs in the hollows of the plateau during December and January.

The upper Palnis above 1500m

After years of deliberation, we have come to the conclusion that 1500m is the altitude at which the Shola grassland eco-system should begin in these hills, while at the same time recognising that the western plateau around 385sq km has a unique character of its own. The plateau, at an average altitude of 2200m, originally consisted of undulating grasslands with numerous streamlets and marshes with peaks rising to 2500m. Within the sheltered folds of these extensive grasslands pockets of woodland locally known as Sholas are found.

These Sholas often stretch down from the slopes and valleys of the plateaus providing corridors between the lower and upper hills. The evergreen trees of the Sholas are characteristically stunted, seldom above 15m, profusely branched, upon often massive trunks and supporting a large number of epiphytes like lichens, mosses and ferns in addition to numerous creepers, stragglers and on the forest floor several species of shrubs and herbs.

For some three decades the Sholas have been the focus of intense conservation activity in South India. "Save our Sholas" (S.O.S) being the rallying cry of the professional biologists as well as school students and even small traders. Much of this activity, and the history of forest degradation has been centred around the popular hill resort of Kodaikanal, a sleepy place in the mid 1980's that has since then undergone massive commercialisation. Despite this growth the campaigns to conserve and restore the Sholas have met with considerable success. It was our chance find of Pambar Shola in 1985 as resident tourists in Vattakanal, and a realisation of its specialness and the need to save it from rapid destruction that put a halt to our travels and launched us into a life of conservation and a deep association, knowledge and love of the plants of the Shola grasslands of the Southern Western Ghats.

The work we embarked on was all made possible by the formidable Flora of the Tamil Nadu Carnatic (1983) and the promise of the Flora of the Palni Hills (1999) to come authored by Dr. Fr. K.M Matthew. In these huge volumes we not only found the means to know, but we found the assurance that there was a solid base of sound committed people around us.
It took a few years of coming and going before we finally founded a tree nursery in the vicinity of Pambar Shola. It was another year or two though before we realised what an extraordinary treasure house of plants we found ourselves in the

midst of. In the odd 2 sq. km of Sholas, ravines and rocky grasslands around us many plants could be found that had passed into extinction elsewhere in the hills. In past decades the western plateau grasslands had supported hundreds of plant species but by the end of the 1980's most of these grasslands had been put under Pine, Wattle and Eucalyptus, and many of the plants described as common and abundant by Dr. K.M. Matthew, had to us become rare and threatened; extinction within the plantations was close to 100%.

Choosing a few plants from this vast catalogue for this article has proven difficult, but the rediscovery and cultivation of those officially thought to be extinct has a special meaningfulness. Probably the best example is the Shola tree *Elaeocarpus blascoi*, which was discovered only in the 1970's – a single tree near Kodaikanal that had by the time of publication of the Flora of the Palni Hills in 1999 fallen to the axe. It was somehow extraordinary that we should rediscover it in our own back yard in 2000, and later discover we had unknowingly planted a sapling from a seed of this tree in 1997. Plate 19 shows the photo of this plant from its first flowering in 2005.

Restoration was at the heart of our work with plants, and for that the forest component presented no difficulties, degraded Shola was there for us to restore so that rare "extinct" species like the tree *Psydrax ficiformis* and the globally threatened *Elaeocarpus recurvatus* could be planted in the weed infested degraded areas around Pambar Shola.

The most threatened plants of all, nevertheless, were those of the grasslands, and there was no obvious way of re-introducing these short of a systematic restoration of their grassland habitat.

Many of these plants, however, such as *Cotoneaster buxifolius*, *Coelogyne mossiae* and *Kalanchoe grandiflora* make excellent garden ornamentals, and there were plenty of people happy to give them a home. The big prize of grassland restoration would have to be fought for and now more than five years after that struggle began in earnest we (Vattakanal Conservation Trust) and the Forest Department planted our first 1000 grasses together on 9.09.08 in a plot of cleared Wattle with a large and beautiful marsh at the centre of the restoration. Apart from the desire to restore the complex diversity of the grasslands, issues such as human animal conflict and declining water tables under timber plantations entwined together in this new policy of restoration which is still in its pilot stage. Before we can think of planting out the many rare and threatened species, we have to make sure that when a plantation coupe is felled alien weeds, most notably *Ageratina adenophora* (*Eupatorium*), do not take over, coupled with planting some of the more common grasses in the Genus *Chrysopogon*, *Themeda*, *Tripogon* and *Heteropogon* to assist the re-grassing process.
We look forward to re-introducing grassland herbs and shrubs, among these *Exacum wightianum* in Gentianaceae and *Lilium neilgherrense (Plate 19).*

***Exacum wightianum* Arn. (Gentianaceae)**

A sub-shrubby herb, usually to a metre in height flowering from June to December. It is reported from a number of places in the Western Ghats but we have not seen it outside the Palni Hills. This plant is not among our officially listed threatened species but we have seen its occurrence decline sharply, along with its grassland habitat. It has been seen over the years to find refuge as a wayside plant, but with the ever increasing numbers of self drive tourists taking to the roads no plant with showy flowers is now safe from being plucked to extinction in this particular kind of habitat. We quickly found in the restoration of Pambar Shola that we had to hide from view the most beautiful of our herbaceous plants.

This short lived plant is very difficult to cultivate from its tiny seeds which it produces in great quantities. It does not tolerate being moved and wild plants taken by gardeners always fail. Direct sowing of seeds in suitable restored habitat offers perhaps the best chance of halting its decline.

Plate 19
Rare Flora of the Upper Palni Hills

Exacum wightianum

Ceropegia thwaitesii

Hoya wightii ssp. palniensis

Lilium neilgherrense

G.S. Goraya

Elaeocarpus blascoi

Lilium neilgherrense Wight (Liliaceae)

This erect unbranched herb with alternate lanceolate leaves can occasionally attain a height of 2m and sometimes bear as many as 5 flowers although solitary flowering is most common. Matthew (1996) described the plant as being common on exposed grassy slopes, but being decimated from over collecting for the showy, scented flowers. Today it is never seen as Matthew described as all the slopes are under plantation. Now it is most commonly seen surviving among steep stony fragments of land, growing alongside bananas and other crops at around 1500 to 1700m. Its general distribution is the S.W. Ghats and the Nilgiris but we have only seen it in the Palnis.

Fortunately, it is an easy plant to reproduce by separating the "flakes" that make up the bulb of the plant. Each flake may produce a flowering plant within 4 or 5 years. For obvious reasons any restoration of this plant to the wild will have to be kept well hidden.

Elaeocarpus blascoi Weibel (Elaerocarpaceae).

A large Shola tree that is endemic to the Palni Hills. There is only one known surviving adult specimen in the wild but we have planted one along our roadside and have several saplings. The tree flowers in June and sets seed by October. Unfortunately, our mother tree is located beside a steep stream that runs down to the plains and most seed gets washed down in the monsoon.

Ceropegia thwaitesii Hook. (Asclepiadaceae)

Another plant of the wayside, described by Matthew as occasional above 1800m, is now considered to be vulnerable (Nayar & Sastry 1987-88), is *Ceropegia thwaitesii*, an extensive twiner in the family Asclepiadaceae. We have only ever found one clump of this plant on the edge of our own Pambar Shola at 2100m. The genus is much favoured by horticulturalists on account of their interesting lantern like flowers. At 5cm *C. thwaitesii* has the largest flower of the six species found in the Palni Hills. It is fortunately very easy to reproduce from stem cuttings. The plant is also found in Sri Lanka and the far Southern Western Ghats of Tinnevely district of Tamil Nadu. Some web sites we have found falsely claim the plant to be a Pambar endemic.

Hoya wightii Hook. f. ssp. *palniensis* K.T. Matthew (Asclepiadaceae)

Staying in the same family (Asclepiadaceae) we should finish with a true Pambar Shola endemic. This sub species was only described in 1992. Another genus favoured by horticulturalists on account of its "wax" flowers. The plant has thick, coriaceous, elliptic leaves on stems that trail over massive boulders that lie at the bottom of Pambar ravine. There was some doubt as to whether the plant would survive in the wild as a seed bearing follicle had not been seen since 1914. This was until late 2007 when one of our plants raised from a stem cutting bore two follicles which successfully produced seedlings in August of this year.

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20.0 Genus *Strobilanthes* in High Ranges of Kerala: Diversity, Distribution and Endemism

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Introduction

Since the Cenozoic uplift, the vegetation of Western Ghats has witnessed drastic transformation from humid tropical Malaysian and Afro-tropical types to present form and composition. The formation of the lava plateau namely Deccan Trap and the geodynamic events such as continental drift and Pleistocene glaciation accelerated the formation of new and unique microclimates in the region (Nayar 1996). The massive depopulation of vegetation occurred during the movements of Indian plate towards northward to duck on to Laurasia (Raven & Axelrod 1974) making this landmass a unique cradle with numerous micro-habitats. These habitats were gradually re-vegetated giving rise to present day physiognomic types some of which are unique to these ranges such as Shola-Grassland complex, which represent the juxtaposition of distinct ecosystems and abrupt changes in habitat types.

The genus *Strobilanthes* (Acanthaceae), an old world taxon having over 300 species within South / South-east Asia, has speciated and diversified in the hill ranges of Western Ghats. This genus has over half of world's species in India. The hill ranges of peninsular India have 59 species. The most popular character of *Strobilanthes* is its *monocarpic* nature and they flower after a long period of vegetative growth ranging from 1-15 years and some rare species produce flowers even after 35 years. The Neelgiri hills of south India (Blue Mountains) are named after *Strobilanthes kunthianus*, locally known as 'Neelakkurinji' that flowers in profusion once in 12 years. Likewise a number of other species within this group exhibit the unique features of habitats and phytogeography which have little been investigated. This article throws some light on the diversity, distribution and habitat specificity of this genus in the High Ranges of Kerala, Western Ghats.

The High Ranges of Kerala

The southern Western Ghats *i.e.*, the hill tops south of Palakkad Gap in the state of Kerala (Idukki district), represent highly dissected valleys and camel-hump peaks and unique habitats. These ranges include some of the tallest peaks in Peninsular India, highest being the famous 'elephant head' or Anamudi peak (2690m). The lower parts of these ranges are highly productive and therefore, for last two centuries these tracts have been encroached for commercial plantations. Presently three categories of land use can be seen this area (Moench 1991). These are: (i) Protected Areas (PAs), (ii) Tea plantations, and (iii) areas of extensive cardamom cultivation. The PAs include Periyar Tiger Reserve, Eravikulam National Park, Chinnar and Idukki Wildlife Sanctuaries and Thattekkad Bird Sanctuary. In addition to these five PAs, there are 35 tea estates spread over Munnar and Peermade of the High Ranges (Anonymous 1970). The rest of the High Ranges, were opened since early 1800s to establish cardamom cultivation. This area is known as Cardamom Hill Reserve (CHR). It was reserved in 1897 as Government Reserved Forest and had an area of 870 km^2 that falls under Udumbanchola Panchayat (old) of Idukki District (Anonymous 1978, Nair 1991). From early 1800s, the area has undergone severe deforestation due to extensive planting of cash crops, especially cardamom (Anonymous 1984). The major vegetation types include Tropical Wet Evergreen, Tropical Semi-evergreen, Montane Shola and Grasslands (Champion & Seth 1968, Chandrasekharan 1962).

Diversity and Distribution of *Strobilanthes* in the High Ranges of Kerala

The hilltops and understory of evergreen forests in the High ranges of Kerala and other parts of Western Ghats are are well known for the *Strobilanthes* thickets (Plates 20A & 20B). The evident domination of Acanthaceae in the shrubby layers of evergreen forests of Peninsular India is mainly due to diversity of genus *Strobilanthes*. There are altogether 43 species of *Strobilanthes* known from the state of Kerala. Of these, 38 are endemic to Peninsular India (Sasidharan 2000). Three species are endemic to Kerala *viz.*, *S. dupeni*, *S. homotropus* and *S. virendrakumarana* . Two species, *S. homotropus* and *S. andersonii* are exclusive endemic Idukki District. *Strobilanthes andersonii* is so far not known from Kerala and it is the first report of its occurrence in the state. Almost all the species (40) of *Strobilanthes* are found in the High ranges. Fortunately, most of them occur within the existing PAs. For example, 17 species and one sub-species were known to occur in Eravikulam NP according to earlier researchers (Biju 2004). The author has added five more species from Eravikulam which are being reported here. These are *S. andersonii*, *S. neoasper*, *S. urceolaris*, *S. anamallaica* and *S. barbatus*. Anamudi Chola NP harbours 18 species (Kishore 2004) while Periyar TR has as many as 27 species. Interestingly only one species (*Strobilanthes cuspidatus*) has been reported from Chinnar WS so far. More studies are required within this and adjacent sanctuaries. The species of *Strobilanthes* in high ranges (40) are as follows:

1. *Strobilanthes amabilis* Clarke: Endemic to Southern Western Ghats. Rare along shola margins. Flowering periodicity: 10 years.
2. *S. anamallaica* Wood: Endemic to Southern Western Ghats. Common along margins of evergreen forests. Flowering periodicity: Annual.
3. *S. anceps* Nees: South India and Sri Lanka. Common; in evergreen forests at high elevations. Flowering periodicity: Not known.
4. *S. andersonii* Bedd.: Endemic to Eravikulam National Park. Rare along shola margins. It was collected by Beddome (Beddome 1868-1874) and there was no collection after that and is considered as extinct. Flowering periodicity: not known.
5. *S. asperrimus* Dalz. *ex* Gibbs.: S. India and Sri Lanka. Common; along forests margins. Flowering periodicity: Annual.
6. *S. aurita* Wood.: Western Peninsular India; endemic. Rare; in evergreen forests at high elevations. Flowering periodicity: 5 years.
7. *S. barbatus* Nees: Endemic to Western Ghats. Common in Evergreen forests. Flowering periodicity: 7 years.
8. *S. calycina* Nees: Southern India and Sri Lanka. This species was so far considered endemic to Sri Lanka. Flowering periodicity: not known.
9. *S. ciliatus* Nees: Southern Western Ghats; endemic. Common; in evergreen forests. Flowering periodicity: Annual.
10. *S. consanguineus* (Nees) Clarke: Peninsular India. Common; in evergreen forests at higher elevations. Flowering periodicity: 4 years.
11. *S. cuspidatus* (Benth.) T. Anders.: Peninsular India. Common; in evergreen forests. Flowering periodicity: 7 years.
12. *S. decurrens* Nees: Southern Western Ghats. Common; in evergreen forests. Flowering periodicity: 5-6 years.
13. *S. dupeni* Bedd. *ex* Clarke. Endemic to Kerala (Nayar 1997). Flowering periodicity: 3-5 years.
14. *S. foliosus* (Wight) T. Anders.: Peninsular India. Rare; in evergreen forests at high elevations. Flowering periodicity: 2 years.
15. *S. gracilis* Bedd.: Southern Western Ghats. Common; in evergreen shola forests at higher elevations. Flowering periodicity: 10 years.

16. *S. heyneanus* Nees: Southern Western Ghats. Very common; in evergreen forests at lower elevations. Flowering periodicity: Annual.
17. *S. homotropus* Nees: Southern Western Ghats. Rare; in evergreen shola forests at higher elevations. Flowering periodicity: 10 years.
18. *S. integrifolius* (Dalzell) Kuntze: Endemic to Western Ghats. Evergreen forests at higher elevations. Flowering periodicity: 7 years.
19. *S. ixiocephalus* Benth.: Endemic to Western ghats. Common along margins of Evergreen forests. Flowering periodicity: 7 years.
20. *S. jeyporensis* Bedd.: Peninsular India. Very rare; along the margins of evergreen forests. Flowering periodicity: 10 years.
21. *S. kunthianus* (Nees) T. Anders. *ex* Benth.: Peninsular India. Common; in grasslands at higher elevations. Flowering periodicity: 12 years.
22. *S. lawsonii* Gamble: Southern Western Ghats. Rare; along the cuttings in evergreen forests. Flowering periodicity: 7 years.
23. *S. luridus* Wight: Southern Western Ghats. Common; in evergreen forests at higher elevations. Flowering periodicity: 6 years.
24. *S. matthewiana* Scotland: Endemic to Southern Western Ghats Flowering periodicity: not known.
25. *S. micranthus* Wight: Southern Western Ghats. Common; in evergreen forests at higher elevation. Flowering periodicity: 15 years.
26. *S. microstachya* Benth. *ex* Hohen.: Endemic to Peninsular India. Flowering periodicity: 5 years.
27. *S. neilgherrensis* Bedd.: Endemic to Southern Western Ghats. Flowering periodicity: 7 years.
28. *S. neoasper* Venu & P. Daniel: Endemic to Southern Western Ghats. Flowering periodicity: 3-5 years.
29. *S. papillosus* T. Anders.: Endemic to Southern Western Ghats. Occasional; along shola borders at low altitudes. Flowering periodicity not known.
30. *S. perrottetianus* Nees: Endemic to Southern Western Ghats. Common; in low and medium altitude sholas. Flowering periodicity: 10 years.
31. *S. pulneyensis* Clarke: Southern Western Ghats. Very common; in semi-evergreen forests. Flowering periodicity: Annual.
32. *S. rubicundus* (Nees) Anders.: Peninsular India. Common; in evergreen forests. Flowering periodicity: 5 years.
33. *S. sessilis* Nees: Southern Western Ghats (Kerala). Rare; in grasslands. Flowering periodicity: Annual.
34. *S. tristis* (Wight) T. Anders.: Southern Western Ghats. Very common; in evergreen forests. Flowering periodicity: 3 years.
35. *S. urceolaris* Gamble: Southern Western Ghats. Common; in evergreen forests at high elevations. Flowering periodicity: Annual.
36. *S. violaceus* Bedd.: Endemic to Southern Western Ghats. Occasional; in shola borders at medium altitudes. Flowering periodicity: 13 years.
37. *S. virendrakumarana* Venu & P Daniel: Endemic to Kerala. Flowering periodicity: 10 years.
38. *S. warreensis* Dalz.: Southern Western Ghats. Common; in evergreen forests. in all elevations. Flowering periodicity: 5 years.
39. *S. wightianus* Nees: Southern Western Ghats. Common; in evergreen and semi-evergreen forests. Flowering periodicity: Annual.
40. *S. zenkerianus* (Nees) T. Anders.: Endemic to Southern Western Ghats. Flowering periodicity: 16 years.

Discussion

Based on the distribution and diversity of this genus, it can be ascertained that the High ranges of Kerala is a hotspot of endemic *Strobilanthes*. Possible reasons for species explosion and endemism could be geographical isolation of many highland valleys and gorges coupled with compression of altitudinal and eco-climatic zones within small geographical area. The High Ranges range between 700 and 2690m asl and there are many hills and peaks above 2000 m. Only a few species are found to occur below 500m namely *S. barbatus*, *S. warrensis*, *S. heyneanus*, *S. rubicundus* which may reach up to 1400m asl. Likewise, some species such as *S. homotropus*, *S. violaceous*, *S. zenkerianus*, *S. andersonii*, *S. gracilis*, *S. wightianus*, *S. urceolaris*, *S. foliosus*, *etc.* are seen exclusively above 2000m asl. *S. andersonii* and *S. zenkerianus* are present in certain pockets of shola forests only in Eravikulam NP. The altitude specific distribution of these 40 species can be attributed to recent isolation of the various populations of the ancestral stock and speciation of these taxa as neoendemics. The evolution of grassland specific species like *S. kunthianus* and *S. sessilis* are still more recent as the evolution of grasslands in South Indian hills are thought as comparatively recent (Subhash Chandran 1997). But the distribution of *S. kunthianus* is wider than many other species which are with narrower distribution. It may be noted that habitat destruction may not be the only cause for the narrow distribution of *Strobilanthes* spp. Micro-habitats specificity may also contribute towards narrow distribution. Cladistics and adaptations of ancestral stock within the group may through some light on the evolutionary divergence. It is interesting also to note that several species (around 50%) are vagile and do not disperse far from their habitats.

Occurrence of largest number of *Strobilanthes* species (27) within Periyar TR can be attributed to the large tract of evergreen forests and wide ranges of altitudinal variation (200 to 2016m asl). Species like *S. tristis*, *S. warrensis*, *S. rubicundus*, *S. pulneyensis*, *S. micranthes*, *S. luridus*, *S. homotropus*, *S. heyneanus*, *S. decurrens*, *S. ciliatus*, *S. asperrimus*, *S. anceps*, *S. virendrakumarana*, *S. ixiocephalus*, *S. andersonii*, *S. barbatus* and *S. dupenii* prefer evergreen habitats. *Strobilanthes foliosus*, *S. wightianus*, *S. urceolaris*, *S. caudatus*, *S. violacea*, *S. zenkerianus and S. gracilis* prefer margins of evergreen shola forests.

The monocarpic nature and gregarious flowering (species specific periodicity) makes the biology of this species most interesting. The periodicity of flowering varies from annual to 16 years. Species such as *S. anamallaica*, *S. asperrimus*, *S. ciliatus*, *S. heyneanus*, *S. pulneyensis*, *S. sessilis*, *S. urceolaris* and *S. wightianus* produce flowers every year while *S. amabilis*, *S. gracilis*, *S. homotropus*, *S. jeyporensis*, *S. kunthiana*, *S. micranthus*, *S. perrottetianus*, *S. violceus* and *S. zenkarianus* flower after more than 10 years of vegetative growth. There are six species which flower after seven years of growth. Except for certain well known popular species like *S. kunthianus*, *S. carvi*, *etc.* the flowering periodicity can be studied only through tracing the herbarium collection. But it is not always correct. There are sporadic flowering for some species which may also be included in the herbarium collection. Also, in certain species there is more than one population in the same locality. Best example of this is *S. kunthianus*, which is with three different populations in Munnar (a major centre of *S. kunthianus* distribution). One population of this species is located on one side of a hill and the second is on the other side. During the last 8 years, there were three massive blooming of this shrub whose flowering periodicity is once in 12 years. This may due to the delay of seed germination due to some reason in earlier seasons. The species with long flowering periodicity and monocarpic nature is also a potential cause for their rarity. In many local floras there are some unidentified or misidentified collections of *Strobilanthes* which were collected during their vegetative stage. So at least some rare species were left unidentified in many local floras and the presence of them were not documented.

The mass flowering is a usual feature of *Strobilanthes* spp. The process has been well documented in case of *S. kunthianus*. During the last flowering (year 2008) in Eravikulam NP, flowering started at Rajamala (southernmost part), moved northward and the entire NP was covered with the gregarious flowering. Mass flowering of *S. homotropus* and

Plate 20A
Strobilanthes of High Ranges, Kerala - I

1. Eravikulam NP, *S. kunthianus* flowering
2. People queuing to view Kurunji flowering
3. *S. andersonii;* 4. *S. kunthianus*;
5. *S. anamalaica*; 6. *S. barbatus*;
7. *S. consanguineus*; 8. *S. dupenii*;
9. *S. foliosus*; 10. *S. gracilis*

Plate 20B
Strobilanthes of High Ranges, Kerala - II

11. *S. heyneanus*; 12. *S. homotropous*; 13. *S. ixiocephalus*; 14. *S. lawsonii*; 15. *S. luridus*; 16. *S. micranthus*; 17. *S. neoasper*; 18. *S. pulniensis*; 19. *S. tristis*; 20. *S. urceolaris*; 21. *S. wightianus*; 22. *S. zenkerianus*

S. gracilis makes the entire shola as a flowering forest. When we analyze the last flowering of *Strobilanthes* spp. in the High Ranges it is again miraculous. More than 25 different species flowered simultaneously and the entire High Ranges became the paradise of *Strobilanthes*. One wonders how much of intermixing and hybridization goes on when 25 different species flower synchronously.

Conservation and management implications of mass flowering

Ecologically mass blooming of *Strobilanthes* and synchronous flowering of various species can have several consequences, which are not understood fully. The dying out of these species subsequent to flowering produces enormous combustible material within and around shola forests which are very susceptible to forest fires. Most of the 25 species flowered during 2008 are shola specific and they occupied more than 90 percent of shrubby regime. So the entire shrubby stratum of shola forests has become vulnerable to fire. The seeds of these species are just liberated into soil and some of them are at the state of maturing. Occurrences of fire in these shola forests will definitely burn the seeds and hence it may cause extinction of narrow endemics. As a strategy for the future development of Idukki District the tourism industry (Anonymous 1998) is much significant. In this context the blooming of *Strobilanthes* (Kurinji) is an item for revenue. It is estimated that the last mass blooming of *Strobilanthes kunthianus* (Neelakkurinji) had generated a revenue of around Rs. 2000 crores within three months. Sadly, very little of this money is ploughed back for effective conservation and management of these species.

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21.0 Rocky Outcrops as Special Habitats in North Western Ghats, Maharashtra

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Introduction

"Rock outcrops" is the term used for habitats where portions of freely exposed bedrock protrude above the soil level due to natural reasons. Rocks exposed due to human activities such as deforestation are not included in this habitat category. Cliffs, isolated hills and platforms of rocks formed due to landscape level activities of weathering are the types of outcrops seen commonly in India. Well known rock outcrops habitats in the world are inselbergs, barrens, cedar glades, cliffs, serpentine, ultramafic, limestone and gypsum outcrops. Each of which is known to harbour highly specialized vegetation rich in habitat specific and endemic plants.

Rock outcrop habitats are generally of small extent within a region and present particular habitat limitations *e.g.*, exposure to sun and lack of soil. The microenvironment at the rock surface ranges from very hot and arid in dry season to water logged in the wet season. Hence edaphically controlled herbaceous plant communities are characteristic of rock outcrops. On an outcrop a variety of microhabitat types have been recognized such as seasonal rock pools, ephemeral flush communities, shallow depressions, boulders, crevices, *etc.* Owing to the diversity of microhabitats, rock outcrop are actually "habitat complexes" sheltering a diversity of plant groups ranging from succulents to hydrophytes within a relatively small area. Extreme microenvironmental conditions present on the outcrops differ widely from the surrounding mesic areas and hence they function as terrestrial habitat islands. In many regions of Africa, America and Australia, it has resulted in the formation of narrowly endemic species which are adapted to the microclimatic conditions of the outcrops and cannot thrive elsewhere.

In India, the habitat is represented in many ways. Large monolithic inselbergs and koppjes are common in South India. Cliffs are dominant outcrop type in the mountainous regions. Rocky plateaus of basalt and laterite present in Western Maharashtra (between 16^0-19^0 N latitude), are of high botanical value due to presence of endemic plants (Plates 21A & 21B). In spite of western Maharashtra being floristically well studied and rich in endemic species, scant information is available about the general ecology and diversity of vegetation of these outcrops.

The lateritic outcrops are indurated rocky plateaus of laterite, known as duricrusts or ferricretes. These are formed around 65m years ago, due to chemical leaching of the parent rock in high rainfall conditions followed by hardening leading to formation of laterite, a red coloured stone rich in iron and aluminium. Lateritic outcrops (known as '*sadas*' in Marathi) can be divided into high level laterites located between 800-1200m asl in the Western Ghats and low level laterites located below 100m asl in the Konkan region. They occur between 16^0-18^0 N in Maharashtra. The outcrops of basalt are exposed on flat topped hills of the northern Western Ghats and are more common at the northern tip of the Western Ghats, between 18^0 - 21^0 N. All the outcrops are widely separated from each other by highly weathered landscape, predominantly covered by woody vegetation, and thus exist as "*terrestrial island habitats*".

Soil formation on the outcrops is extremely slow. Soil depth varies from a few centimeters on flat areas to about a meter in deep cracks and depressions. It is sandy to sandy loam in texture, highly acidic and poor in phosphates. In the dry period, the temperature of exposed rock surface is very high (maximum recorded 58^0C) and humidity is very low (lowest recorded 14%). In the monsoon, conditions go to other extreme when the rains are continuous and heavy from July to September, leading to formation of ephemeral wetlands. Scarcity of soil and extremes of microclimate are

unfavourable for the growth of perennial vegetation. Hence, vegetation dominated by annuals thrives on outcrops only in moist conditions. Following vegetation types can be categorized on these outcrops. The microhabitat categories follow Porembski *et al.* (1998) with some modifications.

Vegetation of rock surfaces

Cryptogamic vegetation of rock surfaces [R] :

Exposed rock surfaces on laterite as well as basalt are completely covered by cyanobacterial crust and some crustose and foliose lichens. Immediately after the onset of monsoon, the rocks become slippery due to the slimy sheaths of the cyanobacteria.

Cryptogamic vegetation of boulders [B] :

Boulders of different sizes up to a meter in height occur often on the outcrop surfaces. On some lateritic plateaus, the entire surface is covered by loose boulders which make it look like rock field. The boulders are also covered by cyanobacterial crust, and have other species according to the available surface, crags and height of the boulders. Moss cushions and ferns including desiccation tolerant *Cheilanthes* sp. are frequent on the boulders. Lithophytic orchids such as *Eria* find this a suitable place for growth.

Vegetation of rock crevices [CR] :

Crevices in rocks provide opportunities for establishment of the plants. Depending upon the depth and width, they can be small or large. Small crevices are very common on the outcrops and provide safe growing sites for mosses, ferns and some angiosperms like *Flemingia neilgheriensis.*

Vegetation of depressions:

Vegetation of ephemeral pools [SRP] :

c1.1. Shallow pools are commonly formed in places where water accumulates after flowing over a gently sloping area. They have gently sloping sides, little accumulated soil at bottom and about 2-5cm depth of water. Shallow pools on lateritic plateaus of the Western Ghats are habitats of rare *Ericaulon tuberiferum* and *Aponogeton saterensis*.

c1.2. Deep pools are more common on the basaltic outcrops. They form in large potholes, with well defined and almost vertical rocky edges, have 10cm or more water depth and often have a few cm of soil accumulated at the bottom of the pothole. Some of the deep pools can be more than 1m deep and retain some water in the deepest part almost through the year.

Soil filled depressions: Soil filled depressions occur where rock is relatively flat and soil and humus have accumulated over the years.

Ephemeral flush vegetation [EFV] :

The term ephemeral flush vegetation (EFV) is a special type of vegetation that grows on rocky areas where water slowly seeps through soil. During the rainy season, EFV has a meadow-like physiognomic appearance whereas the dry season aspect is almost desolate with the bare exposed soil covered with sparse desiccated plant remnants. It is the

most interesting community on outcrops and includes high percentage of insectivorous *Utricularia* together with *Eriocaulon* spp.

Seasonality of the vegetation is very marked on the outcrops. The rocky plateaus present an entirely dry almost barren appearance during the summer and winter. However, with the first monsoon showers, the plateaus become water logged leading to a sudden greening of the rocks. Although the actual species composition varies with the type of outcrop and its location, the vegetation follows a similar pattern *viz.* vegetative growth of flora and flowering of geophytes in early monsoon, followed by gregarious flowering of ephemerals in late monsoon followed by flowering of grasses signifying the end of vegetation cycle on the outcrops in this region. Very few perennials are seen persisting through summer and winter. A general description of vegetation is provided here.

In the early monsoon, during June and July Poaceae members such as *Glyphochloa forficulata*, *Isachne lisboae* are abundant and dominant together with *Fimbristylis tenera* (Cyperaceae) and *Eriocaulon* spp. although all are in vegetative conditions. This phase is marked by the flowering of *Hypoxis aurea*, *Iphigenia stellata.* In August few species such as *Dipcadi montanum*, *Habenaria heyneana*, *H. panchganiensis*, *Swertia minor* reach flowering peak.

In the late monsoon phase in September, several species of early phases reach flowering peak. Most dominant are *Fimbristylis tenera* together with Poaceae members. *Hedyotis stocksii*, *Rotala* sp., *Flemingia neilgheriensis* , *Jansenella griffithiana Coelachne minuta*, *Indopoa paupercula* are most abundant at this time. This phase also shows mass blooming of *Utricularia* and *Eriocaulon* spp. Plant diversity and richness is highest in this phase (Highest recorded H'=4.417, N=47 in the Western Ghats outcrops). In one monsoon, up to 23 species were recorded in a single 1X1m quadrat indicating very high species richness.

In the post monsoon phase, abundance and dominance of Poaceae reaches peak with some grasses such as *Glyphochloa forficulata* almost singly dominant in most quadrats. Sub dominants include endemic *Dimeria* spp. *Ischaemum* spp. and *Dichanthium* spp. mostly in the fruiting stages. During winter the lateritic outcrops are parched dry with the exception of a few individuals of *Blumea malcolmii*, *B. oxyodonta*, *Crotalaria vestita*, *etc.* In locally moist areas such as drying rock pools, *Pogostemon deccanensis* and *Rotala densiflora* remain. *Indigofera dalzellii* that occurs commonly on the lateritic plateaus starts flowering in May with pre-monsoon showers and continues to flower throughout the monsoon, reaching fruiting stage in October.

Abundance and dominance of endemics is an important feature of this habitat. Based upon primary and secondary data, about 150 endemic species have been recorded to occur on rocky plateaus in the Northern Western Ghats and Konkan areas. Many of these endemics (*viz. Aponogeton satarensis*, *Ceropegia jainii*) show highly restricted geographical distribution and are specific to microhabitats. Forty of these are listed as threatened according to IUCN criteria by the Botanical Survey of India. Monotypic *Indopoa paupercula* and *Bhidea burnsiana* are restricted to the rocky areas in general and are abundant on the rock outcrops. *Dimeria woodrowii* is exclusively seen on the low level lateritic plateaus. Others like *Ceropegia*, *Hedyotis* have obligate endemic species on ferricretes in addition to several related species in the surrounding shrub savannahs, forests and wetlands. Highly specialized ephemeral flush vegetation and abundance of endemic species seen no where else in world, makes outcrop vegetation in Maharashtra globally unique.

Details of some important threatened plants seen on outcrops are provided here:

Cyathocline lutea: endangered

This is a small annual of Asteraceae which grows on basaltic outcrops in shallow depressions. Secondarily it is also seen growing along field edges and in areas of moist soil. It has a small rosette of leaves through which emerges a long

stalk about 10-15 cm high bearing bunch golden yellow coloured capitula. Though small in size the herbs spread over large areas and bloom en masse in September, imparting golden yellow colour to entire landscape. The species is found only on basaltic outcrops atop the Western Ghats, in Nasik and Pune districts. Though locally abundant, it is threatened by changes in land use such as conversion of outcrops in agricultural areas, overgrazing and fires which change the species composition. It is necessary to prevent these activities to conserve this beautiful species.

***Habenaria panchganiensis* : Critically endangered**

This beautiful ground orchid grows mostly on lateritic plateaus at 1000-1200mASL. A cluster of radical leaves emerge from the bulb during heavy rainfall of July. The flowers are bright white and bloom for about two weeks between July and August. Locally the populations are small about 2-3 individuals per 5X5 square meters. The populations are seriously threatened by conversion of the outcrops into entertainment areas for monsoon tourism. In addition mining for bauxite is seriously threatening the habitat. It is necessary to provide special protection from trampling tourists and also develop *ex situ* conservation techniques for this species.

***Aponogeton satarensis* : Endangered**

This tiny geophyte grows in shallow seasonal rock pools on lateritic plateaus at 1000-1200mASL. A short stalk and few leaves emerge above water. The inflorescence stalk is bifurcated, with characteristic Y-shape appearance, bearing tiny pink flowers during July, August. It is known from only a few localities so far and has small populations. These sites are threatened by landscape conversion by mining, tourism development and windmill farms leading to slow degradation of the microhabitats. It can be conserved by protecting the sites and also by *ex situ* conservation in shallow aquatic gardens.

***Euphorbia panchganiensis* : endangered**

This geophyte has a large underground rhizome which remains dormant for almost 7 months. The inflorescence of bright red colour emerges above ground during summer (March-April). The radicle leaves appear as rosettes during monsoon after the fruiting and dispersal of seed is over. Locally the populations of this species are moderate sized, but the sites are heavily grazed, and trampled. Summer fires set by people are highly disturbing to the outcrop vegetation, and though this species survives through it, the dispersal becomes limited. It is necessary to develop *ex situ* as well as *in situ* measures for its conservation.

***Dipcadi concanense* : Critically endangered**

This is one of the most beautiful ground lilies which grow during the monsoon on lateritic plateaus of Konkan. The species was first recorded about a century ago from Malvan, but has now vanished almost completely through its range. It still survives on the extensive plateau of Ratnagiri town, sometimes growing in the backyards of houses. A few more localities are also known from the same area and Goa. The underground bulb gives out few narrow linear leaves and the flowering scape is tall, about 30cm tall and bears one or two long tubular flowers abt 4cm long and of purest white. The site in Ratnagiri area is being converted for housing and is proposed MIDC area, threatening the large population there. *Ex situ* conservation is thus absolutely necessary for this ornamental species.

The rock outcrops also support insects, fish, amphibians, reptiles and birds which have adapted to live in the stressful environment. Small mammals like rodents feed on underground parts of the vegetation. Bats inhabit underground lateritic caves. During the survey, activity of large mammals such as gaur, leopards was often seen on outcrops in Protected Areas. Recently new species of caecilians have been identified on lateritic outcrops.

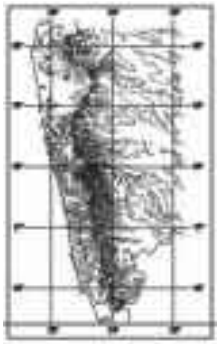
Plate 21A
Rock Outcrops as Special Habitats in Western Ghats

Ephemeral flush vegetation on lateritic outcrops in Konkan with dense growth of *Utricularia reticulata* and *Eriocaulon spp.* ©*Ashok Captain*

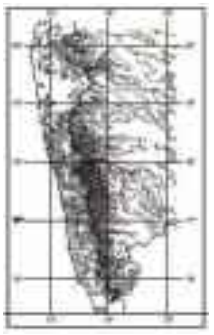
Crevices: on outcrops are very common microhabitats for moss and Poaceae ©*Ashok Captain*

Seasonal rock pool: on lateritic outcrop with dense growth of rare *Eriocaulon tuberiferum* ©*Aparna Watve*

Plate 21B
Threatened Species of Rocky Habitats – W. Ghats

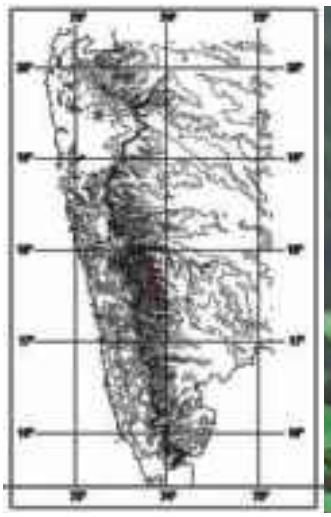


Cyathocline lutea growing in soil filled depressions on basalt outcrop [©*Aparna Watve*]

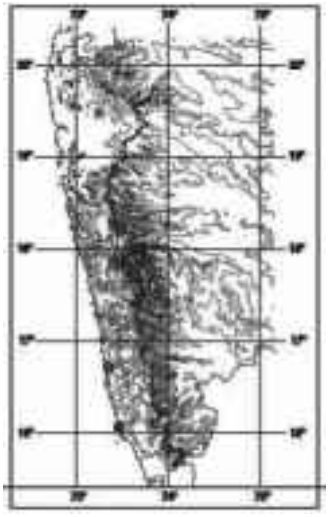


Euphorbia panchganiensis [©*Aparna Watve*]

Habenaria panchganiensis [©*Sanjay Thakur*]



Aponogeton satarensis [© *Sanjay Thakur*]



Dipcadi concanense [©*Ashok Captain*]

Rock outcrops are important as grazing lands for surrounding villages. The shrines of deities worshipped by shepherds and places of ancestral worship on these outcrops have a special socio-cultural value for local communities. The rocky plateaus also serve as watershed areas, and support large ponds or have perennial water sources along the edges which are extremely important for local people as well as livestock.

There is however, a serious lack of awareness in society regarding the biological, social and cultural importance of rock outcrop habitats. The dry physical appearance has misled government departments to classify these as wastelands. This has led to disastrous results as many activities have been allowed on the outcrops without adequate Ecological Impact Assessments. Mining for bauxite has led to destruction of prime habitats in Kolhapur. Ferricretes in Konkan are converted into mango orchards. Extensive rocky plateaus in Satara district have been converted to windmill farms, causing a slow degradation of vegetation by invasion of weeds, changes in drainage pattern and fragmentation by roads and fencing. Rocky plateaus at Panchgani and Kas, known for exceptional natural beauty are under threat from growing tourism, insensitive to the fragility of their environment. Only those outcrops which are present within wildlife sanctuary areas of Chandoli, Koyana, Radhanagari and Dajipur receive some protection. However, they have not received any special locale specific importance. It is thus necessary to take immediate steps towards the preservation of these unique habitats both within and outside PAs.

Suggested measures:

- Limiting destructive activities such as mining, plantation, tourism, constructions and burning on plateaus
- Enhanced protection of rock outcrops within existing protected areas and protection of additional representative sites to complement currently protected outcrops

Complete assessment of the floral and faunal richness of the habitat including those in the Reserved Forests and revenue lands

- Awareness generation about the importance of preserving these habitats

In addition to this, it is extremely necessary for researchers, environmental managers and others to understand the special nature and uniqueness of rock outcrop habitats and their global conservation significance.

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Pankaj Kumar

Section VI:
Deccan Peninsula

22.0 Vegetation Characteristic and Special Habitats in the Transition Zone of Vidarbha – Dandakaranya, Deccan Plateau

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Introduction

The eastern Vidarbha in Maharashtra- especially the Gadchiroli and Gondia districts, forms part of biogeographic province 6B *i.e.*, Central Plateau (Rodgers & Panwar 1988). This province is contiguous with southern flanks of Balaghat (Madhya Pradesh; MP), Chhattisgarh, and northern districts of Andhra Pradesh (AP) and more or less uniform in terms of floral diversity, physiography, geology and zoogeography. The soil is sandy to sandy-loam in texture and reddish in colour. Mean annual rainfall is about 150cm. The boundaries of biogeographic provinces *i.e.*, Eastern Plateau (6B2) and Eastern Highlands (6C2) are not very sharp and they inter-grade into each other. Interestingly the recent physiographic map adopted by the Forest Survey of India also classifies this region into three zones *viz.*, North Deccan, East Deccan and South Deccan by apparently giving more weightage to the political boundary between Maharashtra and Chhattisgarh. The entire area forms the South-Western and Westernmost part of historical Dandakaranya region. This region extends up to North- Eastern Ghats.

Vidarbha – Dandakaranya transition harbours some of the charismatic wildlife species of India including the tiger (*Panthera tigris*), wild buffalo (*Bubalus arnee*) and chousinga (*Tetraceros quadricornis*). There is high diversity of butterflies all over the area. All the hill streams above 400m altitude show presence of majestic Orange oak leaf butterfly (*Kallima inachus*) with remarkably high density (about 40-50 individuals per every 10 m length of stream). The Southern open lands along the Godavari plains have been known for the presence of Jerdon's courser (*Rhinoptilus bitorquatus*), the endangered bird while the hill forests form the abode of Indian hill myna (*Gracula religiosa* ssp. *peninsularis*) which is the indicator of this habitat. Giant squirrel, *Ratufa indica* ssp. *centralis* shows its easternmost distribution in this region and is confined to moist riverine forests.

The floristic account of Vidarbha and South Chhattisgarh region is known from the works of Malhotra & Moorthy (1971,1992), Moghe (1993), Patil (1991), Verma *et al*. (1985), Ugemuge (1985), Almeida (1996, 1998), Sharma *et al.* (1996) and Singh *et al.* (2000, 2001). This article gives a brief overview of the habitat and vegetation characteristics in this tract along with status of selected rare and locally threatened plant species.

Biophysical Features

The Vidarbha – Dandakaranya tract falls under Godavari river basin which consists of Wainganga, Indravati, Pranhita sub-basins. This area encompasses the Northern Maikal- Satpura ranges and Southern Abujhmarh - Bastar hills with several deep valleys, minor hill ranges and peaks (locally called as *metta*) and lateritic plateaus (locally called as *madum*). The other important hill ranges in this landscape include Dongargad, Tipagad-Palasgarh, Borgaon, Wadwi (Surjagad), Gatta (Damkondawahi), Sirikonda, Aheri, Lakkametta and Kolamarka. On eastern side Rajnandgaon plateau and Bastar - Bijapur highlands form a part of larger Chhattisgarh plateau, flanked by Chhattisgarh plains. These hill ranges, except Abujhmar, are more or less scattered and discontinuous. Several small streams passing

through the valleys finally meet the main river of the sub-basin. The rainfall starts in late June and lasts up to November in some hilly parts. Summers are relatively cooler in comparison to adjoining plains. Altitude ranges from 250m to almost 900 m and temperature fluctuates from about 3°C to 47°C.

Since the area discussed above is situated in the transition zone of North Deccan (Eastern Maharashtra), South Deccan (Telangana) and East Deccan (West Dandakaranya), it shows influence of all the elements and forest types of all adjoining areas. The floristic elements show some affinities with the flora of Assam- Bihar, Eastern Ghats, Western Ghats as well as Central region. Sal (*Shorea robusta*) is confined to the eastern part of the region (Rajnadgaon-Rengakhar) while best quality teak forests (C P Teak) flourishes towards West in the places like Sironcha and Allapalli and influence of Assamese flora can be seen along entire North South length (*e.g. Cephalostachyum pergracile*, *Lasia spinosa*, *Bambusa tulda*). Influence of Eastern and Western Ghats can be seen in the form of species such as *Macaranga peltata*, *Eriolaena hookeriana*, *Syzygium heyneanum*, *Schefflera venulosa*, *Homonoia retusa*, *Bridelia retusa*, and *Curcuma pseudomontana* among others. Some of the relatively rare species of Bastar and East Gadchiroli area include *Naravelia zeylanica*, *Canseja rheedii*, *Osbeckia muralis*, *Canscora heteroclita*, *Hygrophila balsamica*, *Rhenacanthus nasutus*, and *Amorphophallus sylvaticus*. The predominant forest types in the region are Tropical Dry Deciduous and Tropical Moist Deciduous forests with scattered Tropical Semi-evergreen and Dry Evergreen forests.

Special Habitats

The region exhibits a great deal of habitat heterogeneity in the form of highlands, valleys, moist slopes and riverine areas which run along North-South direction and connecting Maikal range with Chattisgarh highlands. The Indravati and Wainganga sub-basins have contributed a lot in plant dissemination and influenced the flora of the region. There are several hundred hill streams connected through rivulets to the Indravati river, which itself crosses Bailadilla hill ranges some hundred kilometers eastwards. Thus, Indravati must have played a major role bringing Eastern Ghats elements as well as Orissa- Mahanadi Basin elements through Bailadilla towards Abujhmar – Bastar highlands and Lower Godavari basin. Some of the habitats have been discussed here.

i. *Salekasa-Darekasa-South Balaghat- Dongargarh Forests*

The tracts in Gondia district of Maharashtra adjacent to Dongargad hills (West Kawardha) and South Balaghat form a kind of moist and swamp forests thereby representing a unique habitat. These forests being moist almost throughout the year and the presence of several water bodies and marshy areas and pools (locally called as '*doh*') in the lowland areas, represent flora which otherwise is missing from Western part of Maharashtra. The Navegaon and Nagzira area and other marshy areas support very interesting aquatic and semi-aquatic flora as well as fauna. Plants like *Butomopsis latifolia*, *Oryza rufipogon*, *Lasia spinosa*, *Cephalostachyum pergracile* are noteworthy.

ii. *Abujhmar-Bastar hills - Lahiri - Damkondawahi Hill Forests*

These forests are a mix of moist deciduous, dry evergreen and riverine forests. Although they are not as marshy as those of Darekasa-Gondia forests, they have formed a unique habitat with respect to deep valleys and riverine moist forests where water is available throughout the year in deeper hill streams. These streams are very important water source for all the fauna during pinch period. The moist areas harbour diverse insect and reptile species. Butterfly diversity and density in the summers is amazing. The summer flora even includes plants like *Drosera burmanii*, *Utricularia scandens*, Pteridophytes, 10-12 species of *Ficus* a variety of grasses and sedges, which are altogether missing from the adjoining lowland flora. *Memecylon umbellatum* var. *umbellatum* which otherwise found at a higher altitudes in moist Western and Eastern Ghats, is common at streamside at altitude 250 to 300m, while species like *Melastomata malbathricum*,

Macaranga peltata which are found even at lower altitudes in Western Ghats are found only above 500m in this region. Abujhmar hills- Bastar hills is a compact but huge block of large number of undulated hills, valleys and streams bounded by Indravati on the Southern side, Parlkota on the Northern side and Pamulgautam passing through its middle. These hill ranges extend both in Maharashtra and Chhattisgarh and through Bastar-Jagdalpur are remotely linked with Eastern Ghats through Bailadilla hills and other discontinuous hill ranges. The plateau or *madum* occurring between altitude 650 m to 850 m shows lateritic formation and trees are represented by typical stunted dry type vegetation. The Abujhmar hills habitat spreads over 3000 km^2 area.

iii. *Kopela – Kolamarka-Bijapur Ghati and Parsewada Forests*

These forests extend to the South-eastern Gadchiroli district which continues in the Dantewada area (through Indravati Tiger Reserve-Sundra- Pharsegarh up to Bijapur Ghati-Alabaka hills) in the east and adjoining eastern Adilabad District towards West. These are basically moist deciduous forests with dry evergreen patches interspersed in them. The dry evergreen species include *Manilkara hexandra*, *Vitex leucoxylon*, *Syzygium heyneanum*, *Diospyros malabarica*. The Eastern flat areas adjoining Indravati river (e. g. Chitweli) provides swampy habitat for endangered wild buffalo. These forests are unique in the sense that the hills are not so prominent but lowland areas show rich moist dense vegetation including canebrakes in some patches (Plate 22A). Pure *Hardwickia binata* and *Manilkara hexandra* patches are interspersed with other forest types in drier areas.

Plants of High Conservation Significance

Though this landscape is quite rich in plant species diversity, it exhibits very low degree of endemism. This may be due to contiguity of landmass with adjacent phytogeographic regions. Nevertheless a large number of species in this tract are common between Western Ghats, Central Highlands, Chotanagpur and North-East India which signify the past climatic conditions and corridor for floral migration. *Macaranga peltata*, *Melastomata malabathricum*, *Memycelon umbelatum*, *Glochidion zeylanicum*, *Ficus semicordata*, *Entada phaseoloides*, *Buchnania axillaris*, *Calamus pseudotenuis*, *Euonymus godaverensis*, *Calophyllum inophyllum*, *Thysonalena maxima*, *Caryota urens*, *Ardisia solanacea*, *Cephalostachyum pergracile*, *Premna gmelinoides*, *Bauhinia retusa*, *Hydrocotyle sibthorpiodes*, *Schefflera elliptica* and *Butomopsis latifolia* among others occur in this region which have otherwise distribution along moist areas of rest of the India or Western Ghats of Maharashtra. One of the prominent species in this region, *Hardwickia binata*, can be considered a typical (broad endemic) of Deccan plateau. Locally, several species of lower plants *e.g.*, *Isoetes* and other pteridophytes may turn out to be endemic which await detailed taxonomic studies. A few species of high conservation significance (Plate 22 B) have been given below:

i. *Cephalostachyum pergracile* Munro. (Poaceae)
Local Name : *Panbamboo*, *Bansari bans*

A beautiful bamboo 10 -25 m tall, having yellow-brown sheath and black hair. Culms thin, 5-8cm in diameter. Internode up to 70 cm, branching divergent from all nodes. This species has been recently reported by the author from hilly tracts of Gadchiroli district (Maharashtra). Earlier, it was known to occur in moist tracts of northern AP and MP. Its present distribution in this area gives a complete picture on its pattern of dispersal *i.e.*, Assam to northern parts of AP through Chhota Nagpur Rajmahal- Maikal –Abujhmar and western Orissa. It is confined to hilly regions above 450m, especially in cooler valleys and moist slopes.

Since the culm is hollow it is used by the local communities for 'Toddy' extraction. Its long internodes and fine straight fiber is useful in fine bamboo crafts. It is heavily exploited in the region without any conservation or management inputs.

ii. *Bambusa tulda* Roxb. (Poaceae)
Local Name : *Bhalin bans*

Another interesting bamboo, 7-20 m high, culms 5-10 cm in diameter, sometimes with yellow streaks. Till recently this species was known to occur only in the North Eastern parts of Central Highlands . However, it has recently been recorded from Bhamaragad forests of Gadchiroli district, Maharashtra. (Dr. Mukteshkumar, KFRI *Pers. Comm*.) This species mainly grows in moist localities above 400m asl and invariably along narrow strips of hill streams. This species flowered gregariously during summer of 2008. Presently it is found with about 150 km^2 area of Surjagad, Gatta, Bhamaragad-Abujhmar hills.

The species has largely been neglected so far as it was though to be an ordinary bamboo *Dendrocalamus strictus*. No proper strategies for its scientific management has been evolved.

iii. *Lasia spinosa* (L.) Thwaites (Araceae)

An aroid herb. Rootstock stout with horizontal stem and spiny petioles. Leaves peltate-entire to saggitate dissected. *Lasia spinosa* is a recent addition to the flora of this region. Basically this is an eastern element seen in riparian marshy places and spring sites. Its present distribution is discontinuous, however habitat is well defined. It will be quite interesting to study the probable movement of this species from North-East to the South and its restricted distribution..

This species is restricted to Gondia (Darekasa) and Gadchiroli districts (along Bhamaragad, Surajagad and Venkatapur-Aheri hill streams and Abujhmar). At present no specific threats are known except restricted habitats and small, vulnerable populations.

***Strobilanthes auriculata* Nees (Acanthaceae)**

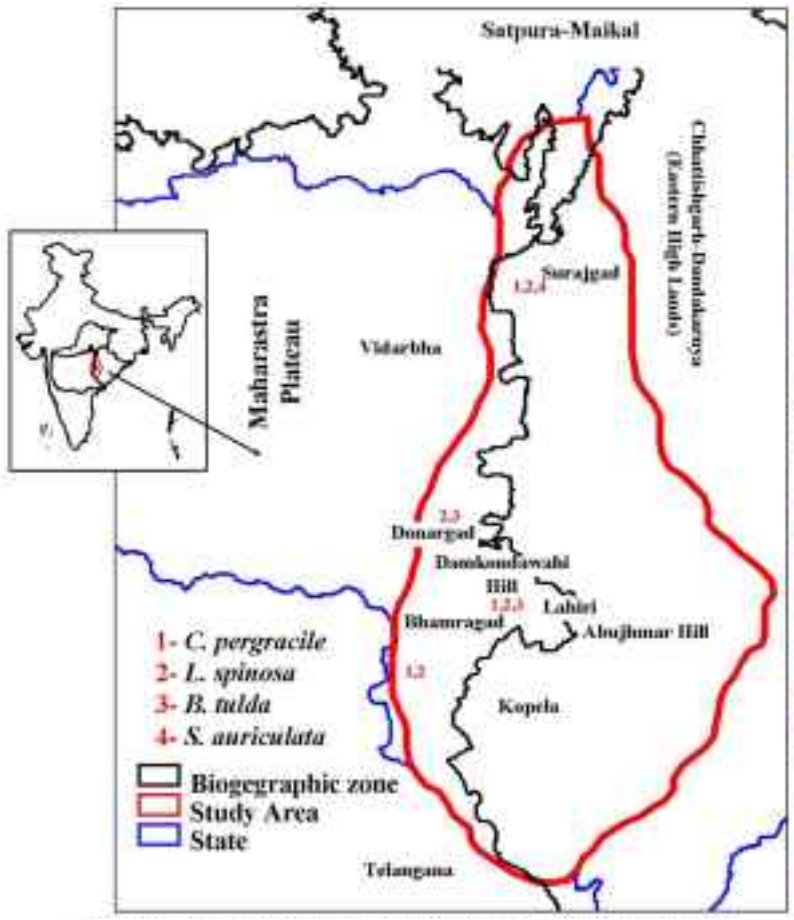
This species also grows in moist streamside areas at higher altitudes of Darekasa forests of Gondia. It has recently been rediscovered from Maharashtra from where it was thought to have gone extinct. (Dr. Bhuskute, Principal, Godia College, *Pers. Comm*.) Earlier, it was known to occur in moist forests of Panchmarhi hills (MP). As it represents semi-evergreen moist forests and has affinities with the species of Western Ghats as well as Himalaya, it has special conservation significance. As of now, no direct use and immediate threats are known.

Threats to Habitats and Conservation Implications

One of the major threats in this region is shifting cultivation which is practiced in and around Abujhmar hills- Rajnandgaon and Bastar Hills by Mainly *Maria* and *Bada Maria* tribes. Thousands of hectares of prime moist and subtropical- hill forests are slashed, burned and used for cultivation of *Kosari*, the local minor millet (a variety of *Panicum sumatrens*). Earlier 30-40 years of cultivation cycle has now come down to 15 years. Thus pristine moist forests are converted rapidly into miscellaneous low quality open forest dominated with bamboo. This also leads to soil erosion. The area is prone to frequent fire, which is largely intentional for NTFP collection, getting better Tendu leaves and hunting. Since the terrain is rugged, one can hardly control forest fires once set. Another serious threat to the habitat and threatened species in this tract is spread of alien invasive species such as *Lantana camara* and *Eupatorium adenophorum* especially in shifting cultivation area.

The Vidarbha – Dandakaranya landscape harbours one of the ancient forest formations in Deccan plateau that has undergone several changes over the millennia. Today one can trace back a number of relict patches of vegetation representing interesting micro-habitats and special assemblages of plants. These elements indicate that this landscape is unlike general Deccan plateau but has great affinity with Eastern highlands. The ecotone between dry and moist

Plate 22A
Little Known Species from Vidarbha



Localities of Botanical Interest & Distribution of Important Plants in Vidarbha-Dandakarnya Landscape

1. *Bambusa tulda*; 2. *Cephalostachyum pergracile*; 3. *Lasia spinosa*
4. *Ochna obtusa*; 5. *Memycelon umbellatum var. umbellatum*

Plate 22B
Special Habitats of Eastern Vidarbha

Abujhmar forests in April.
Bhamaragad Sanctuary

Summer pools at about 600m

Surjagad

Moist riverine forests at low altitude

Shifting cultivation at 600m, Abujhmar

Plateau flora at 650m, Abujhmar

deciduous forests, dry evergreen and riparian forests formed due to hill streams and soil type. Distribution of birdlife and other animals and butterflies distribution also indicate the cohesiveness of the two regions. Presence of butterfly species Orange Oak-leaf in such a high density as reported by the author in the hill streams has a significant bearing on the distribution of plants. This species has been reported to occur in eastern Ghats south of Godavari, Jharkhand, hilly places like Panchmarhi and Bhimashankar. The exceptionally high density of this species in this transition zone underlines the fact that flora and fauna have distribution along the moist gradients on entire Deccan.

*This region can be treated as a large '*in situ' *plant conservation laboratory and studies on phytogeography and floral migration. It is believed that moist and cool forested habitats of past have gradually transformed form much of the Deccan plateau but for certain pockets which can be seen even today. Thus*, *there is an urgent need for studying conservation status of such micro-habitats and plants assemblage which would help in understanding the ecological history of the area and predicting the future changes.*

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23.0 Vegetation and Floral Characteristics of Kanger Valley National Park, Chhattisgarh

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Introduction

Kanger Valley National Park (KVNP; 200 km^2; 18^{0}45'00" to 18^{0}56' 30" N and 81^0 51' 30" to 82^{0}10' 00" E) is located in the Bastar district of Chhattisgarh state. It is approachable from Jagdalpur town, some 25 kms towards south-east on Jagdalpur-Darbha road (Plate 23). The park, starting from Tirathgarh waterfalls to the Kolab River (Orissa boundary), is nearly 33.5 km long and about 6 km broad. The Kanger River forms the main drainage that begins near the Tirathgarh and runs through the middle of the park. The altitude varies from 338 to 781m. The mean annual rainfall is *ca* 1516.31mm while the mean temperature varies from 10 to 38 ÚC with relative humidity ranging from 40% to 98% (Jha & Khanna 2005). So far, 456 species of flowering plants have been reported (Dixit & Roy 1992, Jha & Khanna 2005). However, during recent floristic surveys the authors have added more than 60 species to the existing list including about 30 species of orchids.

The KVNP comes under Chhattisgarh-Dandakaranya (Province 6 C2) of Deccan Peninsula (Rodgers & Panwar, 1988). According to Vedic literature Dandakaranya has mythological importance where Lord Rama spent a considerable time during exile. Dandakaranya is derived from the Sanskrit word: *Dandaka* (= punishment) *aranya* (= jungle). According to Ramayana, it was home of many deadly creatures and demons. Exiled persons resided here and sages had to cross it in order to reach the Vindhya Mountain Range.

This article gives a brief description of vegetation, habitat and selected plants of high conservation significance.

Vegetation Types

The KVNP has a special ecological significance as it forms a natural transition zone between Sal (*Shorea robusta*) and Teak (*Tectona grandis*) forests in Peninsular India. Though the park is relatively small in size, it supports several distinct vegetation types in close vicinity of each other *viz*., Tropical Moist Deciduous, Tropical Dry Deciduous and Tropical Semi-Evergreen Forests (Champion & Seth 1968, Jha & Khanna 2005). The special habitats within the park are riverine forests, rocky outcrops and hill tops which harbour a large number of interesting species and a variety of medicinal plants. Broadly the forests of this park can be categorized into following types:

i. *The Tropical Moist Deciduous* (*Sal*) *Forests* : This type consists of two sub-types (a) Moist Peninsular Hill Sal and (b) Moist Peninsular Valley Sal. The former type occurs in undulating slopes and hill tops. The common trees of this type include *Shorea robusta*, *Terminalia tomentosa*, *Dillenia pentagyna*, *Miliusa tomentosa*, *Anogeissus latifolia*, *Pterocarpus marsupium*, *Emblica officinalis*, *Buchanania lanzan*, *Diospyros melanoxylon*, *Ougeinia oojeinensis*, *Kydia calycina*, *Bridelia retusa*, *Dendrocalamus strictus*, *Phoenix acaulis*, *Grewia* sp., *Woodfordia fruticosa*, *Bauhinia vahlii*, *Smilax zeylanica*, and *Butea superba.* The Moist Peninsular Valley Sal is largely found along the valleys. The common associates of Sal in this category are *Terminalia tomentosa* but *Dillenia* is not present. Champion & Seth (1968) reported excellent Sal regeneration in these forests.

ii. *Southern Tropical Moist Deciduous* (*Mixed*) *Forests* : Tirathgarh and Darbha come under this type of forest. The dominant species are *Boswellia serrata*, *Chloroxylon swietenia*, *Sterculia urens*, *Bridelia retusa*, *Erythrina suberosa*, *Butea monosperma*, *Garuga pinnata*, *Cleistanthus collinus*, *Lannea coromandelica*, *Bombax ceiba*, *Anogeissus latifolia*, *Gardenia* sp., *Madhuca longifolia*, *Diospyros melanoxylon*, *Woodfordia fruticosa*, *Ziziphus oenoplia*, *Celastrus paniculatus*, *Dendrocalamus strictus*, *etc.*

iii. *Tropical Moist Deciduous* (*Teak*) *Forest* : Teak forest is present in small portion of the Kotomser range and the major plant species includes is *Tectona grandis*, *Terminalia tomentosa*, *Bombax ceiba*, *Diospyros tomentosa*, *Dalbergia paniculata*, *Schleichera oleosa*, *Syzygium cumini*, *Careya arborea*, *Miliusa tomentosa*, *Bauhinia vahlii*, *Butea superba*, *Combretum decandrum*, *Ichnocarpus frutescens*, *Clerodendrum viscosum* and *Dendrocalamus strictus.*

Special Habitats and Interesting Plant species

Some of the special and interesting habitats of KVNP which harbour rich flora and interesting species are described, in brief, below:

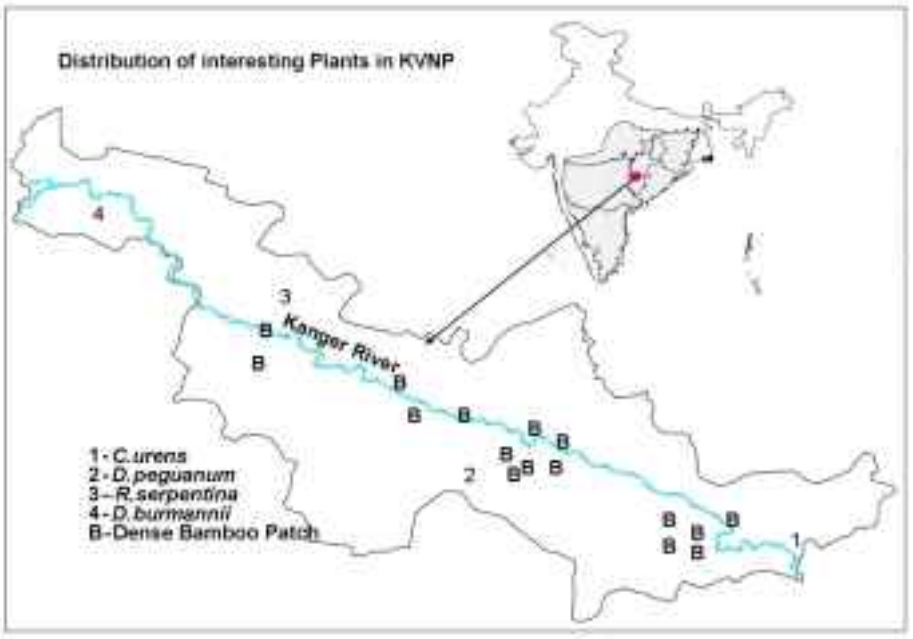
(a). *Undulating and Rocky Slopes* : The terrain of KVNP is almost hilly with deep gorges of Kanger river. Hill tops and slopes have poor and skeletal soil derived from lateritic and ferruginous conglomerates. This type of habitat is dominated by *Shorea robusta* in association with *Dillenia* sp., *Anogeissus latifolia*, *Terminalia tomentosa*, *Pterocarpus marsupium*, *Syzygium* sp., *Schleichera oleosa*, *Haldina cordifolia*, *Mallotus philippensis*, *Garuga pinnata*, *Xylia xylocarpa*, *Zanthoxylum rhetsa* and *Hedyotis auricularia.* A few species of high conservation significance in these areas include *Zingiber roseum*, *Curcuma amada*, *Costus speciosus*, *Curculigo orchioides*, *Asparagus racemosus*, and *Chlorophytum arundinaceum*. Besides, a few terrestrial orchids (*e.g.*, *Geodorum densiflorum*, *Habenaria* spp., and *Peristylus plantagineus*), some epiphytic orchids *viz.*, *Rhynchostylis retusa*, *Aerides* sp., *Dendrobium* sp., *Cymbidium aloifolium* and *Pelatantheria insectifera* can be seen in this habitat. *Dendrophthoe falcata*, *Viscum angulatum*, and *V. orientale* are common parasites.

(b). *Dry Plateaus* : Some parts of Tirathgarh, Kotamsar, Darbha and Koleng area represent dry plateau which have mixed Sal and Teak forests. Other characteristic species on the plateau *Chloroxylon swietenia*, *Boswellia serrata*, *Sterculia urens*, *Alstonia venenata*, *Lannea coromandelica*, *Anogeissus latifolia*, *Gardenia turgida*, *G. latifolia*, *Madhuca longifolia*, *Butea monosperma* and *Ziziphus oenoplia*. Around Darbha and Koleng, Sal grows in association with *Cleistanthus collinus*, *Erythrina suberosa*, *Ochna obtusata*, *Garuga pinnata*, *Sterculia urens*, *Anogeissus latifolia*, *Lannea coromandelica*, *Bombax ceiba*, *Cochlospermum religiosum*, *Dendrobium peguanum* and *Dendrocalamus strictus*. The Kotamsar and Tirathgarh plateaus have open teak forests with common associates such as *Pterocarpus marsupium*, *Sterculia urens*, *Schleichera oleosa*, *Lannea coromandelica*, *Anogeissus latifolia*, *Diospyros melanoxylon* and *Dillenia* species.

(c). *Riverine Habitats* : Kanger River and some perennials streams represent riverine habitats which are characterized by the presence of *Salix tetrasperma*, *Trema orientalis*, *Terminalia arjuna*, *Diospyros malabarica*, *Mitragyna parvifolia*, *Pongamia pinnata*, *Syzygium* spp, *Ficus* racemosa and *Memecylon umbellatum*. Typical herbaceous species of riverine area include *Centella asiatica*, *Caesulia axillaries*, *Ludwigia hyssopifolia*, *Ludwigia perennis*, *Ficus lanceolata*, *Lippia javanica*, *Polygonum* sp., *Carex cruciata*, *Cyperus* sp., *Fimbristylis* sp., *Kyllinga* sp. and *Vetiveria zizanioides.* In addition, several seasonal herbs appear in such areas subsequent to rains. *Ottelia alismoides*, *Vallisneria natus*, *Hydrilla verticillata* are common submerged aquatic herbs. Open moist areas harbour a few insectivorus plants such as *Drosera burmannii*, *Utricularia aurea* and *U. bifida*, associated with lower plants *viz.*, *Pteridium* sp., *Pteris* sp., *Equisetum* sp., *Marsilea* sp. and *Riccia fluitans*.

(d). *Bamboo brake* : Bhainsadarha area is dense with bamboo forest including four different species *viz*. *Dendrocalamus strictus*, *Oxytenanthera nigrociliata*, *Cephalostachyum pergracile* and *Bambusa arundinacea.* Foothills and shady moist ravines are mostly covered by *Cephalostachyum pergracile*.

Plate 23
Threatened Plants of Kanger Valley NP, Chhatishgarh



Riverine Habitat

Dry Plateau

Caryota urens

Rauvolfia serpentina

Dense Bamboo Patch

Dendrobium peguanum

Drosera burmannii

Undulating and Rocky Slopes

Threatened Plants: Roy & Chaturvedi (1987) and Kumar & Sikarwar (2002) studied the rare and endangered plants of Bastar region and reported that over exploitation, invasive species and encroachment are the major threats to native plants and their habitat. *Drosera burmannii*, *Eulophia* sp., *Dendrobium peguanum*, *Rauvolfia serpentina*, *Gymnema sylvestre*, *Strychnos nux-vomica*, *Vitex leucoxylon*, *Gloriosa superba*, *Caryota urens*, *Riccia fluitans* and *Costus speciosus* have declined in the area over the years and hence, need to be prioritized for long term conservation. Some of these species are briefly described below:

***1. Drosera burmannii* Vahl. (Droseraceae)**
Local Name: *Mohinibooty*

Insectivorous herb. Leaves in basal rosettes, appressed to ground, green with purple center, margin glandular-hairy. *Fl. & Fr.*: Sep.-Jan. growing along the bank of Kundru-Jodi nallah (Plate 23).

***2. Caryota urens* Linn. (Arecaceae)**
Local Name: *Salphi*

A tall palm. Spadices 3-4m long, Flowers unisexual. *Fl. & Fr.*: October-March. Stem sap is tapped for making alcohol (Sulphi). At places it is planted by the local people because it serves as cash crop. However, it is highly threatened in other areas due to over exploitation. Within KVNP only 2-3 individuals can be seen especially in Pulcha beat.

***3. Dendrobium peguanum* Lindl. (Orchidaceae)**

Epiphytic orchid. Pseudobulbs globose with membranous sheaths. Leaves linear-oblong. Inflorescence terminal on leafless stem. Flowers fragrant, 1–1.5cm across, white, lip pale brown, veined with dark brown to purple, anterior lobe purple. Fruits globose. *Fl. & Fr.*: December–March. Threatened species for Central India. A few individuals can be seen in Koleng beat.

***4. Rauvolfia serpentina* (L.) Benth. *ex* Kurz. (Apocynaceae)**
Local Name: *Kukut-chandi*

Erect under-shrubs. Leaves in whorls of 3-7. The flowers are drupaceous, white, pinkish or red. Heavily exploited throughout India for its medicinal properties. Rare in KVNP. *Fl. & Fr.*:Oct.-Dec.

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24.0 Chotanagpur Plateau: Relict Habitats and Endemic Plants

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Introduction

Chotanagpur plateau is one of the oldest landmasses on earth. It is composed of Precambrian rocks which are more than 540 million years old. It is a collective name for the Ranchi, Hazaribagh, and Koderma plateaus, having an area of *ca* 65,509 km^2. Of these, Ranchi is the largest. The plateau in its entirety lies between the basins of the Ganges and Son rivers to the north and the Mahanadi River to the south. Through its centre, from west to east, runs the coal-bearing, faulted Damodar Valley. Numerous streams have dissected the uplands into a peneplain (an area reduced almost to a plain by erosion) with isolated hills. To the north of Chotanagpur lies the Rajmahal Hills which are very important on account of their fossiliferous deposits. Some of the important fossils found in the area are *Sahnioxylon rajmahalense*, *Pentoxylon sahnii*, *Sahania nipaniensis*, *Nipaniophyllum hobsoni*, *Carnoconites compactus* and *Nipanioxylon guptaii.*

Biogeographically, Chotanagpur plateau has a special significance. It forms the northern limit of Peninsular India that lies within Paleotropic region. Rodgers and Panwar (1988), in their Biogeographic Classification of India, recognized this plateau as part of province 6B (Deccan peninsula). The plateau has drawn the attention of several phytogeographers. Nayar (1996) identified 20 centres of plant endemism in India, of which Chotanagpur is one that has been recognized as an important 'microcentre'.

In this article we give an overview of the plant wealth, patterns of plant endemism and localities of botanical interest on the Chotanagpur plateau and suggest a few measures for their conservation.

Biophysical Features

The forest vegetation of the Chotanagpur Plateau is represented by three major groups as per the classification by Champion & Seth (1968): (i) Tropical Moist Dedicuous Forests (3C/C3a and 3C/E1), (ii) Northern Tropical Dry Deciduous Forests (5B/C1c, 5B/C2 and 5/DS2) and (iii) Central Indian Subtropical Hill Forests (8A/C3). The total vegetation cover on the plateau is about 29.61 %. Out of this, 3.19% area is under very dense forest cover whereas 11.39% has moderately dense forests, 13.76% has open forests and 0.92% area has scrubland. There are 3 National Parks and 20 Wildlife Sanctuaries (Singh *et al.* 2001). According to Wildlife database there is 1 existing National Park and 2 proposed, whereas 11 Wildlife Sanctuaries existing and 2 are proposed (http://www.wii.gov.in/nwdc/index.html).

The climate of the plateau is Tropical monsoon type with three distinct seasons, *viz.*, summer (March to mid June), Monsoon (mid June to October) and winter (November to February). May is the hottest month with temperature going up to 45ÚC. During May and June the state also experiences hot winds knows as *loo*. January is the coldest month with temperature ranging from 6ÚC to 22ÚC. The average rainfall varies between 100 cm to 150 cm. Likewise, the humidity varies from 38% (April - May) to 94% (August – September). On the basis of the ratio of total monthly precipitation and total monthly evaporation, Thronthwaite (1933) has placed the state under dry sub-humid category. The plateau has predominantly red soil that is derived from peculiar rock formations. This soil exhibits high percentage of acid soluble Ferric oxide and lower pH ranging from 5 – 6.8. In some higher parts of the plateau laterite soil is also found.

Chotanagpur has a human population of around 26.91 million of which 22.50% are of tribal origin, belonging to more than 30 different tribes. They are mostly dependent on the forest resources for their living. Some of these tribes are, Baiga, Santal, Asur, Chero, Gond, Larmali, Kond, Kurmi, Tharu, Munda, *etc*. Recent findings have suggested that the pre-Dravidian aborigines, whose descendants are speakers of the Munda Austric languages, living today in parts of Chotanagpur (Jharkhand), Chhattisgarh, Orissa, Bengal, and so on are the original inhabitants of India. This fact makes the area anthropologically unique.
(http://en.wikepedia.org/wiki/Dravidian_people).

Floral Wealth and Endemism

Despite a large number of floral surveys, there is no comprehensive account on the angiosperm flora of Chotanagpur Plateau. However the flora of erstwhile Bihar (that includes the state of Jharkhand which encompasses maximum part of the Chotanagpur Plateau), has recorded 186 families, of which 148 are dicotyledons and 38 are monocotyledons. Total number of species in erstwhile Bihar is 2963 which belongs to 1151 genera (Singh *et al.* 2001). The plateau has played an important role in the migration of plants from Eastern Himalayas, Assam, Myanmar, Malaya and other countries of the South-East. Plants have migrated from here to Western and Eastern Ghats and Sri Lanka. It is also believed that in the geological past, this plateau formed a link between Satpura Hill Ranges and eastern Himalaya that allowed species exchanges between these ranges (Hora 1949). Jharkhand is even recognised as a distinct geographic region (IND-JK) in Indian subcontinent by Kew (Brummitt 2001).

The plateau has altogether 14 endemic taxa (Some endemic to India and others endemic to Jharkhand). The following table gives the details of these taxa:

Table 1 : List of Endemic Plant species of the Chotanagpur plateau (Singh *et al.* 2001)

No.	Species name	Family
1.	*Clematis roylei* Rehder var. *patens* (Haines) Kapoor	Ranunculaceae
2.	*Dendrocalamus strictus* (Roxb.) Nees var. *sericeus* (Munro) Gamble	Poaceae
3.	*Dimeria ornithopoda* Trin. var. *gracillima* Bor	Poaceae
4.	*Iseilema holei* Haines	Poaceae
5.	*Leucas lanata* Wallich *ex* Benth. var. *nagpurensis* C.B.Clarke *ex* Haines	Lamiaceae
6.	*Ligusticum alboalatum* Haines	Apiaceae
7.	*Sophora bakeri* C.B.Clarke *ex* Prain	Fabaceae
8.	*Swertia angustifolia* Buch.-Ham *ex* D.Don var. *pyramidalis* Haines	Gentianaceae
9.	*Zingiber purpureum* Roscoe var. *palamaunsis* (Haines) K.K.Khanna	Zingiberaceae

Table 2 : List of Orchid species Endemic to India and found in Chotanagpur Plateau

No.	Species name	Habit	Remarks
1.	*Dendrobium herbaceum* Lindl.	E+L	Wide Endemic *
2.	*Dendrobium regium* Prain	E	Endemic
3.	*Habenaria gibsoni* var. *foetida* Blatt. *et* McCann	T	Endemic
4.	*Nervilia carinata* (Roxb.) Schltr.	T	Endemic
5.	*Nervilia falcata* (King *et* Pantl.) Schltr.	T	Endemic

(* found only in India and Sri Lanka)

Some Unique Habitats and Associated Flora

i. Parasnath Hills : Parasnath Hills are situated towards the centre of the state of Jharkhand in the Giridih District. Apart of it (49.3 km2) was designated as a Wildlife Sanctuary in 1984. The highest elevation goes to approximately 1500m asl. Clarke (1898) and Haines (1921 – 24) have suggested that the hills of Parasnath may have served in the past as stepping stone for the passage of plant species between the hills of Peninsular India and Eastern Himalaya. With respect to vegetation this area is unique due to the presence of Montane subtropical forests (8A/C3) above 1220 m asl

on this hills (Champion & Seth 1968). Some of the commonly found species in this area above 1220m are, *Pittosporum wightii*, *Grewia* spp., *Meyna spinosa*, *Berberis asiatica*, *Reinwarditia indica*, *Thallictrum foliolosum*, *Polygala* spp., *Lobelia alsinoides*,, *L. heyneana*, *Clematis gouriana*, *etc*. The areas between 650 – 1220 are dominated by *Litsea monopetala*, *Ficus microcarpa*, *F. mollia*, *Symplocos racemosa*, *Alangium salvifolium*, *Indigofera pulchella*, *Vitis* spp., *Bauhinia vahlii*, *B. sericea* var. *anguina*, *Persea bombycina*, *Chionanthus ramiflorus* and *Caesalpinia bonduc* to name a few (Plates 24A, 24B & 24C).

ii. Saranda Forests : Saranda is a dense forest in the hilly region of West Singhbhum district. Saranda literally means seven hundred hills. It is supposed to be one of the largest sal forests in Asia. The forest covers an area of 820 km². Amongst these forests lies a scenic village, called Thalkobad, at a height of 550 m (1,800 ft) in the heart of the forest. This area represents a very nice habitat for Orchids including all the 11 species of *Dendrobium*s and it is a home for the last remnant population of *Bulbophyllum*, an epiphytic orchid represented by single species, *Bulbophyllum crassipes*. Another interesting orchid of this region is *Pecteilis triflora*, which is found only at two places in India, one being Saranda forests and the other site is in the western Himalaya in Tons Valley, Uttarkhand. Saranda also hides amongst its dense forests, Ligirdah swamp which harbours unique swamp vegetation dominated by the members of family Zingiberaceae such as *Hedychium coronarium* and other families of sedges and grasses. The swamp is deep enough to engulf huge wild Elephants and is surrounded by dense sal forests. The reserved forests are the home for many animals like, wild elephants (common), sambar, chital, bison, leopards and even tigers, though they were never numerous but they are there.

iii. Netarhat : This is a densely forested area dominated by both moist and dry deciduous sal forests. The elevation ranges from 600m – 950m asl, with minor and major streams. One of the highest waterfalls called the Lodh Falls is located in these forests along with the famous Mahuadanr Wolf Sanctuary. Lodh Falls represents an ideal riverine ecosystem, harbouring a very important economic orchid of this region, called *Pholidota imbricata*, locally called "*Pathal Kela*", literally meaning, 'banana growing on high cliff rocks'. The forests are ideal habitat for orchid species, especially *Dendrobium*s (Plate 24C). Ten out of 11 species of *Dendrobium*s are found in this locality. Economically this area is highly suited for the cultivation of *Pyrus cummunis* (Family: Rosaceae), commonly called as Naspati.

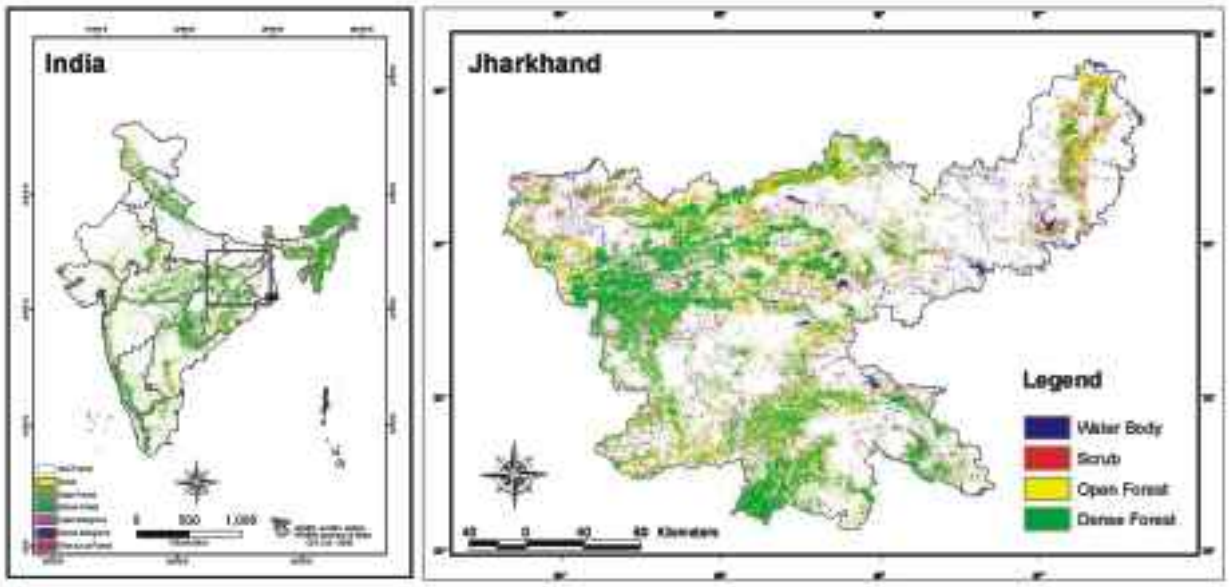
iv. Barkapahar, Ranchi – Khunti Highway : This is a small hillock of aproximately 130m high ranging from 650m - 780m above sea level and it is called Barka Pahar by the locals of the area, which is basically in comparison to another small barren hillock nearby. On the steep slopes there are Sal forests at some places and at some places there are mixed forests with Acacia spp. and *Bauhinia variegata*. On the gentle slopes towards the foothills are *Shorea robusta*, *Bauhinia*, *Nyctanthes arbor-tristis*. There are some *Terminalia alata* trees too scattered all over the hillock. In the mixed forests *Shorea robusta* is dominant species alongwith many species of undershrubs. A river runs along half the stretch of its foothills.

This hillock practically remained untouched by the scientific community and uninhabited by the local tribal community. Local tribal communities, use the land at the foot of the hillock for agriculture. The hillock recently gained importance due to the presence of 24 species of orchids of which 19 were collected specifically from the hillock and rest were from the trees scattered distantly on the plains below the hillock. Out of these 19 species, 16 are terrestrial, 2 are epiphytic and 1 is saprophytic. These represent around 40% of the total Orchids found in the whole state of Jharkhand.

Conservation Issues and Strategies

Despite all its marvelous biogeographical significance and uniqueness, Chotanagpur Plateau is not even prioritized for conservation by the Indian government, most probably because nowadays, conservation is based on effortlessness, rather than the necessity!

Plate 24A
Chotanagpur Plateau: Vegetation and Habitat Features - I



Sal Forest, Netarhat, Latehar

Moist Mixed Deciduous Forest, Saraikela

Swamp Vegetation
(Ligirdah, Thalkobad, West Singhbhum)

Riverine Habitat
(Lodh Falls or Budhha Ghag Falls, Latehar)

Plate 24B
Chotanagpur Plateau: Vegetation and Habitat Features - II

Forested Habitat Islands around Chainpur, Gumla

Parasnath Wildlife Sanctuary
(Giridih)

Saranda Forests, West Singhbhum

Netarhat Plateau, Latehar

Barkapahar, Ranchi – Khunti Highway

Plate 24C
Threatened Orchids from Chotanagpur

Geodorum attenuatum Griff.

Odisha cleistantha S.Misra

Habenaria marginata Colebr.

Dendrobium herbaceum Lindl.

Bulbophyllum crassipes Hook.*f.*

Acampe papillosa (Lindl) Lindl.

Dendrobium formosum Roxb. ex Lindl.

Pholidota pallida Lindl.

According to Joshi and Dash (2006), the biodiversity of Jharkhand is under severe threat due to human induced activities, industries, mining, settlement, development projects and removal of forest products, overgrazing and forest fires. Majority of forest is lost due to industrialization and extraction of minerals from the earth crust. There is an urgent need to conserve the rich biodiversity of the state before the treasure is lost. There is an immediate need for the *in situ* conservation of this special habitat, *i.e.*, Chotanagpur Plateau on whole as well as its biodiversity. Being one of the oldest landmasses on earth, the Chotanagpur Plateau might be hiding some unforeseen information concerning the evolution of earth as well as its biodiversity.

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25.0 Threatened Plants of Orissa and Priority Species for Conservation

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Introduction

The state of Orissa (1,55,707 km^2; 17^0 49' N to 22^0 34' N and 81^0 27' to 87^0 29' E) is situated on the eastern coast of India. It is bestowed with varied physiographic conditions, moderately high rain fall (142.2-157.5 cm. per annum) and relative humidity (61.5-78.0%), and a fine network of perennial river systems providing congenial conditions for a rich flora. The state has about 37% forest cover which is much higher than the national average (Anonymous 2006) and it is credited with five of the sixteen major forest types and 32 sub-types occurring in India (Champion & Seth 1968). The five main categories of forests within the state are (i) Orissa Semi-evergreen forests (ii) Tropical moist deciduous forests (iii) Tropical dry-deciduous forests (iv) Central Indian hill forests and (v) Littoral and Tidal swamp forests (Panigrahi 1983).

Biogeographically, the state falls in three zones *viz.*, Deccan Peninsula (Chotanagpur and Eastern Highlands), Lower Gangetic Plain (7B) and East Coast (8B) as per classification by Rodgers *et al.*, (2002). Meher-Homji (2001) has recognized three phytogeographic regions in the state, *i.e.*, Deccan Plateau, Eastern Ghats and the Coastal Plains. The state is underlain largely by the Precambrian rocks. The geological formations reflect a complex of igneous metamorphic and sedimentary rocks with alluvial and coastal alluvial plains, each giving rise to distinct soil type which range from alluvial (coastal and riverine types) to lateritic and Black cotton.

Till date about 3,000 species of angiosperms and Pteridophytes have been recorded from the state (Panigrahi 1990). The flora of the state is mainly known through the monumental work of H.H. Haines (1921-25). His treatise "The Botany of Bihar and Orissa", supplemented by H.F. Mooney (1950) serves as a much-needed baseline for all further floristic studies in the state. The contribution by Gamble & Fischer (1915-36) who provided accounts of northern forest circle of the Madras Presidency (southern part of modern Orissa) also remains invaluable. Similarly, the work of Panigrahi *et al.* (1964), Rao & Banerjee (1967) and Saxena & Brahmam (1994-96) and the district flora scheme of Botanical Survey of India covering different districts of the state have made significant contributions in recent times. In addition, exhaustive work by S. Mishra and A.K. Dubey need special mention who have contributed immensely on Orchidaceae and Poaceae of Orissa respectively. Biswal & Choudhury (1994) have documented flora of different protected areas in the state. However, no comprehensive assessment of the rare, threatened and endangered species have been carried out, except for report of the CAMP (Conservation Assessment of Medicinal Plants) Workshop organized under the aegis of Orissa Forest Department and Foundation for Revitalisation of Local Health Traditions, Bangalore which has listed 41 species (Ved *et.al.* 2008). Other exercises which aim at prioritization have been woefully short of their desired aim – for instance, in a recently concluded meeting of experts for state-wide identification of critically endangered species, just a single species was identified for Orissa. This was despite the fact that the habitat and species richness of the state is very rich and represents about 20 percent of the total flora of India (Panigrahi 1990) with 2727 species (1062 genera, 228 families of angiosperms with 28 endemic species) reported from the entire state (Saxena & Brahmam 1983).

In this paper we present a synoptic overview of the state and its floristic regions with special emphasis on botanical hotspots, along with a tentative list of the rare, endangered and threatened (RET) species with brief descriptions of selected threatened taxa. A few localities of high botanical interest have been mentioned which have remained under-explored and need studies. This exercise has largely been undertaken by consulting existing information derived from published works mentioned above, supplemented by primary data collected by the first author from various parts of the state during the last two decades and intensive field work done by both authors in Mayurbhanj district from 2006 to 2008. The IUCN Red list categories (Mace & Stuart 1994) have been followed for the criteria used for the present assessment, which includes factors such as population reduction, extent of occurrence, area of occupancy, population size and the probability of extinction in wild. We realize that in many cases, there is data deficiency on the exact population status of different taxa due to paucity of studies. Further, there might also be differences in opinion regarding the relative abundances, degree of threats and potential for long-term survival in different areas of the state. Nevertheless, an attempt is made to generate a baseline which can be supplemented/modified in future with availability of more concrete data from field.

Prioritising taxa for conservation : the approach

The plant specimens from Orissa housed in various herbaria *viz*., Central National Herbarium Calcutta (CAL), Forest Research Institute, Dehradun, Institute of Minerals and Materials Technology, Regional Plant Resource Centre, P.G. Department of Botany, Utkal University (all three in Bhubaneswar) and that of P.G. Department of Botany, North Orissa University, Baripada were critically examined. The work of some notable workers (Haines (l.c.), Mooney (l.c.), Gamble & Fischer (1925-1936), Jain & Rao (1983), Jain & Sastry (1983), Nayar & Sastry (1987), Saxena & Brahmam (1994-96), Anonymous (2007a) and Ved *et al.* (2008) also served as major sources of information. In addition, field observations made in the forests of Orissa since 1989 in connection with different projects provided supplementary information for assessing the status. The CAMP workshop report (Ved *et. al.* 2008) was also referred.

Phytogeographical Divisions and Characteristic Floral Elements

Orissa has four distinct geographical and ecological divisions:

Coastal plains having 40,191 sq. km (18% of the state) and a forest cover of 7958 sq. km, includes 11 districts and the brackish water Chilika lake and Bhitarkanika mangrove forests. Apart from a host of mangrove and mangrove associates, species of special conservation significance which occur in this region include *Rhizophora stylosa*, *Sonneratia griffithii*, *Avicennia marina* var. *acutissima*, *Kandelia candel*, *Indigofera*, *aspalathoides*, *Synostmon bassiforme*, *Stylosanthes fruticosa*, *Cassipourea ceylanica*, *Salicornia brachiata*, *Phoenix paludosa*, *etc.*

The Northern Plateau with 28,433 sq. km. in area, includes four districts with a forest cover of 11,046 sq.km covering the Similipal Biosphere and large hill ranges with a general slope from North to South. The important hill ranges are Malayagiri (1,188 m), Mankarnacha (1,177 m) and the Meghasani (1,116 m). The major rivers namely Brahmani, Baitarani and Budhabalanga and numerous rivulets have their origin from this plateau. Among the the threatened species confined to this region are *Eria meghasanienesis*, *Hypericum gaitiii*, *Aspidopterys tomentosa* var. *hutchinsonii*, *Zeuxine affinis*, *Peristylus parishii*, *Acanthephippium bicolor*, *Acanthephippium sylhetens*, *Phoebe lanceolata*, *Clematis roylei, Baccaurea ramiflora*, *etc.*

Central table lands having 36,536 sq. km in area and which includes seven districts with a forest cover of 10,536 sq. km. The three prominent rivers Mahanadi, Brahamani and Baitarani flow parallel to each other making this region agriculturally fertile and thickly populated. *Eusteralis griffithii*, *Homonoia intermedia*, *Uvaria eucincta*, *Aglaia haslettiana*, *Psoralia corylifolia*, *Desmos longiflorus*, *etc.* are among the interesting taxa of conservation importance.

Eastern Ghats having 49,827 sq. km with 17041 sq. km of mountainous region and forests, spread in eight districts. The prominent mountain peaks of the state namely Mahendragiri (1,500 mt), Singharaju (1,515 mt), Turiakonda (1,599 mt) and Deomali (1,673 mt) are located in this tract. The area is noted for the presence of *Dimeria mahendragiriensis*, *Oryza jeyporensis*, *Selaginella nairii*, *Themeda mooneyi*, *Wendlandia gamblei*, *Pecteilis henryi* and *Strobilanthes jeyporensis.*

Results and Discussion

After analysis, 117 taxa belonging to Angiospermic, Gymnospermic and Pteridophytic flora have been prioritized for conservation in Orissa (Table-1). Of these, 19 have been enlisted as threatened taxa based on IUCN criteria. While 7 taxa were found to be near-threatened, 28 were vulnerable, 22 were data deficient and 21 were not evaluated. Of the 62 families represented, Orchidaceae was the dominant family with 8 taxa followed by Fabaceae with 7; Meliaceae, Clusiaceae, Euphorbiaceae and Mimosaceae with 4 each; Annonaceae, Bignonceae, Caesalpiniaceae, Liliaceae and Lauraceae with 3 each; Acanthaceae, Apiaceae, Apocynaceae, Loganiaceae, Myrtaceae, Salvadoraceae and Sterculiaceae with 2 each while the rest had a single species. In terms of growth form these species represent 47 trees, 20 shrubs, 19 climbers, 27 herbs and 3 ferns.

Some species of high conservation priority

Albizia thompsonii **Brandis (Mimosaceae) :** Large trees, Fls: March. Frts: Nov-Jan. Occurrence: Anugul, Lanjigarh, Kalahandi. No collection made in recent time. Distribution: Orissa, T.N. & Maharastra. Extremely limited distribution with threatened habitat.

Angiopteris evecta **(Forst.) Hoffm. (Angiopteridaceae) :** A magnificent, large fern, 2-3 m. high. Fertile: March-Aug. Occurrence : Similipahar, Mayurbhanj, Pal lahara; Bonai, Mahandrigiri.
Distribution: India, China, Japan. Vulnerable in Orissa due to fragmentation of habitat.

Aspidopterys tomentosa **(Bl.) Juss. var.** ***hutchinsonii*** **(Haines) Srivastav (Malpighiaceae) :**
Stout climber, Occurrence: Bhanjam hills, Mayurbhanj. Highly localized distribution.
Distribution: Orissa. This taxon was reported by Haines in 1920. No collection/report made in recent times.

Atylosia cajanifolia **Haines (Fabaceae) :** Perenial shrub up to 2m. Occurrence: Damp forest Hills of southern Orissa: Khurda and Ganjam. Distribution: Andhra Pradesh & Tamil Nadu.

Blepharispermum subsessile **DC. (Asteraceae) :** Perennial, glabrous shrubs. Rare in moist deciduous forest, Nawapara and Koraput. Distribution:- India.Assessed as Endangered taxon from Orissa, FRLHT, Bangalore.

Cerbera odollam **Gaertn. (Apocynaceae) :** Small mangrove-associate tree, Fls.: March-Apr. Frts.: August. Occurrence: Bhitarkanika, Threatened due to over exploitation for medicine. Distribution: India, Sri Lanka, Malaysia.

Cycas spherica **Roxb. (Cycadaceae) :** Cycad having an extremely limited distribution. Occurence: Mals of Puri, Distribution: Orissa. Vulnerable in the state due to loss of habitat and overexploitation.

Dendrobium cathcartii **Hook.f. (Orchidaceae) :** Epiphytic orchid. Fls & Frts: April. Occurrence: Similipal, Mayurbhanj, Rare. Distribution: India.

Eria meghasaniensis **(Misra) Misra (Orchidaceae) :** Pseudobulbous epiphytic orchid. Occurence: Entire global population remain confined to a few trees and one rock on the twin peaks of Meghasani and Khairiburu in Similipal hills. Very rare. Distribution: India (Orissa). Endemic.

***Eriolaena hookeriana* Wt. & Arn. var*. viridis* Haines (Sterculiaceae) :** Shrubs. Occurrence: Haines (1921) reported the taxon from Orissa. No report/collection made in recent times. Distribution: Orissa, Endemic.

***Gnetum ula* Brongn. (Gnetaceae) :** Woody climber of high botanical interest. Occurrence: Occassional in semi evergreen forests, Locally common in Similipal. Keonjhar, Mahendragiri, Kotgarh.Distribution: Peninsular India, Andaman, Myanmar. Vulnerable due to exploitation as well as accidental destruction due to silvicultural operations like climber-cutting.

***Hypericum gaitii* Haines (Hypericaceae) :** Conspicuous flowering shrubs, having patchy distribution. Occurence: Along streams in cool valleys of central and southern Similipal .Note: Mooney, 1950 reported from Malaygiri Hill, in Angul District, Orissa. No collection is made from these localities in recent times. Distribution : Orissa & Bihar

***Lasiococca comberi* Haines (Euphorbiaceae) :** A handsome trees with characteristically fluted bole, often showing gregarious growth, in moist valley with semi-evergreen forests; Puri, Angul. Good population in southern Similipal. Distribution: Orissa and Hills of Vishakpatnam, A.P.

***Nothopegia heyneana* (Hook.f) Gamble (Anacardiaceae) :** Small trees growing in rocky ravines. Baula forest, Keonjhar; Mals of Puri, Orissa. Distribution:- Orissa, Western Ghats, T.N.

***Oryza jeyporensis* Govind & Krishnam. (Poaceae) :** Erect annual grass up to 1m, Occurrence: Jeypore, Koraput. Distribution:- Endemic to Orissa.

***Pomatocalpa decipiens* (Lindl.) J.J. Sm. (Orchidaceae) :** Epiphytic orchid. Rajin reseve forest, Puri. Distribution; Orissa. Sri Lanka.

***Saraca asoca* (Roxb.) de Wilde (Caesalpiniaceae) :** State tree of Orissa. Small evergreen tree occasional in valleys along streams. Planted in gardens. The population is declining due over exploitation for bark. Distribution: Indian Sub-continent, Malaysia.

***Stemona tuberosa* Lour. (Roxburghiaceae) :** Climbing herbs.Occurrence: Mahendragiri, Ganjam; Similipal, Mayurbhanj; Kotgarh, Vulnerable because of medicinal use extraction. Distribution:- India, Bangaladesh, China.

***Strobilanthes circarensis* Gamble (Acanthaceae) :** Shrubs. Fls: Dec.Occurrence: Tankanmai, Karlapat, Kalahandi (Mooney 1950). No collection is made in recent times. Distribution: Endemic.

***Strobilanthes jeyporensis* Bedd. (Acanthaceae) :** Shrubs. Occurence :In damp ravines; Kalahandi, Ganjam and Koraput. Distribution: A.P and Madhya Pradesh,India. This taxon has been included as endangered in the Red Data Book of India. (Nayar and Sastry, 1987).

***Uvaria eucinata* Bedd. *ex* Dunn. (Annonaceae) :** Shrubs. Occurrence:Russelkonda, Ganjam. No collection is made in recent times. Distrubution: Orissa; endemic

***Xylocarpus granatum* Koenig. (Meliaceae) :** Moderate-sized mangrove-associate tree. Fls; April-Sept. Frts: Oct-May. Occurrence: Tidal forest, Bhitarkanika and Mahanadi delta. Note: Fruites having therapeutic use, endangered in Orissa due to habitat conversion. Distribution: India, Sri Lanka, Malay, Africa, North Australia

Floral hotspots and suggested areas for future exploration

Orissa enjoys the unique privilege of being the meeting ground of the flora of the northern tropical forests and the largely endemic flora of the southern India. As a whole, it exhibits wide-ranging affinity with the flora of other phytogeographic

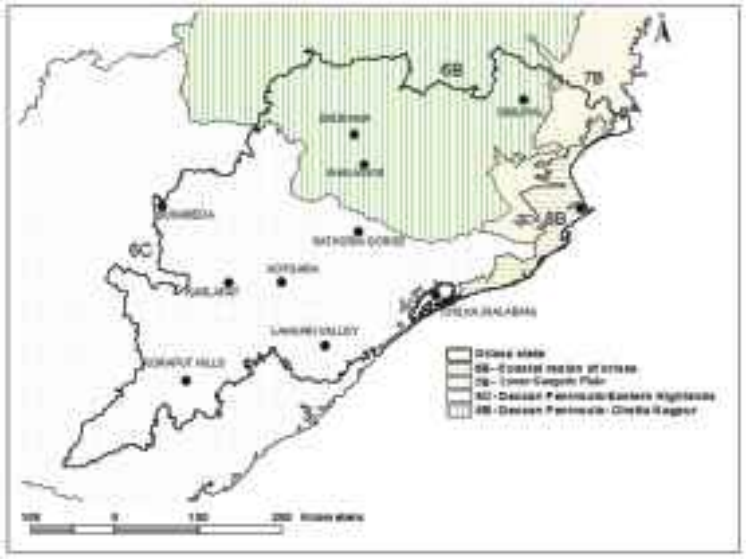
regions of the country, *viz.* Eastern Himalayas, Gangetic Plains and the Western Ghats. Though the state has a vast forest area, there are certain landscapes/areas which harbours a series of unique and special habitats with exceptional floristic richness. The notable among them are the extensive hills of Similipal in Mayurbhanj along with its staellite areas of Kuldiha and Hadgarh, Gonasika-Kanjipani-Telkoi tract in Keonjhar, Karlapat in Kalahandi, Sunabeda plateau in Nawapara, Kotgarh in Phulbani and the high E.Ghat hills of Deomali, Mahendragiri, Niyamagiri and Kondakameru in southern Orissa. Others worth mentioning are Badarama and Khalasuni forests in Western Orissa, and the gorge of Mahanadi at Satkosia. Not to be forgotten are the river deltas of Mahanadi, Brahmani and Baitarani which support a luxuriant mangrove flora, especially at Bhitarkanika. The vast brackish water lagoon of Chilika is also home to an unparalleled aquatic and semi-aquatic floral diversity. Many of these remain poorly explored and await detailed studies which are sure to reveal hitherto unknown species. Predominant among the largely unexplored areas are the remote gorges and evergreen forests of southern Similipal, especially in the core area of the Tiger Reserve; the extensive forests of Daringbadi-Bhanjnagar complex of Phulbani district, Rebna and Ranjagarh hills; Palaspal and forests around Meghanada Parbat; secluded hills east of Banaigarh; the high hills of Kalahandi including Karlapat with peaks beyond 5000 ft; highlands of Koraput, interiors of Sunabeda plateau and high lands of Khariar. Among other relatively less-explored areas are the hilly tracts near Jeypore and Koraput bordering Andhra Pradesh, hills near Russelkonda and Subarnagiri, the spurs east of Rairakhol, and the hilly tracts north-west of Sambalpur. Also of high botanical interest are the farther islands of Chilika lake and some remote tidal creeks and swamps along the deltas of Mahanadi and Dhamra rivers (Plates 25A & 25B).

Threats and Conservation efforts

Among the myriad threats to floral wealth, loss of habitat and fragmentation at an alarming rate must certainly rank as the first. Though anthropogenic habitat alteration by way of cropland conversion, shifting cultivation, *etc.* has existed since eons, there has been unprecedented acceleration recently by way of increasing mining activity, especially in the hilly mineral-rich tracts of hinterland Orissa. Many of the hotspots mentioned elsewhere in this paper are under the imminent threat of being destroyed gradually. Increasing encroachments and subsequent urbanization is also a serious threat to erstwhile pristine areas. Aquatic ecosystems including a number of wetlands get altered irreparably by aquaculture and land reclamation. In addition to these are the chronic problems of forest fire, especially in the dry deciduous forests of western and southern Orissa and gradual spread of invasive species in almost all the forest types. A more serious and recent cause for concern is also the emergent market for herbal products, which has resulted in unscrupulous and unsustainable collection of medicinal plants, many local populations of which have either been wiped out or are at the verge of local extinction. Species which were extremely common till the recent past like *Rauvolfia serpentina*, *Rubia cordifolia* and *Gloriosa superba* are all nearing extermination in the state. The state tree of Orissa, *Saraca asoca* is also no exception!

However, a slew of *in situ* and *ex situ* conservation measures is being adopted by both by government agencies as well as organizations in the non-governmental sector. As many as eighteen wild life sanctuaries and two national parks have been established in order to safeguard the wildlife in general and threatened species in particular. In addition, 5 *in situ* Medicinal Plant Conservation Areas (MPCAs) have been established at Satkosia (Mayurbhanj), Patalganga (Nuapada), Pradhanpat (Deogarh), Kapilas (Angul) and Berbera (Khurda). *Ex situ* collections as in the various Botanical Gardens, most notably that in Nandan Kanan and Regional Plant Research Centre, Bhubaneswar are also valuable steps in the right direction. The recent initiative by the Forest Department to identify, map and conserve all forest blocks with *Saraca asoca* and mass-propagate and plant seedlings is also a commendable initiative aimed at species-specific conservation. More such measures are needed if we are to conserve the entire spectrum of floral diversity of the state for posterity. The first step, however, has to be a comprehensive field-based assessment of threatened flora be carried out in a phased, state-wide and systematic manner in the light of existing information so that existing hotspots can be prioritized for effective conservation and fresh ones identified for future action.

Plate 25A
Some Localities of Special Botanical Interest in Orissa



Localities of Special Botanical Interest & Conservation Significance in Orissa

Semi-evergreen Forests

Moist deciduous slopes

Sacred grove (***Jahira***) of Kolha Tribe

Hill stream vegetation

Steep Gorges

High hills of Eastern Ghats

Grasslands

Plate 25B
Threatened Plants of Orissa

Doryopteris ludens

Hypericum gaitii

Lasiococca comberi

Cochlospermum religiosum

Gnetum ula

Stemona tuberosa

Table-I : Species of high conservation priority in Orissa with their distribution and status.

Habit : C=Climber, H=Herb, T=Tree, F=Fern, S=Shrub;
Threat Status : CR=Critically endangered, EN=Endangered, VU=Vulnerable, NT=Near Threatened, DD=Data Deficient & NE= Not Evaluated. Fls.= flowering time, Frts.= fruiting time
States :- APS=Andhra Pradesh, APN= Arunachal Pradesh, AS= Assam, CHTGH= Chhattisgarh, HP= Himachal Pradesh JK= Jammu & Kashmir, KA= Karnataka, KL= Kerala, MH=Maharastra, MP= Madhya Pradesh, OR= Orissa, TN= Tamil Nadu, UTA=Uttaranchal.

S.No.	Botanical name	Family	Habit	Threat status
1	*Acacia donaldii* Haines	Mimosaceae	T	VU
2	*Acacia tomentosa* Willd.	Mimosaceae	C	DD
3	*Acampe rigida* (Buch.-Ham. *ex* Sm.) Hunt	Orchidaceae	H	VU
4	*Acanthephippium bicolor* Lindl.	Orchidaceae	H	VU:OR
5	*Acrostichum aureum* L.	Acrostichaceae	F	NE
6	*Aerides crispum* Lindl.	Orchidaceae	H	NE
7	*Aglaia cucullata* (Roxb.) Pellegrin	Meliaceae	T	DD
8	*Albizia thompsoni* Brandis	Mimosaceae	T	NE
9	*Albizia orissensis* Sahni & Bennet	Mimosaceae	T	NE
10	*Alphonsea madraspatana* Bedd.	Annonaceae	T	DD
11	*Angiopteris evecta* (Forst.) Hoffm.	Angiopteridaceae	F	EN:APS CHTGH, MP
12	*Aphanamixis polystachya* (Wall.) Parker	Meliaceae	T	VU: KA,KL, OR
13	*Aristolochia tagala* Cham.	Aristolochiaceae	C	DD: OR
14	*Aspidopteris tomentosa* (Bl.)Juss. var. *hutchinsonii* (Haines) Srivastav.	Malpighiaceae	C	VU
15	*Atalantia monophylla* (L.) Corr.	Rutaceae	S	NT:OR
16	*Atylosia cajanifolia* Haines	Fabaceae	S	VU:OR
17	*Azima tetracantha* Lam.	Salvadoraceae	S	DD:OR
18	*Balanophora polyandra* Griff.	Balanoporaceae	H	DD
19	*Blepharispermum subsessile* DC.	Asteraceae	S	EN:OR
20	*Boswellia serrata* Roxb. *ex* Colebr.	Burseraceae	T	VU; CHTGH MP
21	*Brucea mollis* Wall. *ex* Kurz	Simaroubaceae	T	EN: APN, AS
22	*Bruguiera gymnorrhiza* (L.) Sav.	Rhizophoraceae	T	NT
23	*Caesalpinia digyna* Rottl.	Caesalpiniaceae	S	VU:CHTGH, OR
24	*Casearia rubescens* Dalz.	Flacourtiaceae	S	DD
25	*Cassipourea ceylanica* (Garden.) Aston	Rhizophoreaceae		DD
26	*Celastrus paniculata* Willd.	Celastraceae	C	VU: OR, KL, CHTGH, MP
27	*Cerbera odollam* Gaertn.	Apocynaceae	S	VU: OR
28	*Chlorophytum arundinaceum* Baker	Liliaceae	H	EN: MH: LC: APS
29	*Chlorophytum tuberosum* (Roxb.) Baker	Liliaceae	H	VU:CHTGH, MP
30	*Chukrasia tabularis* A. Juss	Meliaceae	T	DD: OR
31	*Clausena excavata* Burm. f.	Rutaceae	S	NT: OR
32	*Clerodendrum serratum* (L.) Moon	Verbenaceae	S	EN: CHTGH MP
33	*Cochlospermum religiosum* (L.) Alston	Cochlospermaceae	T	VU:CHTGH, MP
34	*Cordia macleodii* (Griff.) Hook.f.Thoms.	Ehretiaceae	T	EN: OR

35	*Costus speciosus* (Koenig) Sm.	Costaceae	S	VU: CHTGH, MP NT: APS
36	*Crataeva magna* (Lour.) DC	Capparaceae	T	VU:CHTGH, MP, OR
37	*Cryptocarya amygdalina* Nees	Lauraceae	T	DD: OR
38	*Curculigo capitulata* (Lour.) Kuntze	Hypoxidaceae	H	NE
39	*Cycas spherica* Roxb.	Cycadaceae	T	VU: OR
40	*Cynometra iripa* Kostel.	Caesalpiniaceae	T	NT:OR
41	*Dendrobium cathcartii* Hook.f.	Orchidaceae	H	NT
42	*Dendrobium nobile* Lindl.	Orchidaceae	H	EN:AS, VU: APN, SK
43	*Desmos longiflorus* (Roxb.) Safford	Annonaceae	T	NE
44	*Dimorphocalyx glabellus* Thw.	Euphorbiaceae	T	NE
45	*Diospyros candolleana* Wight	Ebenaceae	T	VU: KA, KL, TN
46	*Diplopora championi* (Lindl.) Hook.f.	Orchidaceae	H	DD
47	*Doryopteris ludens* (Wall. *ex* Hook.) J. Sm.	Sinopteridaceae	F	NE
48	*Drosera peltata* Sm.	Droseraceae	H	EN: KA, TN VU: KL,
49	*Embelia ribes* Burm.f.	Myrsinaceae	C	CR: APS VU: KA,TN, OR
50	*Embelia tsjeriam* cottam (Roem. & Schult.) DC.	Myrsinaceae	C	VU: OR
51	*Eria meghasaniensis* (Misra) Misra	Orchidaceae	H	Rare/Endemic: OR
52	*Eriolaena hookeriana* Wt. & Arn. var. *viridis* Haines	Sterculiaceae	S	NE
53	*Eulophia nuda* Lindl.	Orchidaceae	H	EN:MH
54	*Euphorbia fusiformis* Buch.-Ham.	Euphorbiadceae	H	DD
55	*Garcinia cowa* Roxb.*ex* DC	Clusiaceae	T	VU: OR
56	*Garcinia xanthochymus* Hook.f.	Clusiaceae	T	VU; OR
57	*Gardenia gummifera* L.f.	Rubiaceae	T	VU:KA,KL, TN,OR
58	*Gloriosa superba* L.	Liliaceae	C	VU: ASP, MH, KA, KL,MP, EN: OR
59	*Gnetum ula* Brongn.	Gnetaceae	T	VU: OR
60	*Gyrocarpus americanus* Jacq.	Hernandiaceae	T	DD: OR
61	*Hedychium coronarium* Koenig.	Zingiberceae	S	NT: KA,KL, VU: OR
62	*Heliotropium currassavicum* L.	Boraginaceae	H	NE
63	*Heritiera littoralis* Dryand *ex* Ait.	Sterculiaceae	T	NE
64	*Hibiscus platanifolius* (Willd.) Sweet	Malvaceae	T	NE
65	*Indigofera aspalathoides* Vahl *ex* DC.	Fabaceae	S	NE
66	*Kandelia candel* (L.) Druce	Rhizophoraceae	S	NE
67	*Lasiococca comberi* Haines	Euphorbiaceae	T	NE
68	*Licuala peltata* Roxb.	Arecaceae	S	DD
69	*Mammea suriga* (Buch.-Ham. *ex* Roxb)	Clusiaceae	T	DD
70	*Melasma thomsonni* (Hk.f.) Wettst.	Scrophulariaceae	H	NE
71	*Mesua ferrea* L.	Clusiaceae	T	EN: OR
72	*Mucuna gigantea* (Willd.)DC	Fabaceae	C	NT: CHTGH MP EN:OR
73	*Natsiatum herpeticum* Buch. Ham.*ex* Arn.	Icacinaceae	C	DD

74	*Neocinnamomum caudatum* (Nees) Merr.	Lauraceae	T	NE
75	*Nothopegia heyneana* (Hook.f.) Gamble	Anacardiaceae	T	VU
76	*Operculina turpethum* (L.) S. Manso	Convolvulaceae	H	VU:KA,OR EN:KL, MH
77	*Oroxylum indicum* (L.) Vent.	Bignoniaceae	T	VU: KA, APS, HTGH, MP EN: KL, MH, OR,
78	*Oryza jeyporensis* Govind. & Krishnam	Poaceae	H	DD, Endemic
79	*Pachystylidium hirsutum* (Bl.) Pax & Hoffm.	Euphorbiaceae	C	NE
80	*Paederia foetida* L.	Rubiaceae	C	NT: APS VU:OR
81	*Pandanus fascicularis* Lam.	Pandanaceae	S	DD
82	*Persea macrantha* (Nees) Kosterm.	Lauraceae	T	EN:KA,TN VU: KL
83	*Peucedanum dhana* Buch.-Ham. Var. *dalzelli*.C.B.Cl.	Apiaceae	H	NE
84	*Peucedanum nagpurense* (C.B.Cl.) Prain	Apiaceae	H	VU:CHTGH, MP
85	*Phoenix paludosa* Roxb.	Arecaceae	T	NE
86	*Piper longum* L.	Piperaceae	C	EN:TN, OR VU: CHTGH NT:KL NE:KA
87	*Pittosporum wightii* A.K. Mukherjee	Pittosporaceae		DD
88	*Polyalthia simiarum* (Buch.-Ham.) Hook.f. & Thomas.	Annonaceae	T	VU: OR
89	*Psilotum nudum* P.	Psilotaceae	H	CR: MP
90	*Psoralia corylifolia* L.	Fabaceae	F	VU:OR
91	*Pterocarpus marsupium* Roxb.	Fabaceae	T	VU:MH, CHTGH, MP, EN: OR
92	*Pueraria tuberosa* (Willd.) DC	Fabaceae	C	VU: OR
93	*Radermachera xylocarpa* (Roxb.) K. Schum.	Bignoniaceae	T	DD
94	*Rauvolfia serpentina* (L.) Benth. *ex* Kurz	Apocynaceae	H	CR: APS, MH, CHTGH, PN,HPEN: KA,KL,TN, OR VU: MP, AS,JK,UTA
95	*Rubia cordifolia* L.	Rubiaceae	C	VU: APS, MH, CHTGH, MP
96	*Salacia reticulata* Wt.	Hippocrateaceae	S	EN: KA DD: KL
97	*Salvadora persica* L.	Salvadoraceae	T	VU: OR
98	*Saraca asoca* (Roxb.) de Wilde	Caesalpiaceae	T	EN: KA, APS, MH, DD:KL,TN, CR:OR
99	*Schrebera swietenioides* Roxb.	Oleaceae	T	VU:KA,OR
100	*Scindapsus officinalis* (Roxb.) Schott	Araceae	C	VU: OR
101	*Stemona tuberosa* Lour.	Stemoniaceae	C	VU: APS, OR
102	*Stereospermum suaveolens* (Roxb.) DC.	Bignoniaceae	T	EN:OR
103	*Strobilanthes circarensis* Gamble	Acanthacae	S	Endemic: OR
104	*Strobilanthes jeyporensis* Bedd.	Acanthaceae	S	NE
105	*Strychnos nuxvomica* L.	Loganiaceae	T	VU: CHTGH

106	*Strychnos potatorum* L.f.	Loganiaceae	T	VU:OR
107	*Swertia angustifolia* Buch.-Ham. *ex* D.Don	Gentianaceae	H	DD:OR
108	*Symplocos racemosa* Roxb.	Symplocaceae	T	VU: KA, MH, NT: TN DD:KL CR:OR
109	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae	T	NT:KA,KL,MH,CHTGH, MP
110	*Thalictrum foliolosum* DC.	Ranunculaceae	H	VU:CHTGH, MP,OR
111	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae	C	VU:KA NT:KL,MH
112	*Tylophora fasciculata* Buch.Ham. *ex* Wight	Asclepiadaceae	C	DD
113	*Uraria picta* (Jacq.) Desv. *ex* DC.	Fabaceae	H	VU:CHTGH, MP: EN:OR
114	*Uvaria eucinata* Bedd. *ex* Dunn	Annonaceae	S	EN:OR
115	*Xylocarpus granatum* Koenig	Meliaceae	T	EN:OR
116	*Zanthoxylum armatum* DC.	Rutaceae	C	EN:HP VU:JK,UTA,OR
117	*Zanthoxylum rhetsa* (Roxb.) DC	Rutaceae	T	EN:APS, VU:OR

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26.0 Floristic wealth of Javvadhu Hills, Eastern Ghats, With Special Emphasis on Threatened Plants

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Introduction

Javvadhu hills, an important extension of Eastern Ghats, are spread across Vellore, Tiruvannamalai and Krishnagiri districts of Tamil Nadu. This hill range stretches over 80 kms in length and 32 kms in width. Oriented in northeast – southwest direction, this range lies in the northern part of the Tamil Nadu between 12º 15' to 12º 40' N latitudes and 78º 2' to 79º 10' E longitudes. The hills rise steeply from the plains forming an undulating plateau on the top to the altitude of about 800 m and enclose small valleys. Melpattu, on the Thenmalai hills with an altitude of 1045 m is the highest peak in the range. The average height of the Javvadhu hills is *c* 500 m. *Malayalis* - the hill dwelling tribes inhabit in the hill range (Ravikumar & Vijaya Sankar 2003).

Vegetation and Habitat Characteristics

Javvadhu hills are known for their rich vegetation. They also harbour a number of wild plant resources such as edible fruits, tubers and vegetables and other non-timber forest produces including medicinal plants. The forest types found in this hill range, as per the classification by Champion & Seth (1968) are: Southern Dry Mixed Deciduous Forests, Southern Dry Deciduous Scrub Forests, Southern Dry Savannah Forests, Dry Bamboo Brakes, Dry Tropical Riverain Forests, Southern Tropical Thorn Forests and Southern Thorn Scrub Forests. The hill range is home for several endemics and threatened plants. About 800 taxa of plants are reported to be present in the entire range of Javvadhu hills.

Geologically the Javvadhu hills represent ancient rock formations which are largely ferruginous in composition and chiefly containing hornblende and feldspar. This has given rise to peculiar reddish loam of varying depth and fertility. On the plateaus the soil is usually loamy or gravelly often greyish brown in colour due to admixture of humus. In valleys the soil is clayey and cankarous. The high iron content is always apparent in most of the reserved forests in disturbed areas, where the surface soil has been completely eroded leaving only the hardened subsoil devoid of any fertility owing to excessive grazing in these parts. There is a deficiency of lime in the soils where sandalwood trees are present.

The climate of the hill range is tropical and moderately hot and dry. Forest areas in higher altitudes are cooler than the lower areas. The year can be divided into three seasons *viz.* summer during March-May, rainy during June-October and winter from November to February. It is very hot during April to June. The average maximum temperature in shade is 32º C and the average minimum is 19ºC. Frost does not occur here except for a few occasional dewfalls. The hill range receives maximum rainfall from the southwest as well as northeast monsoons. The average annual rainfall in the district is 1,075 mm.

The Red Listed Plants

The following Red Listed species assessed during rapid assessment workshops conducted by the FRLHT in different states of India (Ravikumar & Ved 2000) have been collected from Javvadhu hills:

Critically Endangered

1. *Cochlospermum religiosum* DC. (Bixaceae)
2. *Holostemma ada-kodien* Schult. (Asclepiadaceae)
3. *Pterocarpus marsupium* Roxb. (Fabaceae)
4. *Pueraria tuberosa* (Roxb. *ex* Willd.) DC. (Fabaceae)

Endangered

1. *Acorus calamus* L. (Acoraceae)
2. *Boswellia serrata* Roxb. *ex* Colebr. (Burseraceae)
3. *Ceropegia bulbosa* Roxb. (Asclepiadaceae)
4. *Clerodendrum serratum* (L.) Moon (Verbenaceae)
5. *Corollacarpus epigaeus* (Rottler & Willd.) Clarke (Cucurbitaceae)
6. *Decalepis hamiltonii* Wight & Arn. (Periplocaceae)
7. *Drosera indica* L. (Droseraceae)
8. *Gloriosa superba* L. (Liliaceae)
9. *Gymnema sylvestre* R.Br. (Asclepiacaceae)
10. *Leptadenia reticulata* (Asclepiadaceae)
11. *Manilkara hexandra* (Roxb.) Dubard (Sapotaceae)
12. *Operculina turpethum* (L.) Silva Manso (Convolvulaceae)
13. *Ougeinia oojeinensis* (Roxb.) Hochr. (Fabaceae)
14. *Santalum album* L. (Santalaceae)
15. *Sterculia urens* Roxb. (Sterculiaceae)
16. *Stereospermum colais* (Bignoniaceae)

Vulnerable

1. *Aegle marmelos* (L.) Corr. (Rutaceae)
2. *Amorphophallus sylvaticus* (Roxb.) Kunth (Araceae)
3. *Andrographis paniculata* (Burm.f.) Wall. *ex* Nees (Acanthaceae)
4. *Arisaema tortuosum* (Araceae)
5. *Buchanania lanzan* Spreng. (Anacardiaceae)
6. *Celastrus paniculatus* Willd. (Celastraceae)
7. *Chlorophytum tuberosum* Baker (Liliaceae)
8. *Citrullus colocynthis* (L.) Kuntze (Cucurbitaceae)
9. *Crateva magna* (Lour.) DC. (Capparidaceae)
10. *Dioscorea bulbifera* L. (Dioscoreaceae)
11. *Embelia tsjeriam-cottam* (Roem. & Schult.) A.DC. (Myrsinaceae)
12. *Gardenia gummifera* L.f. (Rubiaceae)
13. *Gnetum ula* Brongn. (Gnetaceae)
14. *Limonia acidissima* L. (Rutaceae)
15. *Moringa concanensis* Nimmo *ex* Dalz. & Gibson (Moringaceae)
16. *Mucuna monosperma* DC. (Fabaceae)
17. *Naringi crenulata* (Roxb.) Nicolson (Rutaceae)
18. *Phyllanthus emblica* L. (Euphorbiaceae)
19. *Phyllanthus indofischeri* Benn. (Euphorbiaceae)
20. *Plumbago zeylanica* L. (Plumbaginaceae)
21. *Pseudarthria viscida* (L.) Wight & Arn. (Fabaceae)
22. *Rhaphidophora pertusa* (Roxb.) Schott (Araceae)

23. *Rubia cordifolia* L. (Rubiaceae)
24. *Salvadora persica* L. (Salvadoraceae)
25. *Sarcostemma viminale* (L.) R.Br. (Asclepiadaceae)
26. *Schrebera swietenioides* Roxb. (Oleaceae)
27. *Smilax zeylanica* L. (Liliaceae)
28. *Strychnos nux-vomica* L. (Strychnaceae)
29. *Strychnos potatorum* L.f. (Strychnaceae)
30. *Terminalia arjuna* (Roxb. *ex* DC.) Wight & Arn. (Combretaceae)
31. *Terminalia chebula* Retz. (Combretaceae)
32. *Tinospora sinensis* (Lour.) Merr. (Menispermaceae)
33. *Tylophora indica* (Burm.f.) Merr. (Asclepiadaceae)
34. *Urginea indica* (Roxb.) Kunth (Liliaceae)

Endemic species

Javvadhu hills are one of the 'ecological islands' of Eastern Ghats harbouring a number of endemic plants (Plate 26A). A study on the flora of Tiruvannamalai district (Vijaya Sankar 2006) reports several endemic plant species for the hill range such as:

i) **Endemic to Tamil Nadu state :** *Barleria pilosa*, *Brachystelma brevitubulatum*, *Indigofera trita* var. *marginulata*, *Jasminum trichotomum*, *Panicum fischeri* and *Premna latifolia* var. *henryi*.

ii) **Endemic to the peninsula :** *Acalypha alnifolia*, *Aglaia elaeagnoidea* var. *beddomei*, *Alysicarpus scariosus* var. *pilifer*, *Andrographis affinis*, *A. serpyllifolia*, *Anisochilus eriocephalus*, *Argyreia cuneata*, *A. daltonii*, *Asystasia crispata*, *Barleria acuminata*, *B. buxifolia*, *B. longiflora*, *B. montana*, *B. tomentosa*, *Byttneria herbacea*, *Cadaba fruticosa*, *Caralluma adscendens*, *C. diffusa*, *Carissa salicina*, *Chionanthus mala-elengi*, *Chrysopogon orientalis*, *Cleome felina*, *Commiphora berryi*, *Cordia evolutior*, *C. obliqua* var. *tomentosa*, *Crotalaria paniculata*, *C. subperfoliata*, *Cryptolepis grandiflora*, *Curcuma neilgherrensis*, *Cyanotis arcotensis*, *C. tuberosa*, *Dalbergia rubiginosa*, *Decalepis hamiltonii*, *Deccania pubescens* var. *candolleana*, *Dicliptera cuneata*, *Didymocarpus tomentosa*, *Dioscorea belophylla*, *Diospyros chloroxylon*, *Dolichandrone atrovirens*, *D. falcata*, *Elaeagnus indica*, *Endostemon viscosus*, *Eragrostis riparia*, *Gardenia gummifera*, *Grewia abutilifolia*, *G. orbiculata*, *Habenaria ovalifolia*, *H. roxburghii*, *Hedyotis brachiata*, *H. erecta*, *Helicanthes elastica*, *Hemidesmus indicus* var. *pubescens*, *Hibiscus canescens*, *Indigofera barberi*, *Iphigenia maysorensis*, *Justicia glauca*, *J. neesii*, *J. nilgherrensis*, *Kalanchoe bhidei*, *Lepidagathis cristata*, *Leucas wightiana*, *Lindernia oppositifolia*, *Mallotus philippensis* var. *tomentosus*, *M. resinosus*, *Maytenus heyneana*, *M. ovata*, *Melhania incana*, *Micrargeria wightii*, *Moringa concanensis*, *Neolitsea scrobiculata*, *Ochna gamblei*, *Peperomia candolleana*, *P. dindigulensis*, *Phyllanthus indofischeri*, *Polyalthia cerasoides*, *Polycarpaea corymbosa* var. *longipetala*, *Premna latifolia* var. *mollissima*, *Psilotrichum nudum*, *Pterospermum reticulatum*, *P. xylocarpum*, *Pupalia lappacea* var. *velutina*, *P. lappacea* var. *orbiculata*, *Radermachera xylocarpa*, *Randia brandisii*, *Reidia floribunda*, *Rhynchosia heynei*, *Rostellularia diffusa* var. *hedyotidifolia*, *Sansevieria roxburghiana*, *Santalum album*, *Senecio hohenackeri*, *Senna montana*, *Shorea roxburghii*, *Taxillus heyneanus*, *Terminalia coriacea*, *T. paniculata*, *Theriophonum fischeri*, *Tragia involucrata* var. *angustifolia*, *Triumfetta rotundifolia* and *Tylophora capparidifolia*.

iii) **Endemic to India :** *Aganosma dichotoma*, *Alysicarpus bupleurifolius* var. *gracilis*, *A. heterophyllus*, *Andropogon pumilus*, *Aspidopterys indica*, *Boswellia serrata*, *Cassia fistula*, *Cymbopogon coloratus*, *Decaschistia crotonifolia*, *Dipteracanthus beddomei*, *D. prostratus*, *Ehretia pubescens*, *Eragrostiella bifaria*, *E. brachyphylla*, *Eriolaena hookeriana*, *E. stocksii*, *Gardenia latifolia*, *Glossocardia bosvallea*, *Hardwickia binata*, *Indigofera prostrata*, *Leucas diffusa*, *Miliusa tomentosa*, *Nervilia plicata*, *N. prainiana*, *Ougeinia oojeinensis*, *Pavetta indica*, *Phyllanthus debilis*, *P. kozhikodianus*, *Rauvolfia tetraphylla*, *Rostellularia quinqueangularis*, *Tribulus lanuginosus*, *T. subramanyamii* and *Urena lobata* subsp. *sinuata*.

Plate 26A
Vegetation of Javvadhu Hills

Paruvathamalai Peak

Savannah Forest in Paruvathamalai Hills

Melapattu Javadhi Hills

Brachystelma brevitubulatum

Plate 26B
Threatened Plants of Javvadhu Hills

Santalum album

Panicum fischeri

Decalepis hamiltonii

Justicia nilgherrensis

Phyllanthus indofischerii

Acorus calamus

Though several taxa of plants in the hill range are facing a high risk of threat owing to a variety of factors, the following are worth mentioning and need immediate conservation action.

1. *Brachystelma brevitubulatum* (Bedd.) Gamble (Asclepiadaceae)

Slender twiners. Leaves linear-lanceolate, 8-11 × 0.4-0.8 cm, base cuneate, with a brown gland, apex acuminate. Cymes umbellate, 3(4)-flowered. Flowers *c* 3.5 cm long, *c* 1.5 cm across; corolla-tube short, connate at base and apex, up to 3 mm long; petals 5, ovate-lanceolate, 2-3.5 × 0.5-0.8 cm, purple-brown within, greenish yellow without. Follicles *c* 7.5 × 0.4 cm, tapering towards apex. Seeds *c* 10, oblong, compressed, *c* 5 × 2 mm, brown; coma silky-white, unequal, up to 3 cm long (Plate 26B).

This species is Endemic to Javvadhu hills in Eastern Ghats of Tamil Nadu. It is rarely found along exposed grassy slopes in Paruvathamalai and Swamimalai R.F. *Fl.*: Oct.-Nov.; *Fr.*: Nov.-Apr.

Note: This potentially ornamental plant was first collected by Beddome in 1871 from Amerdy (Amirthi) forest of Javvadhu hills near Vellore. During floristic study of Tiruvannamalai district it was rediscovered after a lapse of 131 years and also from other than the type locality. So far only eleven individuals have been noticed (8 from Paruvathamalai and 3 from Swamimalai R.F.) as a result of thorough perambulation in the above localities. There is every possibility for its occurrence in similar habitats (*i.e.* grassy, rocky slopes in woodland savannahs) in adjescent districts too. Planned and focused explorations may help to ascertain the actual population size and distribution of this narrow endemic species.

This species is of prime conservation concern due to its taxonomical and distributional importance. The present locations are facing threats of forest fire and grazing in addition to the growing human interference in the form of pilgrims. An appropriate *in situ* conservation action is urgently needed to preserve this precious species before it disappears from its prestine locality. Moss multiplication through seeds and tissue culture technique and reintroduction in the suitable habitats are also suggested (Vijaya Sankar *et al.*, 2003).

2. *Panicum fischeri* Bor (Poaceae)

Tufted herbs, up to 1 m high. Leaves linear, *c* 30 × 1 cm, base narrowed, apex acuminate. Panicles diffuse, up to 45 × 30 cm. Spikelets: one short-pedicelled (3 mm long), another with long pedicel (11 mm long); lower glume 2 mm long, lobed, acuminate, 3-nerved, midnerve prominent; upper glume 4.2 × 2 mm, 7-nerved, acuminate, lead-grey. Lower floret male or barren; lower lemma 4 mm long, lead-grey, 9-nerved, nerves prominent on the upper half, lower half of lemma transparent; palea scareous, keeled, folded, up to 3 mm long. Upper floret bisexual, with an appendage (which 2.5 mm long), transparent, stiff, acuminate, lanceolate; lemma 3 mm long, smooth, boat-shaped, obtuse; upper palea 3 mm long, smooth, scarious, shiny; stamens 3, pink, 2 mm, divergent; stigma plumose (that starts from 1 mm), 2.5 mm long, dark purple; lodicules 2.

This species is Endemic to Tamil Nadu. It grows among other grasses such as *Apluda mutica*, *Cymbopogon* spp. in the slopes of Savannah forests in Paruvathamalai above 500 m altitude. *Fl. & Fr.*: Oct.-Dec. *RVS* 71245, 102223.

Note: Gamble first collected this unique grass from Kullar (Kallar) in the Nilgiris, Western Ghats, in 1886. The present collection from Paruvathamalai, Javvadhu hills, after a lapse of about 120 years from its type collection, shows its extended distribution in the Eastern Ghats. In the present locality this species also is facing threats of grazing, forest fire and soil erotion in addition to human interference in the form of pilgrims. Suitable conservation measures have to be taken up in order to protect this endemic species before it vanishes from this habitat. Grazing should be completely banned and collection of thatch grass should be regulated. Strict vigilance on forest fire and establishing horizontal raised bunds along slopes may prevent this species from extinction.(Vijaya Sankar 2006).

3. *Barleria pilosa* Wall. *ex* Nees (Acanthaceae)
Tamil : *Sunnaambu chedi*

Undershrubs, up to 1 m high; young parts pilose; mature branchlets terete, young ones obscurely 4-gonous. Leaves ovate-elliptic, 2-4 × 1-2.5 cm, subcoriaceous, densely lineolate and pilose along nerves above, base attenuate, apex acute to very shortly acuminate, margin ciliate; lateral nerves 4-pairs, converging towards apex; petioles up to 5 mm long. Flowers solitary, axillary, shortly pedicellate; bracts ovate-elliptic, *c* 5 × 4 mm, pilose; calyx-lobes 4, outer ones broadly ovate, *c* 2 × 1.5 cm, 5-7-nerved, reticulate, long-pilose, base obtuse, apex acute, margin sharply denticulate-ciliate; inner lobes 2, linear-oblong, *c* 7 × 1.5 mm, pilose; corolla *c* 3 cm across, 5-lobed, puberulous without; tube *c* 2 cm long, greenish white; fertile stamens 2; styles *c* 2.5 cm long; stigma truncate. Capsules ovoid-oblong, compressed, *c* 1.5 × 0.8 cm, without a woody base, glabrous. Seeds 4, appressed-pubescent.

This species is endemic to Tamil Nadu. It is rarely found along streams in Karnatigur R.F., Javvadhu hills. *Fl. & Fr.*: Dec.-Feb. *RVS* 102201.

Note: This species has so far been reported only from the W.Ghats of Coimbatore (Anamalai hills) and Tirunelveli (Courtallam) districts. The present collection of this endemic species from Javvadhu hills forms new report to the E.Ghats as well as extends the known distribution towards north of the State. Only few old collections by Rottler, Wight (Courtallam), Beddome and Fischer (Coimbatore) are available at MH, BSI, Coimbatore.

4. *Premna latifolia* Roxb. var. *henryi* D. Naras. (Verbenaceae)

Shrubs, up to 4 m high. Leaves ovate-elliptic, 3-7 × 2-4.5 cm, base truncate to subcuneate, apex subacuminate, margin irregularly dentate at upper half. Corymbs *c* 3 × 5 cm. Flowers *c* 4 mm across, greenish white. Drupes subglobose, *c* 5 mm across.

This is an another taxon endemic to Tamil Nadu. This species has been collected after type collection and also from other than the type locality, nearly after 23 years. It is occasionally seen in open rocky slopes in the hill range. *Fl. & Fr.*: Mar.-Jun. *RVS* 73672.

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27.0 Shola Forests and Some Important Species of Southernmost Eastern Ghats

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Introduction

Loss of forest cover in the tropics has always been associated with burgeoning human population and rapid changes in land use (Rudel & Roper 1997, Lamb *et al.* 2005). Extensive deforestation leads to formation of forested islands within larger landscapes (Cayuela *et al.* 2006). Forests not only form the most important renewable natural resource on earth but also render numerous ecosystem services to mankind which cannot be equated in monetary terms as some of the economists try to do these days. In developing countries like India, dependence of people on forests is inevitable and in most of the economically impoverished areas pressure on forests is mounting at alarming rate (Jayakumar *et al.* 2002). The poorer forest dwellers regard logging and forest clearing as the only way to earn their livelihood and hardly respond to conservation appeals in the absence of any better alternative (Barbier 1993). As a result, most of the official conservation programmes fail (Rudel 2006). Depletion of forest has many ecological, social and economic consequences, one among them being the loss of biodiversity (Jayakumar *et al.* 2002, Wills *et al.* 2006).

The Eastern Ghats of India harbour diverse tropical forests, which have undergone drastic degradation and fragmentation. Contemporary history of forest fragmentation and its ecological consequences in this tract have not been documented. At the same time there are quite a few natural pockets of evergreen forests which have evolved under peculiar micro-habitats and geomorphological conditions. Such forests are limited in extent and resemble the 'shola' forests of Western Ghats and can be considered as special habitats. Very little ecological studies have been conducted on these forests. In this article we give a brief description of these forests and report the occurrence of a few characteristic plant species which need conservation action.

Shola (Evergreen) Forests of south Eastern Ghats as Special Habitats

The Eastern Ghats of India is a broken chain of hills that runs almost parallel to east coast of India covering three states *viz.*, Orissa, Andhra Pradesh and Tamil Nadu. The southern portion of Eastern Ghats comprises a few major hills namely, Sathyamangalam, Melagiris, Javadi, Shervarayan, Chitteri, Kalrayan, Bodamalai, Pachamalai and Kolli hills. Shervarayan hills with maximum altitude of 1649 m above mean sea level is the most elevated hill in southern Eastern Ghats. In terms of geographical area, Sathyamangalam (1719 km^2) is the largest hill range in the Eastern Ghats. These ranges harbour five major forest types, *viz.* tropical evergreen, semi-evergreen, mixed-deciduous, dry deciduous and thorn forests. Evergreen forests are distributed only at the hill tops. Semi-evergreen forests are distributed at high altitude, and mixed- and dry deciduous forests are distributed on the slopes with middle altitude. While the thorn forests are typically found in the foot hills. Some times they also occur at middle elevation, as a result of degradation of dry deciduous forests. In southern Eastern Ghats, evergreen forests are considered as special habitat as their distribution is restricted to small patches in a few high altitude hill tops of Sathyamamgalam, Shervarayan, Chitteri, Kalrayan, Pachamalai and Kolli hills. Of particular mention include sites such as Alathi shola of Kalrayan hills, Kannimar shola of Pachamalai and Ariyur and Kuzhivalavu sholas of Kolli hills are patches of dense evergreen forests as good and dense as of wet evergreen forests of Western Ghats. Threats to these patches include land use change for hill agriculture and various plantation crops including fruit crop particularly pine apple in Kolli hills, tapioca cultivation in Alathi shola.

The evergreen sholas of southern-most Eastern Ghats are peculiar in various ways. They are located usually at hill tops between 750 to 1649m asl. They share many species with shoals of Western Ghats. They have moderately high plant species diversity with dominant evergreen elements and multi-layered canopy structure. The epiphytic orchids, ferns and mosses are common. Interestingly, they have high frequency of occurrence of latex / resinous rich woody plants. The trees are usually tall and voluminous, loaded with epiphytes and leaves with epiphylls. Climax forest canopy tree species can reach up to 30-40 m in height. Trees are rarely multi-stemmed and lianas are usually abundant and thick stemmed. The forest floor is usually laden with thick layer of litter that harbors dense arthropod population. Site photos and some important plants of southern-most Eastern Ghats are shown in Plate 27.

Geologically these hill ranges comprise masses of charnokite associated with gneisses and varied metamorphic rocks. Sathyamangalam has two large reservoirs, Bavanisagar dam on the south-west and Mettur dam on the north-east direction. Cauvery is the major river that passes through Sathyamangalam forests. Vellar, Ponnaiyar and Kollidam are the three rivers which originate from southern Eastern Ghats. These rivers are the major water source for the farmers in central Tamil Nadu. Among all the areas S Sathyamangalam hills have special biogeographic significance as several floral and faunal elements find their dispersal path through this range between Western and Eastern Ghats. Among large mammals, the Asian elephant and tiger are reported from this area. The other animals of Sathyamangalam include common leopard, sambar, wild dog, Indian bison or gaur, wild pig and golden jackal.

Tribal settlements are common in all hills. The tribal people of southern Eastern Ghats are called 'Malayalees'. The hilly terrain and the surrounding plains of southern Eastern Ghats are densely populated. The ever-increasing human population and settlements in forested areas, and construction of roads and dams, lead to degradation of forest landscape and ultimately forest habitats are threatened at an alarming rate.

Notable plant taxa of high conservation significance

1. *Memecylon parvifolium* Thwaites (Melastomataceae)

A small tree, reaching up to 10 m, with many branches and greyish bark. Branchlets stout, subquadrangular. Leaves elliptic to elliptic-obovate, cuneate at the base and narrowed into a short but distinct petiole, obtuse to rounded or notched or sometimes acute at the apex, occasionally shortly and indistinctly caudate, often with revolute margins, with indistinct intramarginal and lateral veins, coriaceous, more or less shining above, drying dark green. Flowers white, few in nearly sessile cyme. Fruit globose, black.

This species was known to occur only in Srilanka till recently. It forms a new record to tree flora of India (Pragasan & Parthasarathy, in press).

2. *Memecylon madgolense* Gamble (Melastomataceae)

A large shrub or small tree. Leaves green when dry, ovate-lanceolate, base acute, apex caudate-acuminate. Intra-marginal nerves about 8 pairs, indistinct. Flowers few in lateral cymes. Fruit a berry. It is endemic to Eastern Ghats of India. It has been recently rediscovered after a century from Eastern Ghats of India (Pragasan & Parthasarathy, in press)

3. *Cinnamomum malabatrum* (Burm. F.) Blume (Lauraceae)
Vernacular Name : *Ilavangappattai* (Tamil)

Evergreen tree to 15 m; crown compact. Lvs (sub) opp, darh green, shiny, 3-nerved, new flesh reddish brown. Fls in panicles cream. Fruit green ellipsoid-globose berry. Epicarp coriaceous. Economically important species, used as medicine and also as substitute of *C. zeylanicum.* Endemic to Indian Peninsula.

4. *Antiaris toxicaria* (Pers.) Lesch. (Moraceae)
Vernacular Name : *Mara-Uri* (Tamil). English: The Upas Tree

A lofty tree with buttressed base. Young shoots, petioles and midrib velvety. Flowers unisexual, male flowers crowded on the surface of flat pedunculate and fascicled receptacles. Fruits red, velvety, fleshy up to 2 cm in diameter. So far mostly known from Western Ghats. Distributed in India, Sri Lanka, Malaysia.
Economically important

5. *Myristica dactyloides* Gaertn. (Myristicaceae)
Vernacular Name : *Katujathika* (Tamil).

Densely foliaceous, dioecious evergreen tree. Stem up to 1.6 m in girth. Leaves elliptic to broadly lanceolate. Flowers in umbels. Fruit a drupe, ovoid to elliptic, 4-6 x 3-4 cm. Seeds ovoid covered by yellowish orange aril. Endosperm ruminate. An economically important species used as spice. Distributed in India and Sri Lanka.

6. *Dimocarpus longan* Lour. (Sapindaceae)
Vernacular Name : *Kattupuvan* (Tamil)

Evergreen tree. Lvs even-pinnate; lflets (sub)opp, c.7 pairs, oblong-lanceolate. Flowers regular. Fruit Schizocarp; Seed with fleshy aril.
Distribution: India, Sri Lanka, Malaysia, New Guinea
Economically important

7. *Meliosma pinnata* (Roxb.) Maxim. ssp. *arnottiana* (Wight) Beus. (Meliosmaceae)

Tree to 15 m. Lvs odd-pinnate; lflets c.6 pairs, (sub)opp, oblong-lanceolate, inequilateral. Flowers in panicles. Fruit drupe, smooth. Hills >1200 m.
Distribution: Sri Lanka, India, E & SE Asia, Malaysia, Philippines.

8. *Canarium strictum* Roxb. (Burseraceae)
Vernacular Name : *Karuppu Kungiliam* (Tamil)

Evergreen tree to 20 (30) m; girth to 4.5 m. Lvs odd-pinnate; lflets 3-5 pairs, opp, oblong; rusty-villous below. Panicles axillary, interrupted. Flowers 3-merous, polygamous. Fruit drupe, oblong. Hills > 1100 m. An economically important species.
Distribution: India, Myanmar

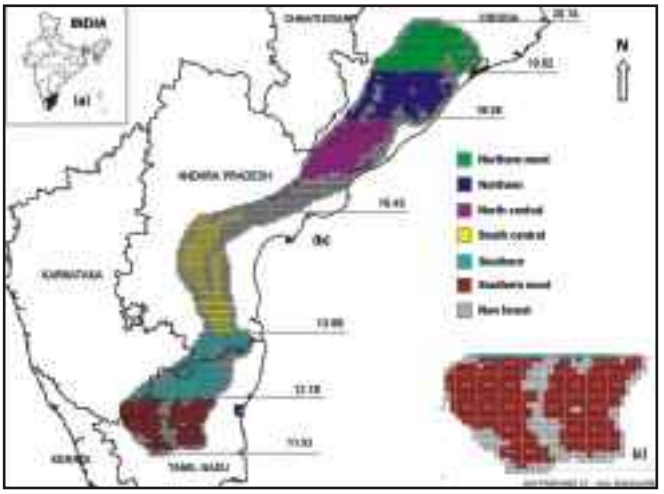
9. *Diploclisia glaucescens* (Blume) Diels (Menispermaceae)
Vernacular Name : *Morasankodi* (Tamil)

A large climber in sheltered forests, up to 1500m. Leaves broad ovate, 5-nerved at back, glaucous beneath; flowers yellow-cauliflorous; drupes red.
Distribution: Peninsular India, Sri Lanka, Malaysia.

10. *Embelia basaal* (Roem. *ex* Schultes) A. DC. (Myrsinaceae)

Large climber, leaves oblong lanceolate, dots and streak-like glands spread over whole leaf, racemes of orange colored flowers from the older branchlets.
Distribution: Peninsular India, Sri Lanka, Malaysia.

Plate 27
Shola Formations of Southernmost Eastern Ghats



Map of Eastern Ghats based on NDVI and Digital Elevation Model

Undisturbed Evergreen forest

Disturbed Evergreen forest

Myristica dactyloides

Canarium strictum

Antiaris toxicaria

Diploclisia glaucescens

Embelia basaal

11. *Entada pursaetha* DC. (Mimosaceae)
Vernacular Name : *Vattavalli* (Tamil)

A gigantic unarmed liana with very small yellowish flowers and huge flat pods. Leaflets 2.5-4.5 cm long, oblong, shining, obtuse or emarginate. Stems spirally twisted.
Distribution: Tropical & South Africa, Sri Lanka, Peninsular India, Malaysia to Australia.

12. *Capparis shevaroyensis* Sund.-Ragh. (Capparaceae)

A spreading much-branched thorny straggler. Leaves lanceolate or oblanceolate, caudate acuminate at apex, glabrous, dull green above, yellowish green at beneath; flower - creamy white; Fruit-yellowish brown – globose.
Distribution: Restricted forests Eastern and Western Ghats of Peninsular India.
Threats: Land use change.

13. *Rhaphidophora laciniata* (Burm.f.) Merr. (Araceae)
Vernacular Name : *Anaitippili* (Tamil)

A large epiphytic climber, from plains to higher elevations; leaves ovate to sub orbicular in outline, inequilateral, sometimes entire and if so perforate with elliptic holes, sometimes pinnatisect.
Distribution: Peninsular India

14. *Gymnema tingens* (Roxb.) Wight & Arn. (Asclepiadaceae)

A gigantic climber, branches soft, not woody; Leaves bright green, membranous, broadly ovate, usually cordate, acute, acuminate or caudate; A spiral raceme with pale yellow flowers.
Distribution: Peninsular India
Category: Rare

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Section VII:
Coasts and Islands

28.0 Mangroves of Orissa Coast: Floral Diversity and Conservation Status

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Introduction

The mangroves are unique ecosystems found in the tropical and sub-tropical inter-tidal regions of the world. They are among the most productive habitats dominated by salt tolerant vegetation, popularly known as 'Tidal Swamp Forests', 'Littoral Swamp Forests', or Oceanic Rain Forests'. The word 'mangrove' is interchangeably used for salt tolerant plants as well as forest ecosystem. Hence, Macnae (1968) proposed the terms **'Mangal'** to denote this special ecosystem and **'Mangroves'** for the plants adapted to grow in such habitats. The mangrove plants are specialized to tolerate high salinity, tidal extremes, high fluctuations in wind, temperature and muddy anaerobic soil. No other groups of terrestrial plants survive well under such conditions. A muddy substratum of varying depth and consistency is necessary for their growth. The plants have special adaptations such as stilt roots, viviparous germination, salt-excreting leaves, breathing roots, and knee roots by which these plants survive in water-logged, anaerobic saline soils of coastal environments. Also, the mangrove plants have great potential to adapt to the changes in climate, rise in sea levels and to the incidence of solar ultraviolet–B radiation (Rahaman 1990, Swaminathan 1991, Moorthy 1995, Moorthy & Kathiresan 1996).

India harbours some of the best mangrove forests of the world which are located in the alluvial deltas of major rivers such as the Ganga, Mahanadi, Godavari, Krishna, Cauvery and also on the bay of Andaman and Nicobar Islands. According to the Forest Survey of India (Anonymous 2003) total area under mangrove forests in the country is 4,461 km^2 which forms 0.14% of the country's geographical area and is 5% of the world's mangrove vegetation. About 58.32% of India's mangrove forests are located along the east coast and 24.61% on the west coast. The Bay Islands (Andaman & Nicobar) account for 15.04% of the country's mangroves. Mangroves are much more extensive on the east coast of India due to nutrient-rich alluvial soil formed by the several rivers which also supply fresh water along the deltaic coast. The west coast mangroves are dominated by estuarine back waters, which include the coastal areas of Gujarat, Maharashtra, Goa, Karnataka and Kerala. The east coast has a smooth and gradual slope which provides larger areas for colonization of mangroves whereas the west coast has a steep and vertical slope. Mangroves in Andaman and Nicobar Islands are oceanic in nature, fringing the creeks, back waters and muddy shores.

Mangroves of Orissa

Mangrove forests along coast of India cover approximately an area of 207 km^2. These forests are distributed in the deltas of six rivers *viz.*, Subernarekha, Budhabalanga, Baitarani, Brahmani, Mahanadi and Devi. While mangroves of Subarnarekha, Budhabalanga and Devi river deltas have been degraded, they are still intact in Bhitarkanika (Baritarani and Brahmani deltaic complex). In fact, Bhitarkanika mangroves (130 km^2) contribute substantially to the state's mangrove vegetation and form second largest mangrove ecosystem in the Indian sub-continent after Sunderbans. Mangroves of Mahanadi delta to the south of Bhitarkanika are open and in a state of degradation due to intensive human interference such as developmental projects and industries. Mangroves were also reported to occur in the fringes of Chilika lake till the turns of previous century which have been disappeared now. Besides protection of the coastal environment from the fury of cyclone, mangroves provide multiple economic benefits to the coastal communities.

Floral Diversity

The Indian mangroves comprise approximately 59 species, belonging to 41 genera of 29 families. Of these, 34 species under 25 genera belong 21 families are present in the mangrove and tidal vegetation along the east coast. There are about 25 mangrove species along the west coast (Banerjee *et al.* 1989). The east coast of India and Andaman-Nicobar Islands exhibit a higher degree of species diversity as well as a unique distribution of mangrove elements. The important mangrove families represented in India are Avicenniaceae, Combretaceae, Arecaceae (Palmae), Rhizophoraceae and Sonneratiaceae (Banerjee *et al.* 1989). Review of literature revealed that about 42 true mangroves and 40 mangrove associates are extant in the Bhitarkanika mangrove forest in Orissa. A comparative account of mangrove and mangrove associates occurring in Mahanadi delta and Bhitarkanika of Orissa and other states along the east coast including Andaman and Nicober Islands have been provided in Table-2. Mangrove ecosystem of Bhitarkanika exhibits maximum species diversity in the country (Rao *et al.* 1970, Banerjee & Das 1972, Rao & Sastry 1974, Banerjee 1984 & 1986, Banerjee & Rao 1990). *Cerbera manghas*, *Sonneratia caseolaris*, *Heritiera kanikensis*, *Amoora cuculata*, *Acanthus volubilis*, *Merope angulata*, *Xylocarpus mekongensis*, *Ceriops tagal* and *Sonneratia alba* are some of the rare and threatened mangrove species in Orissa coast (Plate 28).

Status and Distribution

Orissa has comparatively larger mangrove habitats in the country due to nutrient rich alluvial soils formed by the river Mahanadi delta and the Brahamani-Baitarani delta. The coast also has a smooth and gradual slope which provides larger areas for colonization of mangroves. As per an estimate the state has a total mangrove areas of 207 km^2 distributed over four coastal districts (Table-1) that include 160 km^2 (77%) moderately dense mangroves and 47 km^2 (23 %) open mangroves cover in 2003 (State of Forest Report 2003). Mangroves of Bhitarkanika (Brahmani-Baitarani river deltas) are quite extensive and abundant as compared to those present in the Mahanadi delta. The mangroves of Devi river mouth, Budhabalanga and Subarnarekha river mouths are in highly degraded state.

Table 1. Mangrove distribution in Orissa

Sr. No	District	Moderately dense mangrove (km^2)	Open mangrove (km^2)	Total (km^2)
1	Balasore	0.0	4.0	4.0
2	Bhadrak	17.0	3.0	20.0
3	Jagatsinghpur	1.0	2.0	3.0
4	Kendrapara	142.0	38.0	180.0
	Total	**160.0**	**47.0**	**207.0**

Source: State of Forest Report, Forest Survey of India, 2003

***River Mouths of Subernarekha and Budhabalanga* :** Mangroves of river mouths of Subernarekha and Budhabalanga covering an area of 563ha, at present are in highly degraded state owing to heavy biotic pressure. Vegetation is represented by shrubby elements and stunted forms of tree species. The notable mangrove species are *Avicennia officinalis*, *Bruguiera gymnorrhiza*, *Sonneratia apetala*, *Excoecaria agallocha*, *Rhizophora mucronata*, *Bruguiera cylindrica*, *Ceriops decandra*, *Acanthus ilicifolius*, *Caesalpinia nuga*, *Myriostachya wightiana*, *Suaeda maritima*, *Porteresia coarctata*, *etc.* About 50 ha of degraded lands have been planted with seedlings of *Avecennia* spp., *Excoecaria agallocha*, *Ceriops decandra*, *Rhizophora mucronata*, *Bruguira gymnorrhiza*, *Aegiceras corniculatum*, *etc.* by the Orissa Forest Department during 2001-2002 (Reddy 2002).

***Bhitarkanika* :** Bhitarkanika (672 km^2) harbours luxuriant and wide-spread mangrove vegetation (130 km^2). This area has a total of 42 true mangroves, 40 mangrove associates and 9 obligate mangroves. It provides ideal habitat to estuarine crocodile and several other faunal communities (Pandav 1996, Daniels and Acharjyo 1997). The mangrove

species occurring in Bhitarkanika exhibits two storey systems (Choudhury 1990). The ground flora is either poor or absent, top canopy is dominated by mangrove species *viz.*, *Sonneratia apetala*, *Avicennia officinalis*, *A. alba*, *Excoecaria agallocha*, *Heritiera fomes*, *Pongamia pinnata*, while the second storey is composed of shrubby and under tree species such as *Brownlowia tersa*, *Kandelia candel*, *Lumnitzera racemosa*, *Rhizophora mucronata*, *Ceriops decandra*, *Cynometra iripa*, *Clerodendrum inerme*, *Aegiceras corniculatum*, *Hibiscus tiliaceus*, *etc.* Gregarious and luxuriant growth of *Avicennia* spp. and *Sonneratia apetala* are found along banks of river and creeks in Bhitarkanika. While *Pongamia pinnata* and *Xylocarpus granatum* occupy habitats close to the water bodies, in more elevated areas mixed forests of *Heritiera fomes* and *Excoecaria agallocha* are met with. While *Phoenix paludosa*, *Tamarix indica*, *Hibiscus tiliaceus*, *Heritiera littoralis* are found in pure formations, *Bruguiera gymnorrhiza*, *Cerbera manghas*, *Ceriops decandra*, *etc.* are found in low frequency. The ground level, close to river banks and estuaries is muddy and studded with pneumatophores. Except a few patches of grasses herbaceous elements are devoided. However, a little distance from the river banks, *Acanthus ilicifolius*, *Acrostichum aureum*, *Flagellaria indica*, *etc.* in the moist areas and *Salicornia brackiata*, *Suaeda nudiflora*, *Tylophora indica*, *etc.* are in the dry region are usually found as herbaceous elements. The common associates as the category of climbers/thinners are *Derris trifoliata*, *Mucuna gigantean*, *Acanthus volubilis*, *Caesalpinia nuga*, *Dalbergia spinosa*, *etc.* Some mangrove species like *Cerbera manghas*, *Acanthus volubilies* and *Heritiera kanikensis* are found only in Bhitarkanika. Of these, the later two species are endemic to Orissa. Occurrence of 3 species each of *Avicennia*, *Heritiera*, *Sonneratia*, *Rhizophora and Xylocarpus* and 4 species of *Bruguira* are significant for Bhitarkanika forests (Mukherjee and Mukharjee 1978).

***Mahanadi Delta* :** The dominant mangrove species occurring in Mahanadi delta are *Avicennia officinalis*, *A. marina*, *A. alba*, *Excoecaria agallocha*, *Rhizophora mucronata*, and *Sonneratia apetala*, *etc.* The mangroves in the region are degrading rapidly due to habitat alteration for agricultural system, development of prawn firms and of port facilities at Paradeep. These developmental activities moved many taxa towards threatened categories *i.e.*, *Merope angulata*, *Tamarix dioica*, *Bruguira sexangula*, *Sonneratia caseolaris*, *Sonneratia alba*, *Sonneratia griffithii*, *Sarcolobus carinatus*, *S. globosus*, *Xylocarpus mekongensis* and *Dolichandrone spathacea*. There are 34 true mangroves, 42 mangrove associates and 20 obligate mangroves are present in Mahanadi delta.

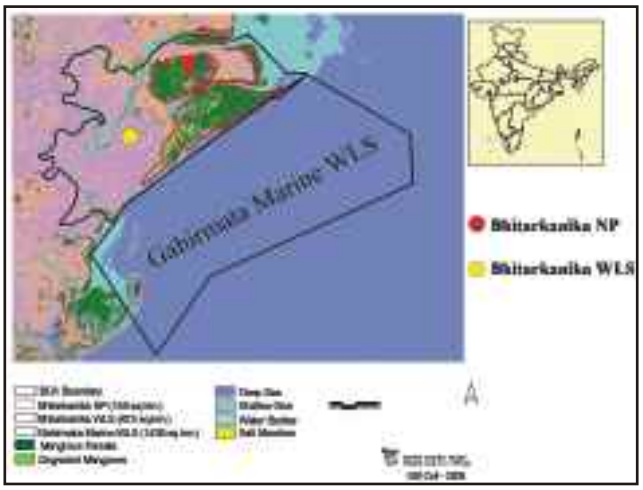
***Devi River Mouth* :** Devi river arises from river Kathjodi, a tributary of river Mahanadi drains into Bay of Bengal forming a tidal estuary with meandering creeks and channels. The estuary of Devi river is almost devoid of typical mangrove elements mainly due to habitat destruction connected with human settlement and paddy cultivation in the areas. Moreover, the ecological conditions have been changed due to formation of sand bars which considerably checked inundation. Only patches of *Acanthus ilicifolius*, *Tamarix troupii*, *Excoecaria agallocha*, *Myriostachya wightiana*, *Phoenix paludosa*, *etc*. are found in denuded condition. At places old stumps of *Avicennia* sp. and *Heritiera fomes* are reminiscent of the existence of past mangrove vegetation. In mud flats, *Suaeda maritima*, *Suaeda monoica*, *Sesuvium portulacastrum* and *Fimbristylis ferruginea* are common elements. Recently, efforts have been made by State Forest Department and M.S. Swaminathan Research Foundation, to introduce a number of species *i.e.*, *Avicennia officinalis*, *Sonneratia apetala*, *Aegiceras corniculatum*, *Ceriops decandra*, *Bruguira gymnorrhiza*, *Rhizophora apiculata*, *Avicennia marina*, *etc.* in the form of plantation. In total, there are 12 true mangroves and 4 mangrove associates are present in Devi river mouth.

***Mangroves of Chilika Lake* :** The typical mangroves have disappeared from the fringes of the Chilika lake and its adjoining regions. Only mangrove associates and transitory taxa like *Aegiceras corniculatum*, *Azima tetracantha*, *Salvadora persica*, *Cressa cretica*, *etc.* are found at places. However, species like *Clerodendrum inerme*, *Excoecaria agallocha*, *etc.* are reported by Narayan swami and Cater (1922) could not be traceable at present. About 10 ha of land near Sipakuda and adjoining area have been planted with species *i.e.*, *Rhizophora apiculata*, *Avicennia marina*, *A. alba*, *A. officinalis* and *Kandelia candel* by Forest Department of Orissa.

Table 2: A comparison of true mangrove species in Orissa, adjacent regions of east coast and Andaman & Nicobar Islands [C = Common, O= Occasional, F = Frequent, R = Rare, + = Present, - = Absent]

No	Name of the family & species	Mahanadi	Bhitarkanika	Sunderbans	Tamil Nadu	Andaman & Nicober
	ACANTHACAE					
1	*Acanthus ilicifolius* L.	C	C	+	+	C
	ARECACEAE					
2	*Nipa fruticans* Wurmb.	+	F	+	-	-
3	*Phoenix paludosa* Roxb.	F	F	+	-	-
	AVICENNIACEAE	_	_	_	_	+
4	*Avicennia alba* Bl.	+	+	+	-	-
5	*Avicennia marina* (Forsk.) Vierh.	+	+	+	+	-
6	*Avicennia marina* Var. acutissima Staf. & Mold	+	+	-	-	-
7	*Avicennia officinalis* L.	+	+	+	+	+
	COMBRETACEAE					
8	*Lumnitzera racemosa* Willd.	+	+	+	+	+
	EUPHORBIACEAE					
9	*Excoecaria agallocha* L.	+	+	+		+
10	*Excoecaria indica (*Sapium indicum)	-	+	-	-	-
11	*Excocaria bicolor* Muell.	-	-	+	-	-
	FABACEAE					
12	*Cynometra iripa* Kostel.	+	+	-	-	+
13	*Cynometra ramiflora* L.	-	+	+	-	-
14	*Derris trifoliatia* Lour.	+	+	+	+	+
15	*Derris umbellatum* DC.	-	-	+	-	-
16	*Intsia bijuga* (Colebr.) O. Kuntze	-	+	-	-	-
	MALVACEAE					
17	*Hibiscus tortussus* Wall.	-	-	+	-	-
	MELIACEAE					
18	*Aglaia cucullata* Roxb.	-	+	+	-	R
19	*Xylocarpus granatum* Koenig	+	+	+	-	C
20	*Xylocarpus molucensis* (L.) Roem.	+	+	+	-	R
21	*Xylocarpus mekongensis* (Prain) Pierre	+	+	-	+	-
	MYRSINACEAE					
22	*Aegiceros corniculatum* (L.) Blanco	+	+	+	+	C
	PLUMBAGINACEAE					
23	*Aegialitis rotundifolia* Roxb.	+	+	-	-	+
	POACEAE					
24	*Porteresia coarctata* Roxb. Takeoka	+	+	+	-	-
	RHIZOPHORACEAE					
25	*Bruguiera cylindrica* Bl.	+	+	+	+	-
26	*B. gymnorrhiza* (L.). Sav.	+	+	+	-	C
27	*B. parviflora* (Roxb.) Wt & Arn.	+	+	+	-	+
28	*B. sexangula*(Lour) Poir	+	+	+	-	+
29	*Ceriops decandra* (Griff.) Ding Hou	+	+	+	+	+
30	*Ceriops tagal* (Perr.) Robb.	-	+	+	R	+
31	*Kandelia candel* (L.) Druce	+	+	+	-	+
32	*Rhizophora apiculata* Bl.	+	+	+	+	C
33	*R. larmarckii* Montr.	-	-	-	+	R
34	*R. mucronata* Lamk.	+	+	+	+	C
35	*R. stycosa* Giff.	-	+	-	-	R
	RUBIACEAE					
36	*Scyphiphora hydrophyllacea* Gaertn.f	-	-	-	R	F
	RUTACEAE					
37	*Merope angulata* (Willd.) Sw.	+	+	-	-	-
	SONNERATIACEAE					
38	*Sonneratia alba* J. Sm	+	+	-	-	+
39	*S. caseolaris* (L.) Engl.	+	+	+	-	+
40	*S. apetala* Buch.-Ham	+	+	+	+	-
41	*S. griffithii* Kurz.	+	+	-	-	-
	STERCULIACEAE					
42	*Heritiera fomes* Buch.-Ham.	+	+	+	-	-
43	*H. kanikensis* Majumdar et. Banarjee	-	+	-	-	-
44	*H. littoralis* Dryand	-	+	+	-	C
	TILIACEAE					
45	*Brownlowia tersa* (L.)	+	+	+	-	R
	Total	**34**	**42**	**35**	**15**	**28**

Plate 28
Mangrove Vegetation of Orissa:
Special Communities and Threatened Species



Bhitarkanika Mangroves

Xylocarpus granatum - an endangered medicinal plant

Kandelia candel - exhibiting vivipary

Lumnitzera racemosa - A Sparsely Distributed Taxon

Sonneratia grifithii

Sesuvium portulacastrum- forming pure patches in hypersaline soils

Pnematophores of *Avicennia officinalis*

Conservation and Management

Mangroves of Orissa did not receive adequate protection in the past. Bhitarkanika forest area was under the control of the erstwhile Zamindari Forests of Kanika Raj till 1951. On abolition of Zamindari system the management of mangrove forests was vested on Government of Orissa. At present, mangroves of Bhitarkanika, Mahanadi and Devi river mouth are being managed by the Mangrove Forest Division, Rajnagar, mangroves of Subarnarekha, and Budhabalanga are managed by Baripada Forest Division and mangroves planted in Chilika are being managed by Chilika Forest Division. Due to reclamation of mangrove forests for settlement of the immigrants, paddy cultivation, prawn culture, over-exploitation of woody mangroves, establishment of port and factories the mangrove forests have been denuded in most part of the state. However, in recent years much effort is being made by State Forest Department, Government of Orissa not only to conserve mangrove forests but also to restore the degraded mangrove areas. Apart from the Forest Department, certain NGOs such as M. S. Swaminathan Research Foundation are also involved in conservation and restoration of mangroves in the state. In view of much devastation of super cyclone that hit Orissa coasts during 29 and 30 November 1999, the ecological role of mangroves has been realized much more than ever before and more emphasis has been laid on protection of this fragile forest ecosystem.

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29. Tropical Dry Evergreen Forests of India: Plants of High Conservation Significance

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Introduction

The tropical dry evergreen forests are among the least known and unique vegetation types confined to a few localities in the world. These forests are reported to occur in Antigua, Bahamas, British Guiana, Jamaica, Trinidad and Tobago in Tropical America; Ethiopian highlands, Tanzania and Zambia in Africa; Thailand, Sri Lanka and Coromandel coast of Peninsular India in Asia. There are no unified features for this rare and unique forest type and it has been chosen based on local climatic, biotic and edaphic factors, which influence the physiognomy, stand structure, species composition, and dynamics.

Champion & Seth (1968) recognized a zone of tropical dissymmetric climate along east coast of southern India where climax vegetation is Tropical Dry Evergreen Forest (TDEF). This type of forest occurs in patches along the Coromandel coast that extends for about 80-100 km inland (Mani 1974). These forests are typically low at 9 to 12 m high with continuous canopy and evergreen species having small, coriaceous leaves. Boles of the trees are short with spreading crowns with some deciduous emergents, without marked differentiation of canopy layers. Floristically, it is distinguished by a fair representation of characteristic and preferential species peculiar to this type (Meher-Homji 1974). Venkateswaran & Parthasarathy (2005) described the TDEF as short statured, largely three-layered evergreen forest with a sparse and patchy ground flora. This author has been conducting ecological studies on the TDEF for a decade documenting plant species diversity, resource use pattern and conservation status covering as many as 75 sites in Pondicherry (11°562 N and 79°53' E), Villupuram (11°93' N 79°48' E), Cuddalore (11°43' N and 79°49' E) and Pudukottai (10°23' N and 78°52' E) areas on the Coromandel coast (Plate 29). The areal extent of TDEF sites studied ranged from 0.5 ha to ~10 ha. In reality, most of the Indian TDEFs, with the exception of two large areas, namely the Kurumbaram section of the Marakanam Reserve Forest and the Point Calimere Wildlife Sanctuary, occur as patches of forest dotted along the Coromandel Coast, and invariably protected as “sacred groves” based on the religious belief of the local people. This unique dry evergreen forest is relatively under-studied on aspects of structural and functional ecology, as compared to the tropical wet evergreen forests.

Biophysical Features

The Coromandel coast receives much of rainfall during the northeast monsoon (October-December), while southwest monsoon (June to September) is very little and inconsistent. The mean annual rainfall recorded at three major towns *viz.*, Pondicherry, Cuddalore, and Pudukottai are 1,282, 1,079 and 1,033 mm respectively. The dry season lasts for six months (January to June), and monthly average rainfall during rest of the months is less than 60 mm. Mean annual maximum and minimum temperatures are 32.58°C and 24.51°C in Pondicherry, 22.75°C and 33.64°C in Cuddalore, and 33.4°C and 25.4°C in Pudukottai. General physiognomy of TDEFs and characteristic plant species are featured (Plate 29).

Systematic study of vascular plants at 75 TDEF sites in the Coromandel coast yielded 149 woody species belonging to 122 genera and 49 families. Of the 149 woody plant species 102 are trees, 47 lianas, and three are characteristic native herbs (Parthasarathy *et al.* 2008) which include the widely-distributed, colony-forming *Sansevieria roxburghiana*, fairly

distributed *Ecbolium viride*, and the rare *Amorphophallus sylvaticus*. Dominant families in Indian TDEFs include Euphorbiaceae, Rubiaceae with 11 species each, followed by Capparaceae, Mimosaceae, Fabaceae and Moraceae with 8 species each, while Alangiaceae, Barringtoniaceae and Burseraceae are represented by single species.

Among various Life-forms, Phanerophytes (trees) are dominant representing 102 species (68% of the total) species, while lianas formed 32% (47 species). Earlier floral inventories in 12 one ha TDEF permanent plots (Parthasarathy & Karthikeyan 1997; Venkateswaran & Parthasarathy 2003; Mani & Parthasarathy 2005; Reddy & Parthasarathy 2003, 2007; Anbarashan & Parthasarathy 2008) resulted in 86 tree species with a range of 19 to 35 species. An ubiquitous tree, *Memecylon umbellatum*, was the most dominant species, accounting for 32% of tree density, followed by *Tricalysia sphaerocarpa* (10.5%) and *Pterospermum canescens* (9.7%) in the TDEF. A total of 44 liana species were recorded with a range of 21-29 species ha^{-1} in the eight one ha plots. Among lianas, *Combretum albidum* (19.2%), *Strychnos minor* (14%), and *Reissantia indica* (6.5%) were predominant species.

Out of 149 species, 75 are evergreen (50%), followed by deciduous (45 species, 30%) and brevi-deciduous species [species with brief deciduous period followed by synchronous leaf-flushing, *e.g.*, *Pterospermum canescens* (29 species; 20%). Analysis of qualitative reproductive traits of TDEF species (Selwyn & Parthasarathy 2006) reveals that many species had rotate-type, white-colored, scented flowers with nectar and pollen as rewards. Drupe and berry were the common fruit types and were found in black and red color, respectively. A strong association between the qualitative reproductive traits and pollination and dispersal spectrum among the TDEF species has been demonstrated (Selwyn & Parthasarathy 2006).

The bioresource potential, especially the medicinal importance of TDEF species, deserves detailed documentation within several unstudied sites. In addition to 75 TDEF sites studied, many more sites remain unexplored. The current understanding of aut-ecology and reproductive biology of most of the dry evergreen species is still at infant stage. The promising areas of future research include: (i) Reproductive biology of important species such as *Pterospermum xylocarpum*, *Casearia elliptica*, *Aglaia elaeagnoidea*, *Tiliacora acuminate*, *Strychnos minor*, *Sansevieria roxburghiana* and *Amorphophallus sylvaticus*, (ii) Genetic diversity of polymorphic species such as *Memecylon umbellatum*, *Pterospermum xylocarpum*, (iii) Bioresource potential of various medicinal plants, typically found within TDEF, (iv) Mass multiplication of multi-purpose species such as *Sansevieria roxburghiana* (used in the treatment of ear diseases and cough, yields silky fiber, leaf mucilage used locally as face cream, an effective sand binder and a hedge plant), *Ormocarpum cochinchinensis* (for bone setting) and *Amorphophallus sylvaticus* (for piles), to name a few, (v) Phyto-chemical screening of important species such as *Memecylon umbellatum*, *Trichosanthes tricuspidata*, *Cassytha filiformis*, *Cissus vitiginea*, *Sarcostemma acidum*, *Atalantia monophylla*, and *Jasminum angustifolium* among others. Threats to TDEFs include forest fragmentation, land use change, encroachments for agriculture, soil removal, over grazing by domestic livestock, and extraction of fuel wood and medicinal plants.

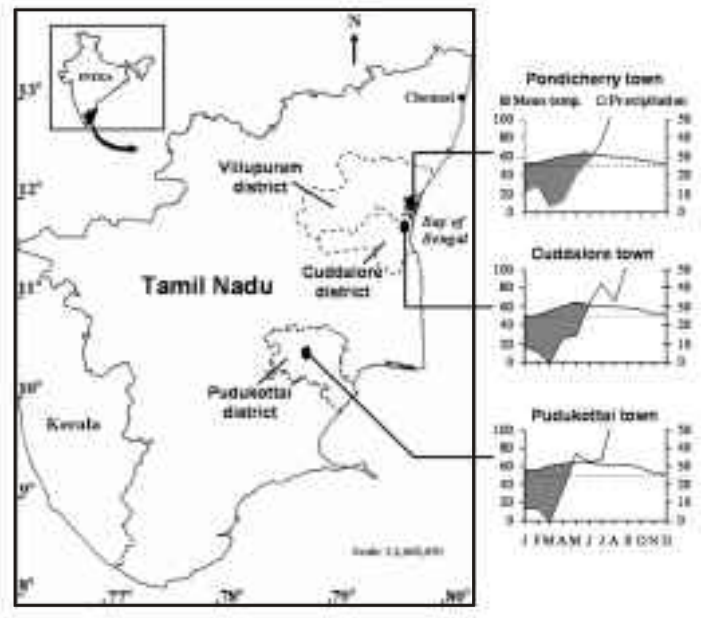
Conservation of TDEF patches and representative floral elements is of utmost priority considering the restricted geographical distribution and unique features. It is high time that the conservation agencies, academicians and non-governmental organizations come together and draw a conservation action plan involving local communities.

Key Floral Elements of High Conservation Significance

Selected economically and ecologically important species of TDEF along with their brief description, distribution and threats are given below:

***Memecylon umbellatum* Burm. f. (Melastomataceae)**
Tamil: Kasan.

Plate 29
Important Plants of High Conservation Significance in Tropical Dry Evergreen Forests



Map

1. & 2. TDEF sites

3. *Memecylon umbellatum* Burm., 4. *Glycosmis mauritiana* (Lam.) Tanaka,
5. *Strychnos minor* Dennst., 6. *Sansevieria roxburghiana* Schultes & Schultes f.,
7. *Garcinia spicata* (Wight & Arn.) Hook.f.

Predominant and characteristic tree species of TDEFs. Small to medium tree bark thinly fissured. Leaves opposite, coriaceous, fibrous. Flowers blue to pink and purple. Fruits purplish black. Medicinally valuable and also yields dye.

***Tricalysia sphaerocarpa* Dalz. (Rubiaceae)**

Common English name: Wild coffee.
A tree. Outer bark often attacked by termites giving it creamish appearance. Leaves dark green. Flowers white, scented. Fruits greenish yellow dispersed by mammals and birds.

***Pterospermum canescens* Roxb. (Sterculiaceae)**

Important tree, endemic to Coromandel coast of India and Sri Lanka. Leaves white beneath. Flowers white. Fruit woody capsule. Seeds winged.

***Glycosmis mauritiana* (Lam.) Tanaka (Rutaceae)**

Common shrub or small tree in all TDEFs. Leaves pinnately compound, gives smell of chilly when bruised. Flowers white. Fruits fleshy, rosy red berry, edible.

***Garcinia spicata* (Wight & Arn.) Hook. (Clusiaceae)**

An evergreen tree. Leaves dark green, coriaceous. Flowers cauliflorous. Fruit yellowish berry dispersed by small mammals.

***Manilkara hexandra* (Roxb.) Dubard (Sapotaceae)**

Large tree, particularly voluminous in Pudukottai TDEFs. Leaves coriaceous. Flowers white. Fruit yellow berry, edible. Endemic to Coromandel coast and Sri Lanka.

***Strychnos minor* Dennst. (Loganiaceae)**

A liana. Tendrils bi-forked. Leaves dark green, tri-nerved. Flowers white, fragrant. Fruits profuse and the berries dispersed by mammals and birds.

***Sansevieria roxburghiana* Schultes & Schultes f. (Ruscaceae)**

Gregarious herbs. Leaves succulent and fiber yielding. Flowers in long panicle, greenish white. Fruit red berries vertebrate dispersed. Medicinally valuable.
Tamil: Marul

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30. Endemic Plants of Andaman and Nicobar Islands

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Introduction

Since the time of Darwin and Wallace, oceanic islands have been recognized to be of great significance in studies of organismic diversity, biogeography and evolution. Isolated from the main lands by vast expanses of water and with relatively little or no human interference, they provide ideal sites for the study of evolution, speciation and adaptive radiation. Such island groups display enormous variety of biota and more importantly, with a sizeable endemic component. However, most of these islands have been subject to overexploitation of natural resources and ill planned developmental activities leading to widespread destruction of natural habitats and loss of biodiversity, which is not yet fully understood and catalogued.

Andaman & Nicobar (A&N) Islands, situated between 6^{o} 45' to 13^{o} 41' N latitudes and 92^{o} 12' to 93^{o} 57' E longitudes (Fig - 1), form the largest archipelago in the Bay of Bengal, consisting of 306 islands and 206 rocks and rocky outcrops. Often described as 'Islands of the marigold sun', they were known as 'Kalapani' because of their having been an area of penal settlement during British rule. These groups of islands are projections of a long narrow submarine range of mountains, with only the peaks being visible above the sea. Geologically these islands are quite young in age, probably formed in upper Mesozoic (*ca* 100 million years ago). This mountain range has a narrow deep oceanic furrow on the western boundary that abuts on the main continental plate on the west. The total geographical area of these islands is 8,249 km^2**,** coast line of 1,962 kms. The northern group of islands, the Andaman group, is 6,408 km^2 and the Nicobar group is 1,841 km^2. This large archipelago is separated from mainland India by almost 1000 kms; the nearest landmass in the north is Myanmar, roughly 280 km north of Landfall Island, the northern-most island is the Andaman Group. The closest landmass to the Great Nicobar Island is Sumatra, 145 km south.

The Great Andaman group of islands comprises North, Middle and South Andaman Islands, with Baratang Island situated between Middle and South Andaman Island. Andaman group is 352 km in length, its extreme width, however is nowhere more than 52 kms. Ritchie's Archipelago, a group of islands, is located east of Middle Andaman while Labyrinth group of islands lies southwest of South Andaman (Plate 30). The Little Andaman is located 55 km south of South Andaman, across the Duncan passage. The land area of 6408 km^2 of the Andaman Group constitutes almost 90% (5629 km^2), as reserve or protected forest of which 36% is Tribal Reserve. The elevation in the Andamans ranges from 0-732m, the Saddle Peak in North Andaman being the highest.

The Nicobar group is spread over an area of 1,841 km^2 of which, 1,542 km^2 area falls under recorded forests. The Nicobars are separated from the Andamans by the 10^0 Channel, a wide gap of 160 km with heavy tidal flows, making sea transport by small boasts difficult. The Nicobars consists of 24 islands in three distinct clusters of which 12 are inhabited having 170 villages and hamlets. The Northern Group consists of Car Nicobar, Batti Malv and the Central or the Nancowry Group. The latter includes Car Nicobar, Tillanchong, Chowra, Teressa, Bompoka, Trinkat, Kamrota, Katchal and Nancowry islands. The southern group consists of the two large islands Little and Great Nicobar, together with Pigeon, Megapode, Kondul, Pilo Milo, Menchal, Treis, Trak and Meroe Islands. The entire Nicobar is a Tribal Reserve and has four sanctuaries. An area of 885 km^2 in Great Nicobar Island is designated as the Great Nicobar Biosphere Reserve and two other areas within it as national parks (Jayaraj & Andrews, 2005). The climate is humid tropical. The average annual rainfall varies from 1,400 mm to 3,000 mm and average annual temperature varies from 24 ^{o}C to 28 ^{o}C.

The A&N islands are the homeland of six tribal communities, *viz*., Great Andamanese, Onge (numbering only 97), Jarwa, Sentinels (numbering 100 – 150). Shompen and Nicobarese. However, there is a distant racial difference between the Andaman tribes and their counter parts in the Nicobars. The former four are Negrito, while the latter are Mongoloid. The Nicobarese are well integrated and assimilated to the Indian mainstream and the Shompen, who are still shy and avoid any interaction with the outsiders but they are not particularly hostile. The Onge, Jarwas and Great Andamanese have accepted outside intervention and are being rehabilitated by the A&N Administration. However, the Sentinels are still hostile.

Vegetation

The A&N has a rich wealth of vegetation. While describing the vegetation of these islands Parkinson (1923) wrote "from the water's edge to tops of the highest hills, the islands are nearly every where densely wooded". According to Balakrishnan & Ellis (1996) and Rao (1999), the climatic climax of the islands is typically the Tropical Lowland Rain Forest, which is in a state of equilibrium, seemingly undisturbed, influenced by warm and wet conditions. These forests are floristically the richest, highly complex, most exuberantly developed, though somewhat influenced by altitude and intensity of monsoons. The higher reaches are also affected by high wind velocity, causing dessication, exhibiting stunted, scrub-like vegetation, called Hill-top vegetation as seen on Saddle Peak in North Andamans, and mount Thuiller in Great Nicobar. Kurz (1876) while working on the Nicobar group of islands has grouped the vegetation of this area into following categories: (i) Mangrove forests; (ii) Beach forests; (iii) Tropical Forests, (iv) Grass-heaths of Car Nicobar and Kamrota islands; (v) Marine vegetation with some sea grasses such as *Halophia ovalis* and *Enhalus acoroides.*

Champion & Seth (1968) treated the forests of A&N Islands under 11 types, *viz.* (i) Giant evergreen forest, (ii) Andaman tropical evergreen forest, (iii) Southern hill-top tropical evergreen forest, (iv) Cane brakes, (v) Wet bamboo brakes, (vi) Andaman semi evergreen forest, (vii) Andaman moist deciduous forest, (viii) Andaman secondary moist deciduous forest, (ix) Littoral forest, (x) Tidal swamp forest, and (xi) Submontane hill valley swamp forest.

According to Balakrishnan & Ellis (1996) the configuration and composition of some of the above major types of forests can be summarized as follows: The giant evergreen forests are typically climatic climax, where optimum conditions are prevalent. Characteristically the top canopy, though irregular, is almost covered. The soil is deep alluvial and able to retain the water content of the abundant rainfall of about 300 cm for long periods. Several species of *Dipterocarpus viz.*, *D. alatus*, *D. gracilis*, *D. incanus*, *D. turbinatus* var. *andamanica* and *Hopea odorata* are found here. The second storey comprises *Baccaurea sapida*, *Sideroxylon longipetiolatus*, *Endospermum malaccense*, *Artocarpus gomezianus*, *Myristica glaucesens* and *Buchanania platyneura.*

The Andaman tropical evergreen forests are less luxuriant, the top storey being irregular and the canopy not complete. They occur at the top of hills with elements of moist deciduous type on the slopes. Many species of *Dipterocarpus* occur here among which *D. kerrii* is prominent, intermixed with *Artocarpus chaplasha*, *Panchonia andamanica*, *Hopea odorata*, *Sideroxylon longipetiolatum*, associated with *Garcinia andamanica*, *Myristica andamanica*, *M. glaucescens* and *Baccaurea sapida*. The climbers include *Gnetum scandens*, *Ancistrocladus tectorius*, the climbing bamboo *Dinochloa scandens* var. *andamanica*, *Artabotrys speciosus*, *Calamus longisetus*, *C. palustris*, *C. pseudorivalis*, *etc.* the last three making cane-brakes at disturbed places having exposed canopy.

The Andaman Semi-evergreen forests occur on immature, alluvial soil, distributed in the main valleys of the Andamans forming some of the densest forests. The top layer mainly includes *Dipterocarpus alatus*, *D. pilosus*, *Petrocymbium tinctorium*, *Sterculia campanulata*, *Terminalia bialata*, *Calophyllum soulattri*, *Atrocarpus lakoocha*, *A. chaplasha* and *Pterocarpus dalbergioides* intermixed with *Dillenia pentagyna*, *Pometia pinnata*, *Litsea panamonja*, *Xanthophyllum*

andamanicum, *Mangnolia andamanica*, *Garcinia andamanica*, *Caryota mitis* and *Parishia insignis.* Climbers include *Dinochloa scandens* var. *andamanica*, *Combretum latifolium*, *Thunbergia fragrans* and *Calamus* spp. Because of many good timber yielding plants, these forests are economically the most important.

The Andaman moist deciduous forests are with leaf-shedding plants reaching a height of about 45 m, attaining large girth and often predominantly buttressed. The second storey includes some evergreen species. Shrubby climbers are common, including canes. These are commonly met with in the Andaman Islands, rarely so in the Nicobars. The hard coarse grained sandstone forms the underlying rock with shale and conglomerate. The soil is rather shallow and sandy loamy. The characteristic species include: *Pterocarpus dalbergioides*, *Lagerstroemia hypoleuca*, *Chukrasia tabularis*, *Sterculia alata*, *Pterocymbium tinctorium*, *Terminalia bilata*, *T. procera*, *etc.* The second storey comprises *Adenanthera pavonina*, *Dillenia pentagyna*, *Lannea coromandelica*, *Diospyros marmorata*, *etc.*, followed by similar trees like *Murraya paniculata*, *Pterospermum alatum*, *Ixora grandifolia*, *Atlantia monophylla*, *Antiaris toxicaria*, *Artocarpus chaplasha*, *Canarium euphyllum*, *Spondias mangifera*, *Garuga pinnata*, *Gyrocarpus americanus*, *Zanthoxylum budrunga*, *etc.*

The Andaman secondary moist deciduous forests comprise elements intermixed with preceeding forest, and they are essentially composed of two canopies, the upper one comprising *Bombax ceiba*, *Pterocymbium tinctorium*, *Terminalia bialata*, *Tetrameles nudiflora*, *Parishia insignis*, *etc.* and the lower canopy comprising *Pterocarpus dalbergioides*, *Lagerstroemia hypoleuca*, *Albizia lebbeck*, *Adenanthera pavonina*, *Planchonia andamanica*, *Diploknema butyracea*, *etc.* This type is more regenerated secondary forests, where semi-evergreen type existed previously.

The Southern hill-top tropical evergreen forests are to be found in some of the high hill tops of these islands, *i.e.*, Saddle Peak of North Andamans and Mount Thuiller of Great Nicobar Island. These hills are subject to high velocity wind with heavy rainfall of over 450 cm per year associated with high humidity during the monsoon season. The trees of these forests are stunted and surrounded by wet evergreen forests at lower hill slopes. The common trees include *Dipterocarpus costatus*, *Phyllanthus andamanica*, *Memecylon collinum*, *M. caeruleum*, *Psychotria balakrishnaii*, *Grewia indandamanica*, *Canarium manii*, *Mesua ferrea*, *Hopea andamanica*, *Cratoxylum formosum*, *Euphorbia epiphylloides*, *Chionanthus sumatranus*, *Crytocarya ferrarsi*, *Phoenix andamanica* and the climbing bamboo *Dinochloa scandens* var. *andamanica* and *Schizostachyum andamanicum* making impenetrable thickets with entangled and matted stems. The ground layer has grasses such as *Oryza indandamanica*, *Imperata cylindrica*, *Heteropogon contortus*, *Chrysopogon aciculatus*, associated with several species of mosses, *Sonerila* sp., *Utricularia exoleta* and *Rostellularia procumbens.* The rocks and boulders here are usually covered by dense moss, especially during monsoon season bearing amidst them the rare North east Indian orchids *Porpax meirax* and *Ascocentrum ampullaceum.*

Parkinson (1923), while dealing with only Andaman Islands, expounds the main forest types under: (i) Mangrove forests, (ii) Littoral forests, (iii) Evergreen forests, (iv) Deciduous and semideciduous forests, and (v) Forests of the parched and shallow-soiled slopes of high hills as at Saddle Peak, the Cladius Range and Mt. Farrington in the Middle Andaman and Mt. Ford on Rutland Island. Thothathri (1960) treats the Andaman forests under seven types including vegetation of the cleared lands and open areas and marine vegetation. Saldanha (1989) demarcates six forest types in the Andamans: (i) Giant Andaman Evergreen, (ii) Andaman Tropical Evergreen, (iii) Andaman Moist Deciduous forests, (iv) Andaman Hill-top Evergreen, (v) Littoral forests and (vi) Mangrove forests. He also calls Bamboo and Cane brakes as local variations.

While dealing with the natural vegetation of the entire A&N Islands, Balakirshnan (1977, 1989) broadly classified the vegetation into 2 major groups consisting of eight types, giving importance not only to forests but also to the other types occurring in various ecological zones. According to him the vegetation of these islands can be broadly classified as tropical evergreen with minor variations from north to south depending upon rainfall, type of soil and degree of salinity

in the soil. Based on the proximity to the sea and salinity of the soil, the vegetation can be placed into two major groups, *i.e.* Littoral and Inland types, each further subdivided as follows:

A. Littoral: (i) Submerged vegetation, (ii) Mangrove vegetation (iii) Strand vegetation, (iv) Tidal or swamp forests.

B. Inland: (i) Evergreen forests, (ii) Deciduous forests, (iii) Grasslands, (iv) Aquatic vegetation.

Floristically, A&N Islands shows close affinities with Indo – Chinese and Indo – Malayan region. Presence of over 2,000 indigenous and 500 non – indigenous angiosperm species within a land mass of 8,290 km^2 is a significant feature of the islands, making them a cynosure not only for plant taxonomists but also for conservationists. Among the non-endemic angiosperms, about 40% are found in mainland India. As regards Pteridophyes, 120 species are known under 36 families. Nearly 365 species are considered as 'threatened' while 40 species have been listed under Red Data Book of Indian Plants. More than 600 species of exotic plants have been introduced to these islands, many of them being aggressive and invasive in nature, which pose serious threat to the native flora and fauna.

Of about 2000 native angiosperms, 14% are endemic to these islands. At the generic level endemism is rather less with only three genera *viz.*, *Sphyranthera* (Euphorbiaceae) with 2 species. *Pubistylis* (Rubiaceae) with one species and *Nicobariodendron* (Celastraceae) with one species. Recently Garbyal *et al.* (2008), Naithani (2008) and Naithani *et al.* (2008) have mentioned some rare, endemic lesser known trees from the Islands. An updated list of endemic vascular plants from these islands is given in Table 1 (Plate 30).

Table 1: Endemic Plants of Andaman & Nicobar Islands: Distribution among major islands and habitat types.

P = Present; A = Absent. Habitats: GAE = Giant Andaman Evergreen; ATE = Andaman Tropical Evergreen; AMD = Andaman Moist Deciduous forests; AHTE = Andaman Hill Top Evergreen; LF = Littoral Forests; MF = Mangrove Forests.

Name of species	Family	Habitat	Great Nicobar	Car Nicobar	Andaman
Cyathea albosetacea	Cyatheaceae	AMD	P	A	A
Cyathea nicobarica	Cyatheaceae	AMD	P	A	A
Alstonia kurzii	Apocyniaceae	LF	A	A	P
Artabotrys nicobaricus	Annonaceae	AMD	P	A	A
Chilocarpus denudatus var. *nicobaricus*	Apocynaceae	ATE	P	A	A
Chisocheton nicobaricus	Meliaceae	ATE	P	A	A
Cleistanthus balakrishanani	Euphorbiaceae	ATE	P	A	A
Claoxylon rostratum	Euphorbiaceae	ATE	A	A	P
Clematis smilacifolia var. *andamanica*	Ranunculaceae	AMD	A	A	P
Codiocarpus andamanica	Icacinaceae	ATE	A	A	P
Connarus nicobaricus	Connaraceae	ATE	P	A	A
Coptophyllum nicobaricum	Rubiaceae	ATE	P	A	A
Cyclea pendulina	Menispermaceae	ATE	A	A	P
Cyrtandroemia nicobarica	Scrophulariaceae	ATE	P	A	A
Cyrtandra burttii	Gesneriaceae	ATE	P	A	A
Cyrtandra occidentalis	Gesneriaceae	LF	P	A	A
Cyathostemma micranthum	Annonaceae	LF	A	A	P
Dillenia andamanica	Dilleniaceae	AMD	P	A	P
Diospyros marmorata	Ebenaceae	AMD			P
Drypetes bhattacharyae	Euphorbiaceae	LF	A	A	P
Dysoxylum alliaceum	Meliaceae	AMD	A	A	P

Elatostema novorea	Urticaceae	AMD	A	P	A
Embelia microcalyx	Myrsinaceae	LF	A	P	A
Friesodielsia forniculata	Annonaceae	ATE	P	A	A
Friesodielsia khoshooi	Annonaceae	LF	P	A	A
Garcinia andamanica	Garciniaceae	ATE			P
Genianthus horei	Asclepiadaceae	AHTE	P	A	A
Glochidion calocarpum	Euphorbiaceae	LF	A	A	P
G. mauritiana var. *andamanensis*	Rutaceae	AMD	A	A	P
Grewia colophylla	Teliaceae	AMD	A	A	P
Hedyotis paradoxa	Rubiaceae	ATE	A	A	P
Ixora brunnescens	Rubiaceae	LF	A	A	P
Ixora cunifolia var. *macrocarpa*	Rubiaceae	LF	A	P	A
Ixora grandifolia var. *kurziana*	Rubiaceae	AMD	A	P	A
Ixora tenuifolia	Rubiaceae	AMD	A	P	A
Jasminum multiflorum var. *nicobaricum*	Oleaceae	AMD	P	A	A
Knema andamanica	Myrsinaceae	GAE	A	A	P
Lagestroemia hypoleuca	Lythraceae	AMD	P		P
Leea grandifolia	Vitaceae	LF	A	P	A
Litsea kurzii	Lauraceae	LF	A	P	A
Macaranga nicobarica	Euphorbiaceae	LF	A	P	A
Mallotus oblongifolius var. *rubriflorus*	Euphorbiaceae	LF	A	A	P
Maesa andamanica	Myrsinaceae	AMD	A	A	P
Mangifera andamanica	Anacardiaceae	AHTE			P
Mangifera nicobarica	Anacardiaceae	ATE	P		
Magnolia andamanica	Magnoliaceae		A	A	P
Memecylon andamanicum	Memecylaceae	ATE	P	A	A
Mesua manii	Clusiaceae	ATE			P
Nicobariodendron sleumeri	Celastraceae	ATE	P	A	A
Nothophoebe nicobaricus	Lauraceae	ATE	P	A	A
Ophiorrhiza infundibularis	Rubiaceae	ATE	P	A	A
Ophiorrhiza nicobarica	Rubiaceae	ATE	P	A	A
Oropheo katschallica	Annonaceae	ATE	A	A	A
Otanthera nicobarensis	Melastomataceae	ATE	P	A	A
Paramignya andamanica	Rutaceae	ATE	A	A	P
Pellionia procridifolia	Urticaceae	LE	A	P	A
Phyllanthus andamanicus	Euphorbiaceae	AHTE			P
Phyllanthus sanjappae	Euphorbiaceae	AHTE			A
Polyalthea crassa	Annonaceae		A	A	P
Polyalthea parkinsonii	Annonaceae	LF	A	A	P
Pseuduvaria prainii	Annonaceae	AHTE	A	A	P
Psychotria andamanica	Rubiaceae	AHTE	A	A	P
Psychotria platyneura	Rubiaceae	AHTE	A	A	P
Semecarpus kurzii	Anacardiaceae	AMD	A	A	P
Sphyranthera airyshawii	Euphorbiaceae	AHTE			P
Sphyranthera lutescen	Euphorbiaceae	ATE	A	A	P
Sterculia rubiginosa	Sterculiaceae	ATE	P	A	P
Strobilanthes glandulosus	Acanthaceae	AHEE	A	A	P
Tabernaemontana crispa	Apocynaceae	LF	A	A	P
Tarenna weberaefolia	Rubiaceae	ATE	A	A	P
Terminalia procera	Combretaceae	ATE	A	A	P
Tetrastigma andamanica	Vitaceae	LF	A	A	P
Uvaria nicobarica	Annonaceae	ATE	P	A	A
Trigonostemon villosus var. *nicobaricus*	Euphorbiaceae	AHTE	P	A	A
Vitex diversifolia	Verbenaceae	LF			A
Vitex wimberleyi	Verbenaceae	AMD			A
Aerides emericii	Orchidaceae	ATE	P	A	A
Anoectochilus nicobaricus	Orchidaceae	ATE	P	A	A
Aglaonema nicobaricum	Araceae	ATE	P	A	A

Bentinckia nicobarica	Araceae	LF	P	A	A
Calamus andamanicus	Arecaceae	ATE	p	A	P
Calamus baratangensis	Arecaceae	ATE	A	A	P
Calamus basui	Arecaceae	ATE	A	A	P
Calamus dilaceratus	Arecaceae	ATE	P	A	A
Calamus pseudo –rivalis	Arecaceae	ATE	P	A	A
Calamus semierectus	Arecaceae	ATE	A	P	A
Calamus uniforms var. *pantong*	Arecaceae	ATE	P	A	A
Daemonorops aurus	Arecaceae	ATE	A	A	p
Daemonorops rarispinosa	Arecaceae	ATE	A	A	P
Daemonoropos wrightmyoenisis	Arecaceae	ATE	A	A	P
Dioscorea vexans	Dioscoreaceae	ATE	P	A	A
Dinochloa scandens var. *andamanica*	Bambusoideae	ATE	P	P	P
Dracaena brachyphylla	Agavaceae	ATE	A	A	P
Dendrobium shompenii	Orchidaceae	ATE	P	A	A
Eria bractescens var. *kurzii*	Orchidaceae	ATE	A	A	P
* *Freycinetia insignis*	Pandanaceae		P	A	A
Homalomena griffithii var.*ovata*	Araceae	ATE	P	A	A
Hornstedtia fenzlii	Zingiberaceae	ATE	P	A	A
Korthelsia rogersii	Arecaceae	ATE	A	A	P
Pandanus leram var. *andamanensium*	Pandanaceae	LF	P	A	A
Phalaenopsis speciosa	Orchidaceae	ATE	A	A	P
Phrynium paniculatum	Marantaceae	ATE	P	A	A
Pinanga manii	Arecaceae	AMD	P	A	A
Pomatocalpa andamanicum	Orchidaceae	ATE	A	A	P
Rhopaloblaste augustata	Arecaceae	ATE	P	A	A
Trichoglottis quadricornuta	Orchidaceae	LF	A	P	A
Vanilla andamanica	Orchidaceae	ATE	A	A	P

* Only woody climber in family Pandanaceae, also found in Malay Peninsula, Java.

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Fig - 1 : Location of Andaman & Nicobar Islands

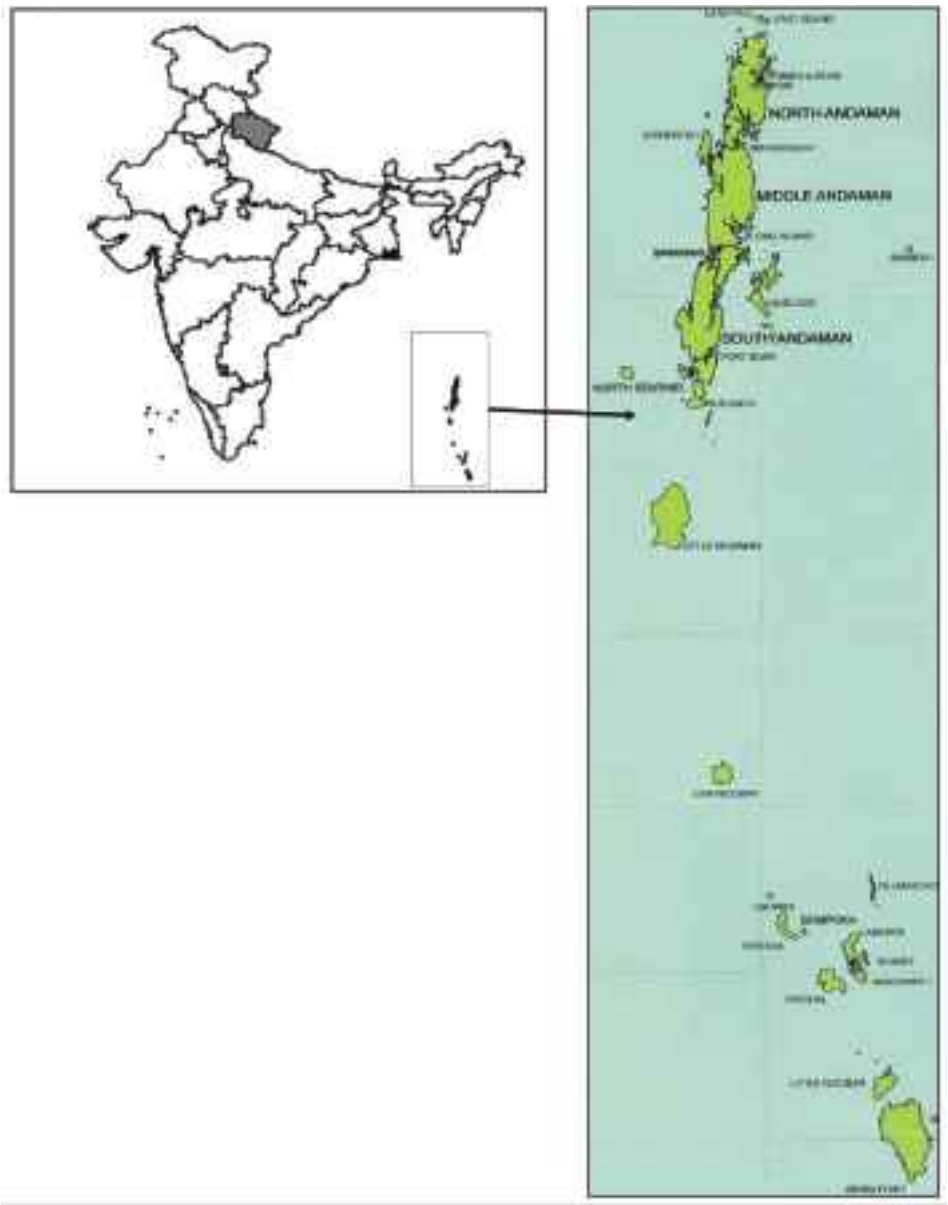

Plate 30
Endemic Plants of Andaman & Nicobar Islands

1. *Vanilla andamanica*
2. *Calamus dilaceratus*
3. *Cyrtandroemia nicobarica*
4. *Cyathea albosetacea*
5. *Dillenia andamanica*
6. *Dinochloa andamanica*
7. *Freycinetia insignis*
8. *Hornstedtia fenzlii*
9. *Bentinckia nicobarica*
10. *Freycinetia insignis*
11. *Pinanga manii*
12. *Calamus semierectus*

B. S. Adhikari

Section VIII:
Miscellaneous

31.0 Sacred Groves: People's Contribution to Conservation

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Introduction

Today when the earth is in a state of biodiversity crunch, environmentalists are looking back through the ages to our ancestors, who had some indigenous ways to conserve nature. One of the traditional ways to conserve nature is the system of Sacred Groves (SGs). Sacred groves must be the first temple of worship in the world, made by primitive human societies to worship nature. If defined, the sacred groves are forest patches of varying size, from a few trees to several hectares. They are sometimes dedicated to some deity or ancestral spirit and are sanctified to the extent that they become divine and cutting them becomes a taboo. Though this tradition has now been receded to remote villages and in some cases to folklores and folk tales, they are quite relevant even today as they always have been. According to famous folklorist of 20th century Charlotte Burne, the tribes of Votiaks of eastern Russia sing that the woods are always sacred from where not a single tree may cut down or else the God of the woods will avenge the injury. Like wise in many parts of the world trees were regarded as being divine and the place having these trees was regarded as sacred groves. Such groves were often located around homes and surrounding the village and to break even a twig off was a sacrilege (Frazer 1919). The supernatural power of some water bodies like healing and curing some ailments in different parts of the world has been documented by many workers (Olsen 2004, Tarasov 2003). Very often sacred groves were considered as having infinite magical power to grant punishment or to carry out miracles (Philpot & Mac Millan 1897, Parish 2005, Altman 2000).

Role of Sacred Groves

Besides social, cultural and economic services, the sacred groves have the potential to serve as gene pool and may help to maintain ecological balance. National Forest Policy (1988) states that the SGs are the last remnants of natural forests and are extremely valuable store house of biodiversity. Larger sacred groves can harbour high species richness and they play a significant role in *in situ* conservation of plants. Sometimes SGs give refugia to rare, endangered and endemic species. The SGs preserve the micro-climate within its area and increase nutrient cycling; it also recharges aquifers and act as primary source of perennial streams. Keeping in view the value of SGs, researchers have given various names to the SGs, such as Refugia for rare and threatened species, Laboratory of environmentalists, Compensation for carbon emissions (Carbon sink), Recreational and spiritual point, Reservoir of medicinal plants, Socially valued ecosystem, Heritage of cultural and traditional knowledge. If harnessed properly these groves along with the indigenous wisdom of its community can serve as multi-functional units of conservation.

Sacred Groves in Uttarakhand

The rural communities in Uttarakhand also have retained the tradition of worshipping sacred places such as Bugiyals (sacred alpine meadows), Dev Vans, *etc.* Mostly a few individual trees of a species *e.g.*, *Cedrus*, *Cupresuss*, *Pinus* and *Quercus* or single tree of some importance in the vicinity of the village are sanctified along with small temple. Such

places are locally known as 'Thans'. They are well preserved lush green patches. Sometimes individual of trees that attain giant size are considered sacred as they are believed to witness the changing history of the place and hence dedicated to local deities. For example, Deodar (*Cedrus deodara*) tree in Jageshwar (8.3m girth and 30m height), Noble cypress (*Cupressus torulosa*) tree in Devi Anusuea temple (6.25m girth and 32m height), Silk cotton (*Bombax ceiba*) tree near Sitarganj (12m girth and 28m height), Mulberry (*Morus serrata*) tree in Joshimath (18m girth and >5096 yrs old).

Though, detailed surveys of sacred groves have not been done in Uttarakhand so far, some of the well known sacred groves which support either an ecosystem or single species conservation are dedicated to a number of deities like Bhadraj (the deity who is known to teach cattle rearing), Mahasu, Shakumbari and Tarkeshwar Mahadev. Other places such as Patal Bhubaneshawar (rocks and caves with calcareous tufa), Garanath, Binsar, Mayadevi Ashram and Narayan Ashram harbor various floral and faunal elements, some of which could be rare, threatened and endemic species.

Most of the sacred groves in the state are located in Deodar zone or dominated by this species, which support various medicinal plants. *Taxus baccata* subsp. *wallichiana* is one of the most important medicinal plants growing under its canopy in Jageshwar and hence protected, while outside the grove this species is under tremendous pressure. The sacred Deodar forest patches spread over 2-5 km^2 area and are devoted to various deities. Some examples of sacred Deodar forests include Jageshwar and Dhauladevi in Almora district, Tarkeshwar in Pauri district, Devalsari (temple devoted to a saint) in Tehri district, Hat-Kali and Chamunda in Pithoragarh district. Some times natural structures (caves and crevices) also enhance the value of forest patches, *e.g.*, Patal-Bhuwaneshwar in Pithoragarh and Gauri Udiyar in Bageshwar districts. The famous deity Golu Devta of Kumaun region has several groves (Chitai, Ghorakhal, Gairar, Minar, Chamarkhan, Bari Goljyu) which are mostly under mixed pine-oak forests. Padiyar Devta, a well known local deity at 3400m altitude above Auli, Joshimath is seated under *Quercus semecarpifolia* forest, where the herders pray before entering the forest to safeguard their cattle from natural calamities and wild animals (Plate 31). Although, the groves have patchy distribution still they play a crucial role in maintaining biodiversity and provide protection to the local flora and fauna (Dhaila-Adhikari & Adhikari 2007).

Sometimes the sacred places give refuge to the rare tree species as in case of Chandhak temple of Pithoragarh. The 'Sweet *Osmanthus'* (*Osmanthus fragrans*) tree, which is an evergreen small tree with lustrous medium sized leaves. The flowers are extremely fragrant and perfume the entire landscape during winter to spring. Larger sacred groves also have their own micro-climate which increase nutrient cycling, recharge aquifers and act as primary source of perennial streams. For example, Shikhareshwer SG in Gangolihat (Pithoragarh) where Deodar forest forms catchment for perennial water stream (Naula).

In many groves villagers perform rituals and ceremonies to please the deity for well being and prosperity of the community. Sacred groves are the mirror image of cultural and economic set up of a community and their respect for nature. Some of the trees which are considered as sacred and worshiped in the state are Peepal (*Ficus religiosa*), Bargad (*F. benghalensis*), Bel (*Aegle marmelos*), Deodar (*Cedrus deodara*), Padam (*Prunus cerasoides*), Timur (*Xanthoxylum alatum*), Amla (*Emblica officinalis*), Mango (*Mangifera indica*), Neem (*Azadirachta indica*), Doob (*Cynodon dactylon*) and Banana (*Musa paradisiaca*). Peepal tree in the villages near Lohaghat is worshiped. These trees had been planted by the ancestors of the village and are still revered by their progeny. These trees are treated as family members and all the rituals, due to family members such as thread ceremony and marriage with some other religious trees as Mango and Aonla, are performed. In Kumaun region of Uttarakhand it is observed that the forest patches which

Plate 31
Sacred Groves of Western Himalaya

A Sacred Grove under Kharsu Oak Forest near Auli, Joshimath (3400 m)

Dhaula Devi Sacred Grove under Deodar Forest

Gairar Sacred Grove under Chir Pine forest

Himalayan Cypress, one of the important species planted around religious sites in Uttarakhand

Group of temples at Jageshwar Sacred Grove under deodar forest

were under severe biotic pressure and over exploited have been dedicated to the local deity after a concent of the community *e.g.*, Shyahi devi in Almora.

There are a number of small SGs in Uttarakhand, but they have not been documented due to their small size. Hence, it is not possible for the forest department to take any action to protect such SGs. Likewise, several other states are still waiting to enlist the SGs. So far, no legal protection has been given to these groves, except at few places *e.g.*, sites of Archaeological Survey of India or where Forest Department is involved. In other places, its belief, taboo or fetishism which makes them inviolate. So, the institute of sacred groves is the cradle, where the faith and beliefs are nurtured together with the habitats and biodiversity.

Threats and challenges

The SGs are rapidly loosing their ground in many parts of India due to following reasons:

- Erosion of traditional beliefs and rapid socio-economic advancement has led to the deterioration of sacred groves. Fading respect towards traditional knowledge among youngsters is one of the causes of concern,
- Developmental projects such as roads, dams, highways and encroachment by people migrating from outside having no respect for traditional values,
- Transformation of traditional worship of nature into formal Hindu practice, which is called *Sanskritization* like shifting the focus to idols than a simple stone, building temples which include clearing of the area.
- Heavy tourism sometimes becomes a burden to SGs, if the tourists are not aware of the fragile aspect of the nature.
- Fragmentation or split among families owning sacred groves.

Way forward

Progress and modernity not at all means avoiding the old customs and traditions. Therefore, the following aspects can be made for well being of SGs conservation.

- Inventory, documentation and the status of SGs.
- Revitalization of traditional culture, such as folk tales and folklores.
- Incentives to the local communities for maintaining and restoring SGs.
- Role of NGOs, Forest department and academia through community participation.

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32.0 Endemic Pteridophytes of India: Distribution and Threat Status

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Introduction

India is extremely rich in the diversity of Pteridophytic flora due to its remarkable variation in eco-climatic conditions, soil types and altitude. Recent assessments reveal that about 900-1000 species of Pteridophytes occur in India (Chandra *et al.* 2008). However, richness of flora is closely linked with palaeo-history and intermingling of flora with other regions. Incidentally, India has only about 5% of the Pteridophytes as endemic. The Himalayan and North Eastern Pteridophytic flora forms an integral part of the large Sino-Himalayan and S.E. Asian floristic zones. This is the reason for a low percent of endemism in Pteridophytes from these zones. In contrast, peninsular India and Islands have relatively higher percentage of endemics as they are insulated by the Indian Ocean and other biogeographic barriers.

The most authentic and foremost attempt to record the endemic Pteridophytes of India was made by Chandra (1982). He reported 96 species endemic to India. Later, Chandra & Kaur (1984) added 41 species to the previous list. Dhir & Saiki (1984) listed 58 species of ferns as endemic to the Himalaya, whereas Dixit (1984) listed 214 species of Pteridophytes endemic to India. Further information on the distribution of endemic Pteridophytes was provided by Bir (1987 & 1989). After that a phytogeographic analysis of the endemic species was done by Dixit & Bal Krishna (1990). Manickam & Irudayaraj (1992) in the Pteridophytic Flora of the Western Ghats enumerated 16 endemics from South India, whereas 17 endemic species were reported from South India by Nayar & Geevarghese (1988, 1993). Subsequently Chandra (1998) catalogued a total of 234 endemic Pteridophytes from India removing 25 species from the earlier lists and adding 14 new taxa. A more significant and valuable contribution has been made recently by Fraser-Jenkins (2008). He has removed many of the earlier endemic species of Pteridophytes as pseudo-endemics which arose mainly due to mistaken synonyms or the lack of understanding of the range of species. He has listed only 47 species of Indian Pteridophytes as endemics. It is observed that there is a vast difference among the observations of Pteridologists regarding the endemic status of the Indian Pteridophytes. One of the reasons for this is that the taxonomy and nomenclature of Pteridophytes is much more confusing than those of any other group of plants.

This article deals with a brief phytogeographic analysis of Indian Pteridophytes with special reference to the distribution of endemic species in different biogeographic regions of India.

Distribution

A total of 49 species of Pteridophytes can be said as endemic to India. This includes three allopolyploids which are neo-endemics of fairly recent origin *viz*., *Athyrium kumaonicum*, *Dryopteris khullari* and *Polystichum polyodon*. These species are distributed in as many as 6 of the 10 biogeographic zones of India (Table 1). Eight species found in the Indian Himalayan region are endemic, while 7 species of endemic Pteridophytes are reported from North-East India. Among these, four species are common between the Himalayan and North-Eastern zones. The highest number of endemic Pteridophytes (33) is reported from peninsular India (Deccan Peninsula and Western Ghats). The only

species reported as endemic in Semi-Arid zone is also found in Deccan Peninsular region. Five species of Pteridophytes are localized in the Andaman and Nicobar Islands. Other biogeographic zones *viz*., Trans-Himalaya, Desert, and Coasts harbour no endemic Pteridophytes.

Threat status

The Pteridophytes appear to face relatively less threat as compared to the angiosperms. The reasons for this may be the efficiency with which their spores are dispersed and the deep forested habitats they occupy making them less vulnerable. Moreover, fewer Pteridophytes are exploited commercially for herbal industries and as non-timber forest products (NTFPs). However, widespread environmental degradation restrains them to grow even in their safe haven. The Pteridophytes with creeping rhizome colonize a habitat more efficiently as compared to the species with erect rhizome. This explains why polyploid species are more successful compared to the diploids as the former are with creeping rhizome unlike the later. Likewise, epiphytic species require specific hosts and are therefore more vulnerable to population decline. Unfortunately, the conservation status of Indian Pteridophytes has not been assessed as yet in view of all the biological and ecological factors and CAMP workshop is still awaited as per the latest IUCN criteria. However, eleven of the endemic Pteridophytes fall into one or the other categories of threatened plants (Extinct, Vulnerable, Endangered and Rare) as per 1997 IUCN Red List (Walter & Gillet 1998). Besides, literature survey and authors' personal observations reveal that populations of 13 species have been reduced to a critical level and they are at a very high risk. Slight disturbance in their habitat can lead to their total extinction. Eight species are thought to be 'very rare' and are likely to be in peril if immediate steps are not taken to stop the destruction of their habitats.

Table 1. Distribution and threat status of the endemic Pteridophytes.
Ex=Extinct, V=Vulnerable, E=Endangered, R=Rare (IUCN Categories); *At Risk; #Very Rare

Name of the species	Distribution	Threat Status
Arthromeris notholaenoides V.K. Rawat & Fras.-Jenk.	**2D:** AP: Lower Debang Valley, Mehao	*
Asplenium exiguum Bedd.	**5B:** TN: Nilgiri	*
Asplenium khasianum Sledge	**2D:** East AP; **9B:** Meghalaya: Khasi hills	*
Asplenium rivulare Fras.-Jenk.	**6:** Deccan Peninsula	#
Athyrium kumaonicum Punetha	**2B:** Uttarakhand: Nainital, Pithoragarh	#
Athyrium parasnathense (C.B. Clarke) Ching *ex* Bir	**4B:** Rajasthan: Aravali Ranges; **6A:** Deccan Peninsula: Central Highlands	
Bolbitis presliana (Fée) Ching	**5A:** Kerala: Malabar; **5B:** Goa: Dudhsagar; Karnataka: Castle Rock, Shimoga, Coorg	#
Bolbitis semicordata (Baker) Ching	**5A:** Kerala: Malabar; **5B:** TN: Anamalais; Kerala: Munnar	#
Bolbitis subcrenatoides Fras.-Jenk.	**5A:** Kerala: Malabar: **5B:** Karnataka: Chikmagalur	
Cyathea albosetacea (Bedd.) Copel.	**10B:** Nicobar Islands: Camorta, Kotchall	V
Cyathea gamblei R.D. Dixit	**2C:** Sikkim; **9A:** Assam	
Cyathea nicobarica N.P. Balakr. & R.D. Dixit	**10B:** Nicobar Islands	
Cyathea nilgirensis Holtt.	**5B:** Karnataka: Coorg, Hassan, Kodagu; TN: Nilgiri, Anamalais, Palni, Shevroy hills; Kerala: Munnar, Travancore hills; **6A:** MP: Pachmarhi	E
Dryopsis scabrosa (Kze.) Holtt. & Edwards	**5B:** TN: Anamalais, Palni hills, Nilgiri	
Dryopteris austroindica Fras.-Jenk.	**5B:** TN: Shevaroy hills (probably extinct), Nilgiri	*
Dryopteris khullarii Fras-Jenk.	**2A:** HP: Chamba; **2B:** Uttarakhand: Below Trijugi-Narayan *en route* Kedarnath	#
Dryopteris odontoloma (Bedd.) C. Chr.	**5B:** TN: Anamalais, Nilgiri	#
Elaphoglossum beddomei Sledge	**5A:** Kerala: Malabar; **5B:** TN: Nilgiri, Anamalais, Tirunelveli hills; Kerala: Munnar, Ponmudi hills	R

Elaphoglossum nilgiricum Krajina *ex* Sledge	**5A:** Kerala: Malabar; **5B:** TN: Nilgiri hills, Pykara falls, Anamalais; Kerala: Travancore	E
Elaphoglossum stigmatolepis (Fée) T.Moore	**5B:** TN: Nilgiri, Palni hills	V
Huperzia nilagirica (Spring) R.D. Dixit	**5B:** TN: Anamalais, Agasthiar hills; Kerala: Ponmudi	#
Isoetes panchananii D.D. Pant & G.K. Srivast. var. *pachmarhiensis*	**6A:** MP: Pachmarhi	
Isoetes sahadriensis Mahabale	**5B:** Maharashtra; Tamil Nadu; Sahyadri hills	
Isoetes sampathkumaranii L.N.Rao	**6:** Karnataka; Andhra Pradesh	Ex
Lindsaea andamanica R.D. Dixit & S.R. Ghosh	**10:** Andaman & Nicobar Islands	
Lindsaea malabarica (Bedd.) Baker	**5A:** Kerala: Malabar; **6A:** MP; **6E:** TN: Kolli hills	R
Lindsaea tenera Dryand.	**10:** Andaman & Nicobar Islands	R
Oreogrammitis austroindica (Parris) Parris	**5B:** TN: Nilgiri hills (probably extinct not reported since 1960)	*
Oreogrammitis pilifera (Ravi & J. Joseph) Parris	**5A:** Kerala: Malabar; **5B:** Karnataka: Chikmagalur	*
Osmunda huegeliana C. Presl	**5B:** TN: Anamalais	
Phymatosorus beddomei S.R. Ghosh	**5B:** Kerala: Idduki; TN: Anamalais	
Polystichum manickamianum Benniamin	**5B:** TN: Agasthiar hills	*
Polystichum palniense Fras.-Jenk.	**5B:** TN: Palni hills	
Polystichum polyodon Wall. *ex* Ching	**9B:** Meghalaya	*
Polystichum subinerme (Kze.) Fras.-Jenk.	**5B:** TN: Agasthiar hills	*
Pteris perrottetii Hieron.	**5B:** TN: Nilgiri hills	
Selaginella adunca A. Braun *ex* Hieron.	**2B:** HP: Simla; Uttarakhand: Pithoragarh, Lohagarh	E
Selaginella cataractarum Alston	**5B:** TN; Kerala	E
Selaginella ganguliana R.D. Dixit	**5B:** Kerala	
Selaginella keralensis R.D. Dixit	**5B:** Kerala	
Selaginella miniatospora (Dalz.) Bak.	**5B:** Maharashtra; Goa	#
Selaginella pentagona Spring	**2D:** AP; **9B:** Meghalaya	
Selaginella radicata (Hook. & Grev.) Spring	**5B:** TN: Palni hills;**6E:** TN: Kolli hills	
Selaginella tenera (Hook. & Grev.) Spring	**5B:** TN: Anamalais, Tirunelveli hills	
Tectaria subconfluens (Bedd.) Ching	**9B:** Meghalaya: Khasi Hills	*
Thelypteris didymochlaenoides (C.B. Clarke) Ching	**9B:** Meghalaya: Sohra (Cherrapunji)	R
Thelypteris kurzii (Holtt.) Fras.-Jenk.	**10B:** Nicobar Islands	*
Thelypteris namburensis (Bedd.) C.F.Reed	**2D:** East AP; **9A**: Assam: Nambor Forest, Jorhat	*
Trichomanes agasthianum (Madhus. & C.A. Hameed) C.A. Hameed, K.P. Rajesh & Madhus.	**5B:** Kerala: Athirapalli, Trichur	*

Concluding Remarks

A comprehensive analysis is still required to be undertaken to re-evaluate the taxonomy and status of endemic Pteridophytes. Methodologies for the same are not yet very explicit, each researcher trying to evolve his or her own view about these species. The number of endemic species is likely to increase or decrease following further nomenclature revision of some of the species. The populations of these species also need to be regularly observed. This is crucial for the successful understanding of their conservation status. Nevertheless these key species are of particular concern requiring adequate efforts for both their *in situ* and *ex situ* conservation. Presently, several *in situ* conservation measures have been adopted for the angiosperms, however, Pteridophytes have not or only been partially given importance in this context. Furthermore, it has been found that in most of the Indian ferneries only ornamental ferns are grown and not the endemic or threatened species. Consequently, *ex situ* conservation of these species also needs to be reinforced through *in vitro* culture techniques.

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